Ecological Restoration in Flanders

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(editor)

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Foreword

Flanders is one of the most densely populated regions of the world. Consequently its natural environment has been, and still is, under large pressure. On the other hand, economically, it is also one of the richest and most prosperous parts of the world. Facing the global challenge of stopping biodiversity loss and preserving ecosystem services for future generations, Flanders not only has the means and the legal obligation, but also has a moral obligation to play an example role in ecological restoration to the rest of the world.

This book does not contain a policy evaluation of ecological restoration in Flanders. It merely presents an impression of the state-of-the-art, as ecological restoration has become more and more important in the Flemish nature conservation policy during the last two decades. The cases in this book will show that ecological restoration can really work! Not only for the benefit of biodiversity, but also for the people, who more and more seek out nature to simply enjoy it, or who understand that a good condition of nature is crucial for the ecosystem services it provides, such as clean air and water or safety against floods.

On the other hand critical reflections are necessary as well. Sometimes large amounts of money were spent, with results that could have been better. It is therefore necessary to learn from mistakes and to keep a sharp eye in order to ensure sustainable results. It is imperative here to realize that fragmentation, eutrophication, climate change, hydrological constraints and so on, remain important challenges for the future. In the long run successful ecological restoration will need a lot of additional made-to-measure efforts! But already now many of the examples show that restoration measures support biodiversity conservation and as such they are an important part of our implementation of the Countdown 2010 objectives in our efforts to halt loss of biodiversity by 2010.

After a short introduction on the legal framework for ecological restoration of nature areas in Flanders, some of the most important Flemish restoration projects, both successes and failures, are presented in this book. We would especially like to thank the different authors who used their site experience and expertise to summarize and evaluate projects, in a much appreciated co-production between our organisations. It is our hope that this book delivers an update of the Flemish ecological restoration scene and may form an encouragement to continue and even increase the efforts in the future.

Jurgen Tack, Director Research Institute for Nature and Forest
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Willy Ibens, Director Natuurpunt

COUNTDOWN 2010
SAVE BIODIVERSITY

I. Policy framework for ecological restoration in Flanders

I.1. Legal obligations

In Belgium nature conservation is within the competence of the three regions: Flanders, Wallonia and Brussels, except for the marine environment (federal). The Flemish region (13,522 km^2) is one of the most densely populated areas of Europe (452 inhabitants/km^2). Consequently open space, environmental quality and natural habitats are under great pressure.

Spatial planning and zoning maps

Although approximately 12.5% of the region has a "green" destination on the spatial planning and zoning maps, only 3% of Flanders is actually protected and managed as a nature reserve or multifunctional nature area. This is a lower proportion than in most of the other densely populated areas of Western Europe. This 3% is almost entirely managed by the Agency for Nature and Forests or specialised NGO's such as Natuurpunt.

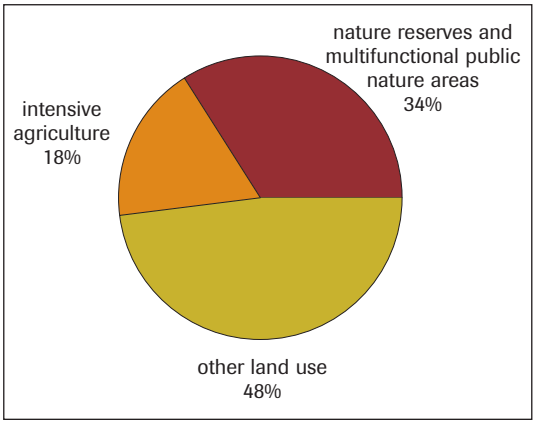
Contrary to what one would expect, 20% of all areas with a "green" destination on the spatial planning maps are actually used for intensive agriculture. Ecological values have almost completely disappeared here due to a failure in ecological maintenance, or were never developed during the last 40 years of rural planning policy. It is clear that there remains a huge challenge here for ecological restoration.

The Flemish Ecological Network

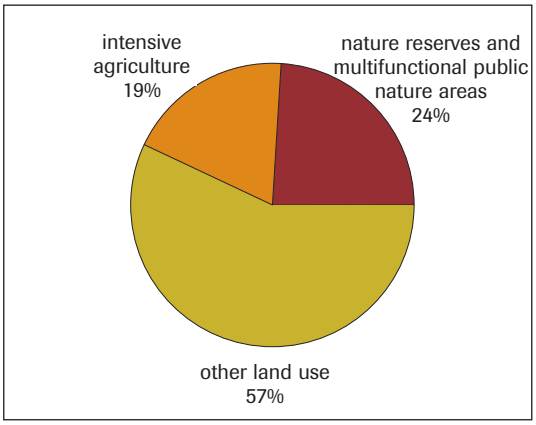
Moreover, many areas with a "green" destination are small or fragmented. In 1997 the Flemish Government therefore approved a new Nature Decree and a Flemish Spatial Structure Plan with the obligation to designate a "Flemish Ecological Network" of 125,000ha, a coherent, interconnected network of large nature areas in which nature is the primary function. The necessary ecological defragmentation was aimed for by designation of 38,000ha of additional "green" areas and 10,000ha of additional forest areas. Moreover, this ecological network of 125,000ha was planned to be supported by 150,000ha of nature areas whit mixed functions (nature is equally important here as other functions such as forestry, agriculture or recreation) and by an undefined area of interconnecting corridor areas as well. Although the legal deadline for this designation was ambitiously set in 2003, by 2008 still 30% of the 125,000ha of the Flemish Ecological Network has not been designated yet. Still 72% of the additional green areas and new forest areas need to be located on spatial planning maps. For the 150,000ha of supportive multifunctional areas in the network less than 1% has been indicated. Clearly, the policy process is proceeding much slower than was anticipated in 1997. The main reasons for this are the high demands on open areas from various policy sectors, acceptance problems that exist with local private owners and stakeholders and the time-consuming participatory process to reach consensus. Nevertheless, if the establishment of a Flemish Ecological Network remains a legal obligation for the future, it is clear that ecological restoration will have to play a key role. For instance, more than 18% of the surface of the actual Flemish Ecological Network is currently used for intensive agriculture with very little or no ecological value.

Natura 2000

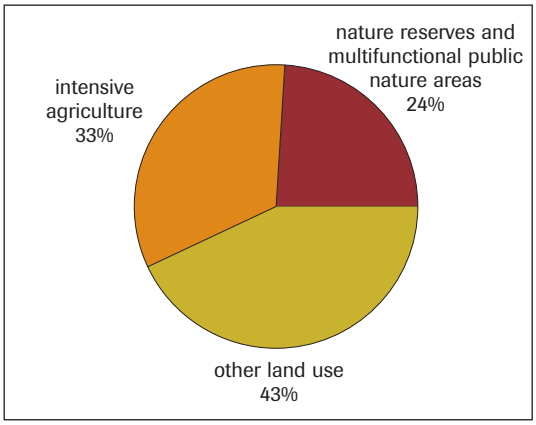
Another legal corner stone for ecological restoration in Flanders is formed by the obligations of the European Habitats and Birds Directives. The designation of Flanders' 166,187ha of Natura 2000 areas (12.2% of Flanders) was done on the basis of scientific criteria, as was prescribed by the directives. 104,888ha (or 7.8% of Flanders) were designated under the Habitats Directive of which almost 22% is actually still used for intensive agriculture. 98,243ha (or 7.3% of Flanders) were designated under the Birds Directive with about 40% of the area still in intensive agricultural use.



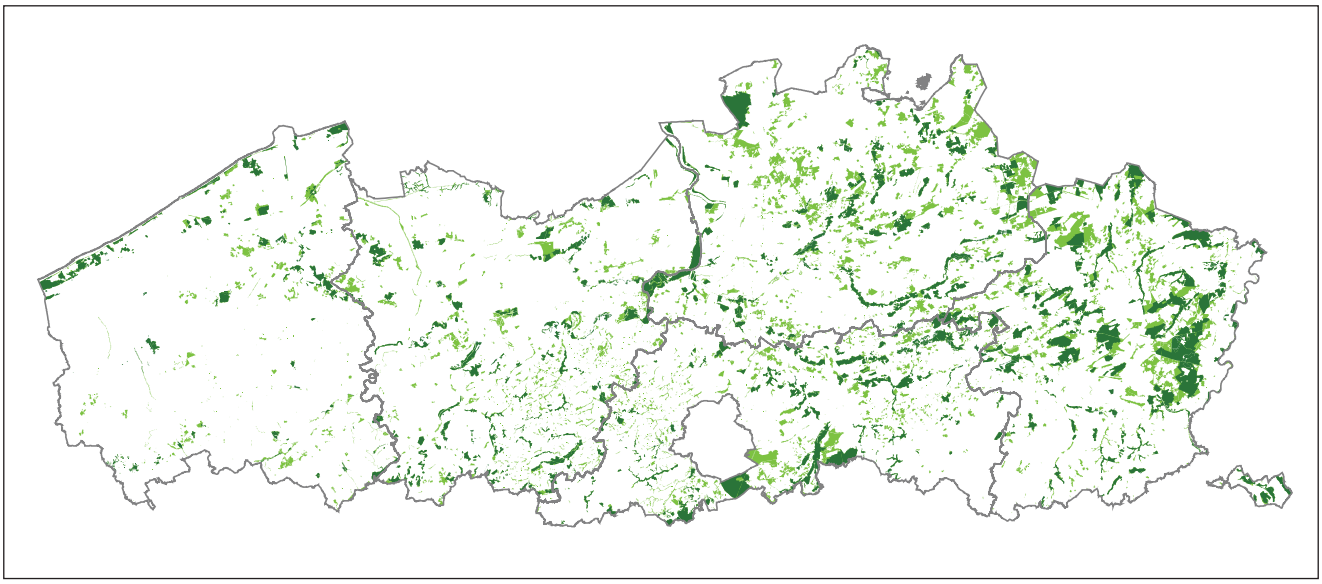
Land use in the Flemish Ecological Network (2008)



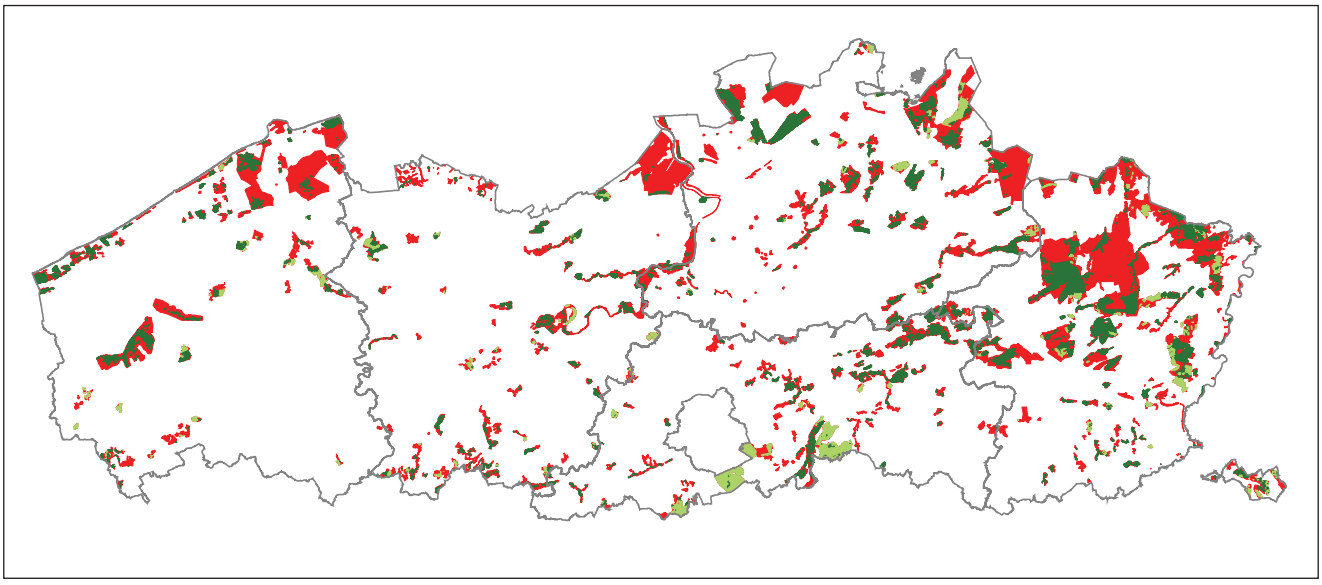
Land use in the 'green areas' of the Flemish spatial planning and zoning maps (2008)



Land use in the Flemish Natura 2000 areas (2008)



Distribution of "nature areas" on the Flemish Spatial Structure and Zoning Plans (light green: c. 170,000ha) with indication of the currently designated "Flemish Ecological Network" (dark green: c. 87,000ha).



Natura 2000 areas in Flanders (Birds and Habitats Directives) and their management regime.
Dark green: an adjusted nature management is sustainable (mainly nature reserves); light green: public forests with multifunctional use, managed by the Flemish government; red: adjusted nature management not (yet) present or sustainably assured.

I. 2. Main instruments for ecological restoration in Flanders

Acquisition of land for the creation of nature reserves

In most cases it is a precondition that an area is public property or owned by a nature organisation before ecological restoration works can be executed. The Agency for Nature and Forests of the Flemish Regional Authority (ANB) and the NGO Natuurpunt are the most active buyers of nature areas in order to establish nature reserves. Recognised NGO's such as Natuurpunt are partly subsidized by the government for the acquisition of nature areas, depending on the price they pay (cheap buying is encouraged) and the spatial destination of the area. Areas that are located within the Flemish Ecological Network benefit from the possibility that ANB has the first opportunity to buy the land (right of pre-emption). In practice this possibility is not used very often, due to for instance the price the owner wants to receive (buying is not approved above an official estimation of the soil value) or the protection of farming practice when the land is already leased for farming. Private owners within the Flemish Ecological Network can urge the government to buy their land, but in practice this is a very rare event, as is expropriation of land for nature conservation.

Management of nature reserves

It is obligatory for Flemish and recognized nature reserves and encouraged for other areas managed as a nature reserve to have an approved management plan, with clear objectives taking into account all legal obligations such as the preservation of protected habitat types or species. The management plan can include particular ecological restoration measures. NGO's such as Natuurpunt are partly subsidized by the government to execute the management plan, depending on the target biotope. Sometimes large scale single restoration measures can benefit from additional subsidies. The same regulation is available for local public authorities such as provinces or municipalities, but in practice this happens only occasionally. Both ANB and Natuurpunt also manage nature areas which are property of other public authorities such as provinces, municipalities, the Flemish Waterways Administration, the Federal Ministry of Defence and so on. This is done on the basis of an agreement, which can include the execution of particular works for ecological restoration.

Ecological restoration as a side effect of large public works

Large public works such as port development, the design of flood control areas, creation of raised fallow land due to infrastructure works or sand and gravel extraction pits sometimes offer opportunities for nature protection, nature creation or ecological restoration. These are often large scale projects with a large budget, enabling for some (co-)financing of ecological restoration works. It is important however that ecologists get involved from the very beginning of the project.

Compensation obligation

It is a legal obligation that the destruction of certain valuable nature areas, such as Natura 2000 sites, is compensated by the creation or restoration of new ones. This principle is often neglected in the case of small scale deterioration of nature areas by private owners or users, unless there is a court sentence on the issue. In the case of large public works such as the building of roads the compensation principle is mostly applied and as a result nature areas are acquired and restored nearby.

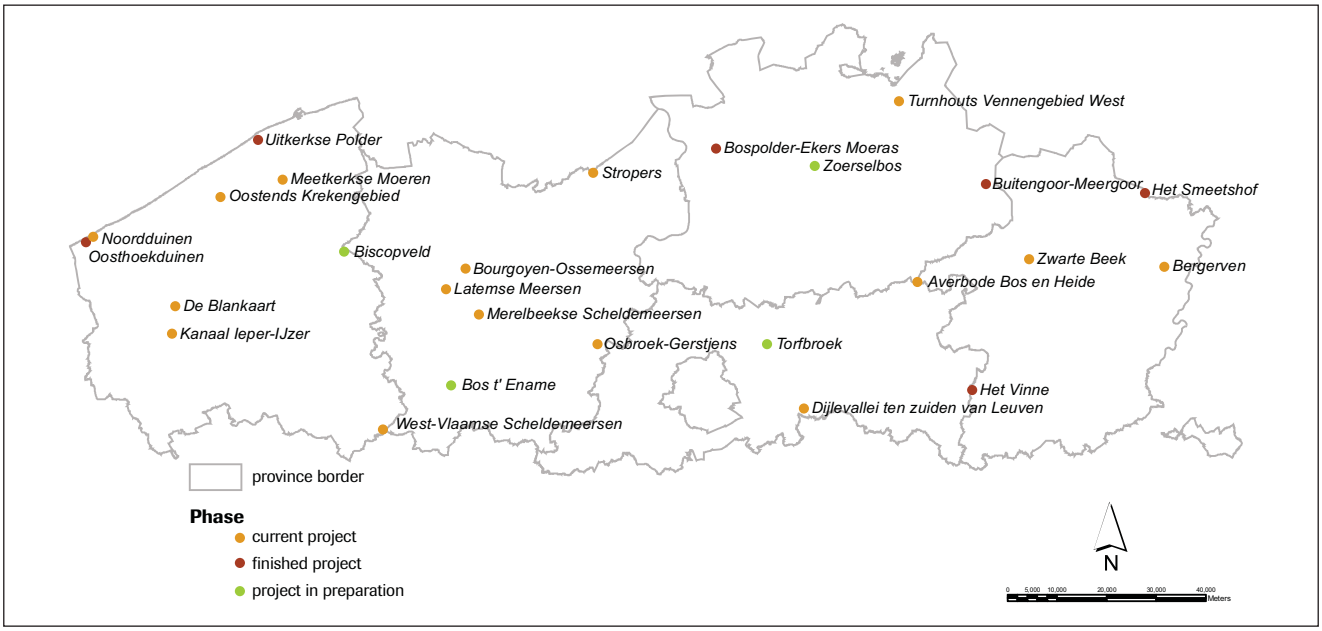
Schemes for land development and land development for nature

Ecological restoration is often a complex event (socially, economically, ecologically, legally). In order to deal with the complexity of projects in open space the Land Development division of the Flemish Land Agency (VLM) has 5 legal instruments at its disposition. Which (combination of) instruments is/are chosen depends on the scope of the project, the area and its main users.

- **'Comprehensive land consolidation'** enables the reorganization of parcels for a smoother agricultural activity. The re-grouping of parcels also offers opportunities for nature and recreation: by law maximum 2% of the area can be used for measures that do not serve agricultural means. In practice this mostly includes the development of small landscape elements such as ponds, hedgerows, pasture strips and so on.

- **'Land development'** departs from the spatial structure and zoning plans and enables a project specific for every area by creating cooperation between several partners. They are each responsible for a part of the execution of the project. By means of partial subsidizing of actions like constructing pools, improving habitat connectivity, constructing individual treatment systems for waste water, creating conditions for the development of rare habitats as marshes, wet forests… land development can contribute to ecological restoration.

- **'Land development for nature'** aims at the development of an area with regard to the conservation and restoration of nature (mostly restricted to nature areas on spatial structure and zoning plans). These projects are prepared, financed and steered by the Agency for Nature and Forests. The VLM takes care of the secretariat of the advisory organs, helps to draw up the project plans, executes the development measures, communicates with the inhabitants of the communities involved and collects the remarks of the public inquiry. This instrument has become more and more important during recent years for boosting ecological restoration in Flanders.



Land development for nature projects in Flanders (2008)

- **'Agri-environmental agreements'** between the VLM and farmers promote the creation or restoration of small-scale landscape elements such as ponds, hedgerows, thickets, botanically rich grasslands or parcel strips. The fact that these agreements only last for 5 years and that they have to be renewed on a voluntary basis are the main disadvantages of this instrument. Ecological results would also improve if hydrological measures would be encouraged (especially in the buffer zones of nature reserves) and if the agreements would involve larger, more coherent areas. An important package is also the financial compensation for the prohibition of fertilization in some agricultural grasslands situated in legally designated nature areas or drinking water production zones.

- The **'local land bank'** is an instrument to acquire land in order to re-allocate owners and users instead of expropriating them. It enables to compensate loss of nature, to create room for infrastructure and facilitate land development for nature or other projects. A team of estimators, negotiators and project managers gives the necessary know-how for fast decisions if land is put up for sale in a project area.

EU (LIFE)

The financial stimuli through LIFE Nature projects of the European Commission have been extremely important for more than 30 ecological restoration projects in Flanders during the last 14 years. Ambitious management and restoration measures have been realized this way, which would otherwise probably never have been executed within the set timeframe. By clustering the execution of a management plan into a complete European nature project with explicit attention for communication, a very strong impetus for the management of an area is given and simultaneously the surrounding people and visitors of the nature area become more involved. At the same time abstract terms like 'Natura 2000' and 'Habitats Directive' become more comprehensive for the public. Without the financial support of the European Union it would not be possible to pay so much attention to communication. In other cases other European Funds were crucial in nature restoration projects (e.g. Interreg funds).

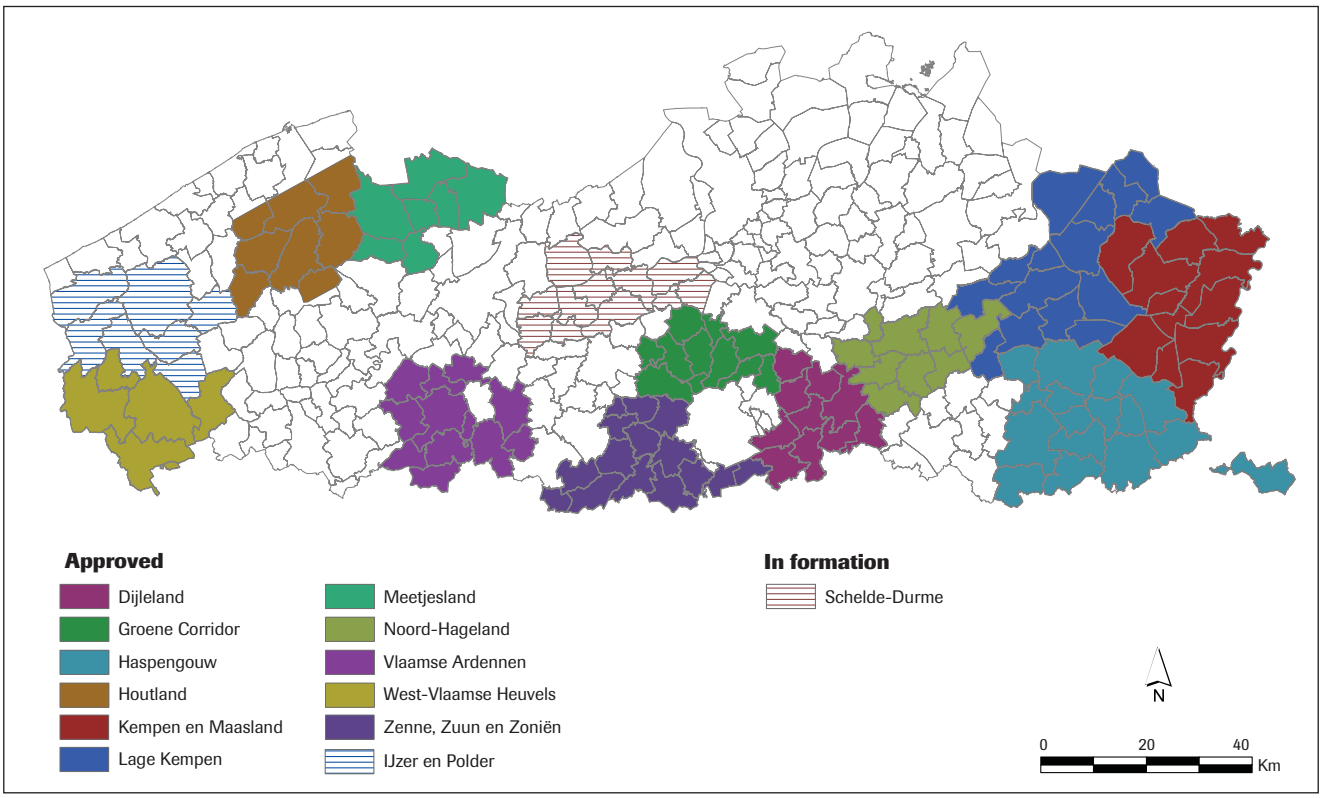
Private-public cooperation agreements for management and restoration

There is a possibility for private owners to make an agreement with the government and receive financial support for management and restoration activities on their land. In practice this instrument is still not so popular nor well-known. One of the reasons is that private owners fear the legal and economic consequences of an increase of the ecological value on their land. There is still a major challenge here to increase public awareness.

Regional Landscapes

A Regional Landscape is a sustainable collaboration between 3 or more municipalities for the promotion of nature recreation, nature education and nature conservation. The focus of the latter is mainly put on the management, restoration and creation of

small-scale landscape elements such as cattle ponds, hedgerows, flower-rich road verges and tickets. The Regional Landscapes are also very important for their specific actions to increase the public support for nature conservation and restoration on the local scale.



Regional Landscapes in Flanders (2008)

The Flemish government approves the objectives of each Regional Landscape and provides financial support for the operation of it. More than 50% of Flanders and 140 of the 308 municipalities of Flanders are currently part of one of the 12 approved Regional Landscapes. 1 additional Regional Landscape is in the phase of official recognition.

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II. Introduction to some of the more prominent ecological restoration projects in Flanders

II.1. Data base on ecological restoration

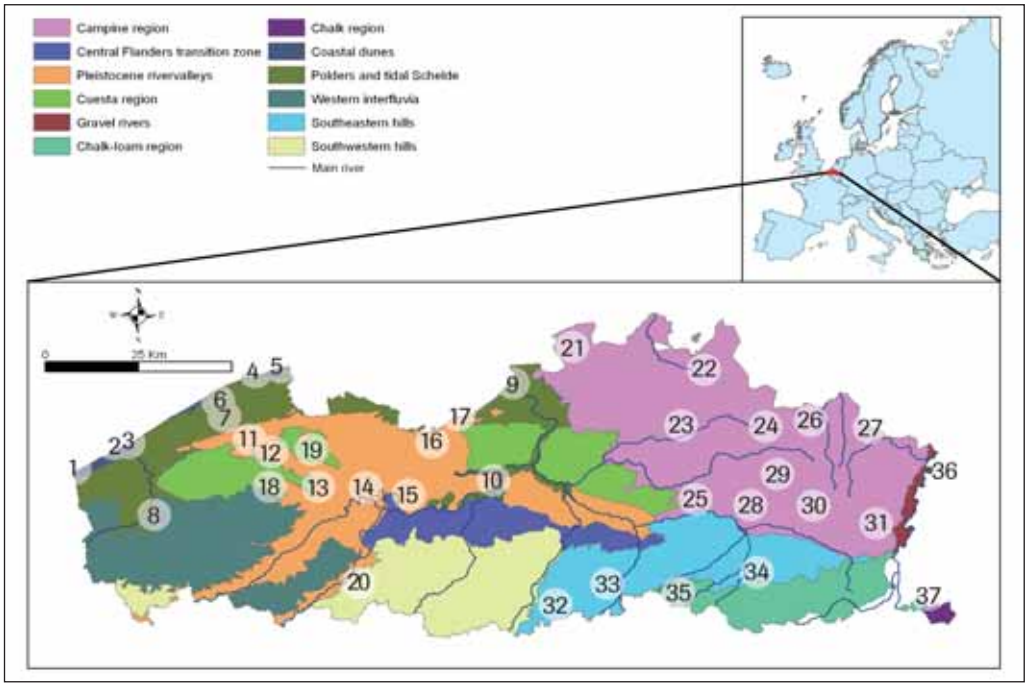
The Research Institute for Nature and Forest manages a data base on ecological restoration in Flanders. The intention is to assemble basic data on the design and evaluation of restoration projects as a source to report on the state of affairs, to enable the exchange of experiences and for advice and research. Ecological restoration projects are defined as projects where specific once-only measures are taken to transform cultural biotopes (e.g. arable land, intensive pasture land, extraction areas) or heavily degraded natural and semi-natural biotopes (e.g. drained or eutrophied areas) to a more natural state with a larger value for biodiversity. Very often these actions go together with measures to increase the possibilities for sustainable nature recreation.
Since the 1990s the (surface) area of ecological restoration projects in Flanders has strongly increased. In 2004 the total area was estimated at more than 3,100ha scattered over more than 540 locations (Van Uytvanck & Decleer, 2004). Most of the projects are small-scaled (35% smaller than 5ha). Recently there is a tendency for larger projects as a result of increased resources provided by EU-LIFE funds and the execution of 'land development for nature' projects. Amongst the most popular restoration measures are sod cutting and topsoil removal (32%), afforestation (19%), spontaneous succession (12%) and different transformation techniques such as nutrient removal by temporary crop harvesting, hay transfer, removal of non-native invasive species etc. (30%). Hydrological restoration only accounts for 5%, probably as a result of the complexity and lack of knowledge, together with the small size of most of the restoration areas. (Van Uytvanck & Decleer, 2004)

II.2. Project information sheets

Introduction

With the objective to present a state-of-the-art of the ecological restoration scene in Flanders, only some of the most important Flemish restoration projects, both successes and failures, are presented in this book. A large number of authors provide brief information on 40 projects. Each information sheet is build around the following structure:
- Name of the area and municipality
- Natura 2000 status
- Management authorities and supporting authorities
- Brief description of the ecosystem type
- Description of the starting conditions (ecological problems), the restoration measures, the objectives and the most important management measures
- Brief evaluation with respect to the presence of particular species or communities and the (change in) abiotic conditions. Optionally information is provided on other lessons learned and future points of attention for sustainable results. Sometimes ongoing or planned measures are described.
- If relevant, some headlines on the public support for the project are presented.
- References for further information (in English)

The 40 projects are not only chosen on the basis of the type of measures and their size or importance. The distribution over the different ecoregions in Flanders was also taken into account. The location of the projects is shown in the map below.



Distribution of the ecological restoration projects in Flanders discussed in this book, with indication of the ecoregions. Numbers refer to the table on the next page.

The 40 project information sheets are arranged according to the different ecoregions with 2 projects covering Flanders at large and one last-minute contribution on the integrated policy for the restoration of the Schelde estuary. An overview of the main characteristics of the different restoration projects is presented in the following table.

			Major target biotopes for restoration												
		Page	wet grasslands	dry grasslands	freshwater marshland	open water	river	inland dunes	wet and dry heathland	forest	brackish tidal marsh and saltmarsh	coastal dunes	sand beach	LIFE-project	land development for nature project
Coastal dunes ecoregion															
1.	Westhoek	14										+		+	
2.	Ter Yde and Hannecartbos	18										+		+	
3.	Ijzermonding	22									+	+		+	
4.	Baai van Heist	26									+	+	+		
5.	Zwinduinen and –polders	29									+	+		+	
Polders and tidal Schelde ecoregion															
6.	Uitkerkse Polder	33	+								+			+	+
7.	Meetkerkse Moeren	36	+												+
8.	Lake Blankaart	38			+	+									
9.	Ketenisseschor and Paardeschor	41									+				
10.	Lippenbroek and Heusden LO	44									+				
Pleistocene river valleys ecoregion															
11.	Vallei van de Zuidleie: Leiemeersen	48	+		+	+									
12.	Vallei van de Zuidleie: Gevaerts-Noord	53		+											
13.	Lake Kraenepoel	56			+	+									
14.	Bourgoyen - Ossemeersen	59	+												
15.	Damvallei	62	+		+	+									
16.	Heidebos	66		+					+					+	
17.	Stropersbos	69		+					+	+				+	+
Cuesta ecoregion															
18.	Gulke Putten	71		+					+					+	
19.	Maldegemveld	75		+					+					+	
South-western hills ecoregion															
20.	Bos t' Ename	78								+				+	
Campine ecoregion															
21.	Kalmthoutse Heide: Biezenkuilen	80				+									
22.	Turnhouts Vennengebied: Zwart Water	82				+			+					+	+
23.	Olens Broek-Langendonk	86	+		+				+						
24.	Buitengoor-Meergoor	90				+			+						+
25.	Vallei van de Kalsterloop: Langdonken	94	+			+			+					+	
26.	Hageven	98			+	+	+	+	+					+	
27.	Smeetshof	103	+		+	+			+	+					+
28.	Vallei van de Drie Beken	107	+	+	+	+			+						+
29.	Vallei van de Zwarte Beek	111	+		+	+			+	+					+
30.	Groot Wijven	115			+	+									
31.	Kikbeekbron	117				+		+	+						
South-eastern hills ecoregion															
32.	Forest reserve Joseph Zwaenepoel	120								+					
33.	De Doode Bemde/Dijle River	124	+		+		+			+					+
34.	Het Vinne	128			+	+									+
Chalk-loam ecoregion															
35.	Hoegaardse valleien	131	+	+	+		+								
Gravel rivers ecoregion															
36.	Vallei van de Grensmaas	135	+	+	+	+	+			+					
Chalk ecoregion															
37.	Altenbroek	138		+						+					
Flanders at large															
38.	Military areas in Flanders	141	+	+	+	+	+	+	+	+				+	
39.	Forest expansion and quality in Flanders	145								+					
Extra															
40.	Schelde estuary	147					+				+				

1. Westhoek (De Panne)

Tanja Milotic (INBO), Maurice Hoffmann (INBO), Sam Provoost (INBO), Jean-Louis Herrier (ANB) & Marc Leten (ANB)

Natura 2000 area: yes

Management authorities: Agency for Nature and Forests, Coast Division of the Agency for Maritime Services and Coast (concerning aspects of coastal defence)

Supporting authorities: EU (LIFE)

Ecosystem type

Spatially heterogeneous coastal dune with embryonic dunes with *Elymus farctus*, shifting white dunes (marram dunes), grey dunes (dune grasslands and moss dunes), dune slacks, dune scrub and spontaneous and planted woodland in the coastal dunes ecoregion (345ha)

Restoration measures & objectives

Starting conditions

In the post WWII period, tourist development and urbanization expanded dramatically at the Belgian coast, causing severe fragmentation of dunes. Parallel to this evolution, agricultural use of the dunes and grazing by rabbits decreased, stimulating fixation and encroachment of tall grasses, shrubs and trees. Although in 1956 the Westhoek was officially recognized as a national nature reserve, the site still changed a lot afterwards. Due to some severe storms causing dune erosion, a concrete seawall was built in the late 1970s. Since 1967 the drinking water company IWVA started with the extraction of ground water in the adjacent dunes, causing large scale lowering of the groundwater table. In 1977-78 most of the WWII bunkers were demolished. From the mid-seventies on a very small part of the reserve (up to max. 6ha) was mown annually in order to maintain some relict plant populations and vegetations. In general the open dune habitats steadily decreased due to scrub expansion though (mainly *Hippophae rhamnoides*).

Restoration measures

Since 1996	– Large scale cutting of scrub (about 19ha) and woodland (about 4ha), followed by removal of litter and local sod cutting in order to restore wet dune slacks and dune grasslands. – Creation and restoration of ponds. – Stimulation of a tidal inlet formation by removing the concrete dune foot revetment at two locations over a distance of 20m and 15m respectively to allow the seawater to penetrate the deflation zones at spring tide. – Fixation of the foothill of the 'central dune' by *Ammophila arenaria* planting to prevent an adjacent road and habitations being covered up by the shifting sand. – Clearing of concrete roads and debris impeding sand-shift. – Run-down of the extraction of ground water in the adjacent dunes.

Objectives	Management measures
A spatially heterogeneous dune landscape with all its natural and semi-natural elements and with control of scrub and tall grass encroachment, including floodmark vegetations on the sandy beach, embryonic dunes with *Elymus farctus* on the transitional zone between sandy beach and foredunes, a tidal inlet with halophytic vegetations, mobile open dune, moss dunes, dry to mesophytic dune grasslands, wet to moist nutrient-poor dune slacks and grasslands, dune pools, scrub and woody fringe vegetation and dune forest.	– Year round grazing by Shetland ponies, Konik horses, Highland cattle and donkeys (about 175ha). – Weeding juvenile *Hippophae* or mowing with removal of the litter of young dune slacks and humid grasslands (ca. 9ha). – Recurrent cutting of recolonising scrub and exotic trees.

Evaluation

Species/communities

- Up to 1996 small scale management of grassland relics and young dune slacks resulted in the conservation of some relic populations of *Schoenus nigricans, Gentianella uliginosa, Herminium monorchis,* etc.
- From 1997 on an important increase in vulnerable plant species was noted in the areas where a mowing regime was introduced or where scrub was removed and grazing animals were introduced, both in the wet dune slacks and the moist to dry dune grasslands. The relict populations of most vulnerable species expanded (*Herminium monorchis, Equisetum variegatum, Helianthemum nummularium,* etc.) and several new species (*Botrychium lunaria, Filago vulgaris, Juncus balticus, Preissia quadrata,* etc.) were noted.
- Outside the areas where scrub was cut, in general only light to moderate effects on vegetation structure and composition can be seen after 10 years of grazing, This rarely lead to an increase in vulnerable plant species. More radical changes were caused by climatic influences (inundations of 2001-2002) and internal vegetation processes (dying off of *Ligustrum* scrub, etc.).
- In general, grazed sites are richer in total number, but poorer in vulnerable plant species then mown ones. Where no significant differences occurred, inundation is a possible explanation.
- Dispersal of seeds by grazing animals (*Helianthemum nummularium,* etc.) or by management machinery (*Rhinanthus* spp*., Linum catharticum*, etc.) plays an important role in the colonisation process. A moderate number of species (*Anthyllis vulneraria, Potentilla erecta, Carex* and *Juncus* species*,* etc.) colonised the newly created grasslands from a persistent seed bank.

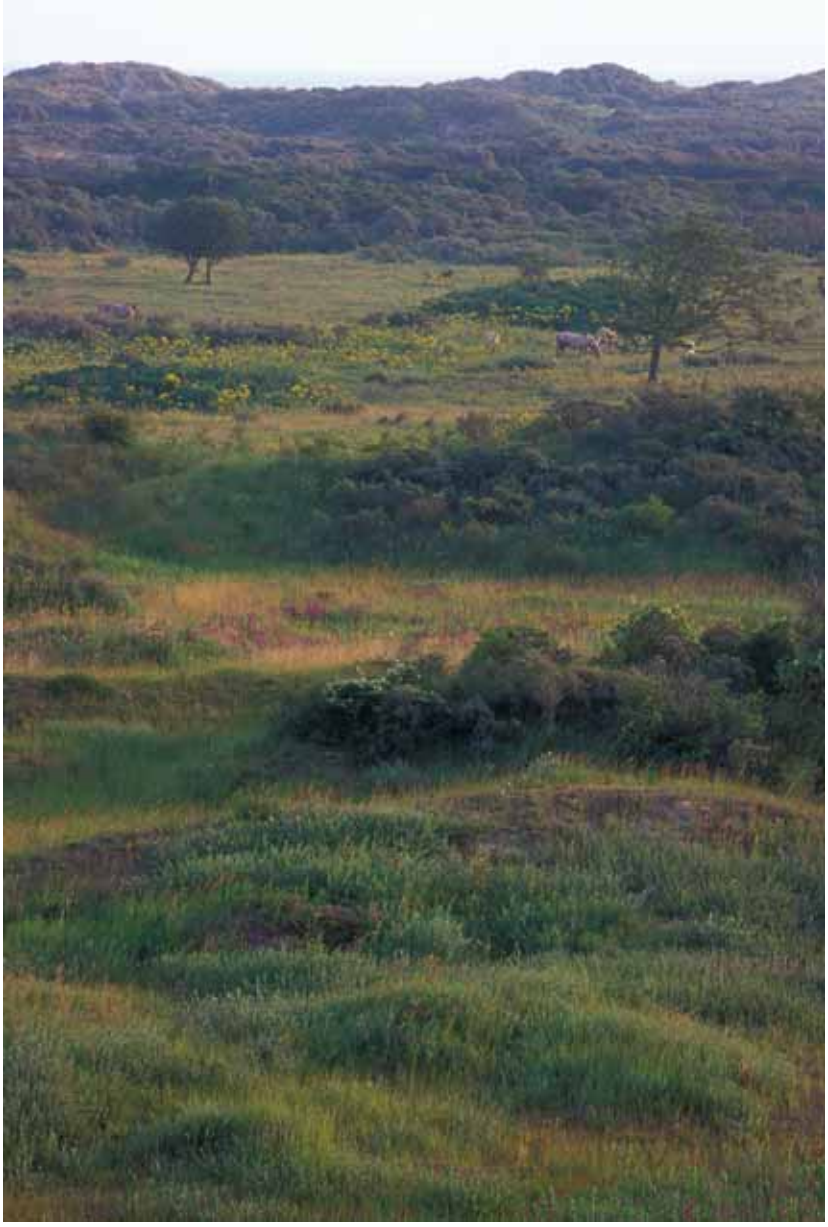
Removal of scrub and litter layer for the restoration of dune grasslands and the results after a few years…

- The newly created or restored ponds have proved to be a good habitat for Great Crested Newt (*Triturus cristatus*), *Chara* vegetations, dragonflies, etc., but eutrophication by cattle remains a problem.
- Several invertebrate species (e.g. the butterfly *Issoria lathonia*) benefited from the opening up of the dune landscape and/or the increase of host plants. Some terrestrial invertebrates of moss dunes and stabilised marram dunes however suffer from trampling by grazing animals.
- Populations of some bird species of scrub and woodland seem to have decreased (e.g. Nightingale (*Luscinia megarhynchos)*, etc.) after large scale scrub removal or natural dying off of the shrubs. Climatic changes may however also play a role, as species such as Cetti's warbler (*Cettia cetti)* and Zitting Cisticola (*Cisticola juncidis*) have colonized the site. Rare and/or characteristic breeding birds of open dune habitats such as Kentish Plover (*Charadrius alexandrinus*), Little Ringed Plover (*C. dubius*) and Wheatear (*Oenanthe oenanthe*) have disappeared, probably due to stabilization of the shifting dunes and scrub encroachment. Meadow Pipit (*Anthus pratensis*), Crested Lark (*Galerida cristata*), Stonechat (*Saxicola torquata*) seem to maintain their populations. Woodlark (*Lullula arborea*) colonized the site after local opening up of the landscape.

Abiotic conditions

- Sand drift is one of the characteristic natural processes in the dunes and is of major importance for the maintenance of young landscape elements and the creation of pioneer dune slacks. Due to large scale geomorphologic and climatic processes and human impact (fragmentation, nitrogen deposition, etc.), the once more than 80ha large mobile dune system (the local so-called 'Sahara') is completely stabilising and the formation of young dune slacks and moss dunes has stopped. Up till now, classical management techniques provide no solutions to this evolution.
- The groundwater level is of essential importance for the maintenance of humid dune slacks. Over the last 15 years, a partial restoration of the ground water table has taken place. Important areas of the older dune slacks however remain too dry, while some more recently formed dune slacks have become unnaturally wet. But in general, the decrease of the water extraction has had a very positive effect on the conservation potential of the reserve.
- As the local coastline has a slight tendency to progress, the mouth of the seawater inlets in the foredunes tends to be blocked by sand. Yearly removal of the sand and other measures are needed to maintain the free access of seawater into the inlets.

The central mobile dune area ("Sahara") has been steadily colonized by *Ammophila arenaria* during the last five years. This used to be the motor for the formation of young dune slacks and moss dunes.



The diversity in vegetation structure is improved by the grazing management.

Other lessons learned

- The grazing by Highland cattle locally led to a gradual opening of scrub. In case a rapid removal is desired, large scale scrub cutting is recommended.
- Where scrub is removed, grazing in itself often cannot prevent slow recolonisation of the grasslands by woody species. A recurrent cutting regime is needed.
- Shallow sod cutting after scrub removal proved to be a better starting point for the restoration of humid dune slacks than simple scrub and litter removal.
- The vegetation structure and composition is evolving slowly and ambiguously. Abiotic factors seem to play a major role in the vegetation development.

Future points of attention for sustainable results

As excessive trampling of the moss dunes in some cases led to loss of vulnerable invertebrate populations, the exclusion of moss dunes to large herbivores should be considered.

To prevent general eutrophication of the dune pools, the exclosure of some of the pools and/or the creation of a larger number of pools seems necessary.
Because of the expected changes (increased evapotranspiration due to climatic change and stabilisation of the large mobile dune, development of seepage areas in formerly dried out slacks, etc.) and the overall importance of the ground water regime on the biodiversity of the dune ecosystem, a meticulous hydrological monitoring scheme should be maintained.
As shifting dunes act as the essential 'motor' of a complete dune ecosystem, possible management techniques in order to maintain at least part of the shifting dunes should be studied.

Public support

Being one of the largest dune areas left along the Belgian coast, special efforts have been made to provide recreational facilities such as the construction of a network of public footpaths, viewpoints and communication infrastructure.

Autumn view of the southern, grazed part of the nature reserve the Westhoek, with a central exclosure, excluding grazers, and managed as a hay meadow.

References

Herrier J.-L. & Van Nieuwenhuyse H. (2005); Herrier J.-L., Killemaes I. & Noels C. (2005); Hoffmann, M., Cosyns, E. & Lamoot, I. (2005); Leten M., Van Nieuwenhuyse H. & Herrier J.-L. (2005); Verwaest T., De Wolf P., Herrier J.-L. & Leten M. (2005); Lamoot, I., Meert, C. & Hoffmann, M. (2005).

2. Ter Yde and Hannecartbos (Koksijde)

Tanja Milotic (INBO), Maurice Hoffmann (INBO), Sam Provoost (INBO), Hannah Van Nieuwenhuyse (ANB), Marc Leten (ANB) & Jean-Louis Herrier (ANB)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Supporting authorities: EU (LIFE)

Ecosystem type

Complex of fragmented coastal dune habitats (including the typical beach to inland gradient) within the coastal dunes ecoregion; the area (total surface c. 260ha) also includes an afforested part (c. 40ha).

Restoration measures, objectives and results

Starting conditions

Fragmented dune landscape influenced by over-recreation, scrub encroachment, afforestation and a big (ruin) building.

Restoration measures

1995	– Demolition of the buildings and access road of the former Home G. Theunis (surface: 4,500m^2 and volume: 12,000m^3), followed by removal of debris and restructuring of the site into a natural looking parabolic dune.
1994-2004	– Scrub clearing (mainly consisting of *Hippophae rhamnoides)* followed by removal of litter and repeated weeding of young shrubs (c. 6ha).
	– Delineation of grazing units and creation of ponds.
1997	– Removal of exotic plant species (*Populus* spec. and *Pinus nigra)* in a levelled slack, followed by excavation up to groundwater level (3,000m^2).
	– Creation of a pond in the cleared slack.
2003-2005	– Cutting down of a 6ha large afforested area, situated on a permanently wet, peaty dune soil (fossil beach plain)
	– Cleaning and restructuring of a dune brook (c. 600m)

Objectives	Management measures
Restoration, conservation and/or creation of wet beach, embryonic dunes, mobile open dune, moss dunes and dry to mesophilic dune grasslands, wet to moist nutrient poor dune slacks, moist nutrient poor grassland on mineral or humus substrate, dune pools, scrub and woody fringe vegetation and spontaneously regenerating dune forest.	– Mowing and cutting of scrub – Weeding of young *H. rhamnoides* individuals – Mowing of hay meadows – Seasonal grazing by Mergellandsheep (autumn-winter) and year-round grazing by Shetland ponies

Evaluation

Species/communities

– Dune slack restoration through scrub clearing resulted in a species rich *Caricion davallianae* vegetation with *Parnassia palustris, Epipactis palustris, Dactylorhiza incarnata, D. fuchsia* and *Herminium monorchis*.

– The clearing of alder afforestation on peaty soil led to rapid restoration of wetland vegetation with *Juncus subnodulosus, Carex nigra, Carex panicea, Valeriana dioica, Anagallis tenella* and several other regionally rare wetland species.

– Water vegetation of alkaline water in the restructured dune brook developed immediately after restoration works. *Potamogeton*

A unique dune brook for the Belgian coast was dredged and reshaped, with return of e.g. *Characeae* vegetations and *Groenlandia densa* as a result.

coloratus appeared in another brook. The pools created in early spring 1997 were already used as reproduction site for *Bufo calamita* in the summer of that same year.

- Grazing favours development of species-rich dune grassland (*Polygalo-Koelerion*) with calcareous grassland elements (*Helianthemum nummularium, Asperula cynanchica, Silene nutans, Cirsium acaule, Thesium humifusum, Potentilla neumanniana*).
- The lowering of the recreational pressure enabled breeding of Kentish Plover (*Charadrius alexandrinus*) in the embryonic dunes.

Abiotic conditions

- Although nowadays fragmented by roads, the Ter Yde site still presents a very remarkable geomorphological sequence consisting of embryonic dunes on the sandy beach, still partially drifting foredunes, high dunes with blowouts, megaparabolic dunes with wet dune slacks, a fossil beach plain and medieval low undulating "hedgehog-dunes". This pattern results from the origins of the site as a former branch of the medieval estuary of the river IJzer.
- The clearing of the Home G. Theunis site and following measures resulted in a natural looking parabolic shaped dune with renewed geomorphologic dynamics.

Other lessons learned

- Important for the success of the measures is the combination of scientific research prior to the restoration planning and involvement of all stakeholders, without neglecting the original conservation goals.
- In order to maintain a visual screen between the reserve and the neighbouring residential area, the birch-willow woodland was at first not removed. This caused a massive spreading of their propagules in the adjacent slack.
- The presence of poplar trees around the Home G. Theunis site shielded the area against the wind. These trees were removed, which initially restored aeolian dynamics. However, after some time, the debris of the demolition works surfaced again and the bare sand was transformed in a 'desert pavement'. The removal of the debris has been repeated. Monitoring is carried out now in order to evaluate the measures in 2010.

"Home G. Theunis" was the first large building in Flanders that was removed for the purpose of ecological restoration (1995). After removal of debris the site was restructured into a natural looking parabolic dune with renewed geomorphologic dynamics.

Part of Hannecartbos, an alder afforestation on wet peaty dune soil, was cleared, resulting in a spectacular return of numerous target plant species from the seed bank.

- The introduction of sheep results in a more open landscape with little or no damage to the moss dunes. The increase of the grazing pressure (6 to 14 sheep) led to decrease of the poplar and *Salix repens* stands. A further increase of the grazing pressure (14 to 26 sheep) does not decrease biomass production of rapid growing grass species such as *Calamagrostis epigejos* and *Arrhenatherum elatius*. (Sheep) grazing in early spring is not without risk for e.g. *Primula veris*.
- Non-selective beach cleaning hampers the colonization by beach plants. The beach in front of the reserve is cleaned manually since a few years as a result of cooperation between the Agency for Nature and Forests and the local municipality. Furthermore, zoning of recreation is essential for the establishment of species-rich flood mark vegetation.
- Although a preceding seed bank survey did not reveal many interesting species, the good results of the woodland clearing are mainly caused by species most probably emerging from the seed bank (*Anagallis tenella, Blysmus compressus, Carex panicea, Potamogeton coloratus* etc.).

Future points of attention for sustainable results

- Disturbance of natural geomorphologic processes (fragmentation and reduction of the shifting dune area) caused by the fixation of (embryonic) dunes. After restoration works, presence of debris can disrupt the aeolian processes.
- Recreational pressure by non-commercial fishing, stray dogs and more intense forms of recreation.
- Encroachment of non-native woody species (e.g. *Populus x canescens, Acer pseudoplatanus* etc.).
- Succession towards tall grass dune grassland, scrub and woodland.
- Domination of *Ranunculus repens, Trifolium repens* and other competitive meadow species in restored dune slack grasslands.
- Lowering of the water table due to neighbouring building activities.
- Relic eutrophication of the dune brook.
- Lack of seed-providing trees of indigenous species (e.g. *Fraxinus excelsior, Ulmus* spec., etc.).

Public support

A communication campaign about the measures by means of information panels, press releases, information evenings etc. was set up for the local inhabitants, visitors and local authorities. Because of this campaign the reactions were positive. The recreational possibilities in the area have increased while the impact on the environment has decreased.

References

Herrier J.-L. & Van Nieuwenhuyse H. (2005); Herrier J.-L., Killemaes I. & Noels C. (2005); Herrier, J.-L., Van Nieuwenhuyse H., Deboeuf C., Deruyter S. & Leten M. (2005); Van Nieuwenhuyse H., Leten M, Deruyter S., Herrier J-L. (2008).

http://www.mina.be/feydra.html

The rare orchid *Herminium monorchis* responded well to the scrub clearing of wet dune slacks in the area.

3. IJzermonding (Nieuwpoort)

Tanja Milotic (INBO), Maurice Hoffmann (INBO), Jean-Louis Herrier (ANB) & Sam Provoost (INBO)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Supporting authorities: EU (LIFE)

Ecosystem type

Estuary and coastal dunes: estuarine salt marsh, fore dunes, calcareous dunes and beach habitats and intermittent ecotones in the coastal dunes ecoregion (c. 128ha).

Restoration measures, objectives and results

Starting conditions

In the 1950s the area was partly raised with clayey-sandy sludge originating from the fairway of the river Yzer and a marine harbour with buildings built on the site.

Restoration measures

1999-2000	- Demolition of 50,000m³ of buildings, 14,000m² of concrete roads and 3,600m of underground pipelines of the former marine base.
2000-2001	- Removal of 8 jetties, 1.3km (c. 2ha) of embankments, a tidal dock and road infrastructure. - Removal of 178,000m³ of raised ground, from which 143,000m³ of dune sand was re-used in the creation of dunes north to the former tidal dock. - Re-use of sandy sods with dune grassland and moss dune vegetation at the edges of the former tidal dock.
2002	- Removal of 250,000m³ raised soil in the south-eastern part. Approximately 58,000m³ of dune sand was re-used in the creation of a dunelike seawall in the eastern part of the area.
2002-2003	- Finishing of the restoration works, creation of dunes in the high-intertidal area, removal of 83,000m³ of raised material in the south-western part (between the old and new salt marsh).
2005	- Demolition of the last building in the area ('Mosselkot').

Objectives	Management measures
Restoration and preservation of the characteristic relief with a broad contact zone between the fresh water conditions of the dunes and the salt water conditions of the salt marsh.	- Periodical sheep grazing management with fluctuating flock size. - Manual removal of anthropogenic litter at the flood mark. - Local periodic haying of rough dune grassland and cutting of scrub.

Evaluation

Species/communities

- Primarily, the restored intertidal areas were colonized by large numbers of fast growing annuals e.g. *Salicornia procumbens* and *S. europaea*, *Suaeda maritima*, *Spergularia maritima* and *S. marina*. After two to three years perennial species such as *Limonium vulgare*, *Puccinellia maritima* and *Elymus athericus* started to colonize newly created salt marsh. Expected species such as *Aster tripolium*, *Triglochin maritimum* and *Artemisia maritima* are still scarce.
- In total 239 higher plant, 20 moss, 3 lichen and 26 macro algae taxa were found in the reserve. The most prominent communities and plant taxa in the dune area are: Ammophilion arenarii (*Ammophila arenaria, Euphorbia paralias,* etc.), Tortulo-Koelerion

The IJzermonding restoration project is certainly one of the most impressive restoration projects in Flanders up till now. An old marine base was dismantled and more than 400,000m^3 of raised ground was removed. Aerial overview in 1957 and 2006.

(*Phleum arenarium*, *Tortula ruralis* ssp. *ruraliformis, Trifolium scabrum, Medicago minima* etc.) and Polygalo-Koelerion (*Galium verum, Phleum bertolonii, Koeleria macrantha, Thymus pulegioides, Orobanche caryophyllacea* etc.). In the salt marsh the following communities can be distinguished: Thero-Salicornion (*Salicornia* spec., *Suaeda maritima*), Spartinion (*Spartinetum townsendii*), Puccinellion maritimae (*Puccinellia maritima*, *Halimione portulacoides*) and Armerion maritimae (*Juncus gerardii*, *Elymus athericus*, *Glaux maritima*, *Artemisia maritima*). In the transition area of salt and fresh water Saginion maritimae (*Sagina maritima*, *Plantago coronopus*, *Parapholis strigosa*) and Atriplicion littoralis (*Salsola kali* ssp. *kali*, *Cakile maritima*, *Atriplex littoralis, Beta vulgaris* ssp. *maritima*) communities are found.

- The following bird species mentioned in the European Birds Directive Annex I are frequently observed in the nature reserve: *Sterna sandvicensis*, *Sterna hirundo*, *Recurvirostra avosetta* and *Oenanthe oenanthe*.
- 15 macrozoobenthos, 26 hyperbenthos and 11 epibenthos taxa were found at the beach zone in rather low densities and showing a moderate biodiversity.
- Invertebrates found in the salt marsh and dune area: 125 taxa of spiders, 93 carabid taxa and 105 dipterid taxa of which many are on the red list.

Abiotic conditions

- Since the completion of the restoration works some changes in topography and sediment accumulation have occurred. Structural erosion occurs at low-water level which is possibly caused by recent dredging works in the Yzer channel. Strong erosion occurs at the former tidal dock and slipway. Locally, sand accumulation takes place at high-water level. Presumably the material originates from erosion of raised areas. A small dune starts to develop, due to aeolian activity.
- The salt to freshwater gradient has been successfully restored. A freshwater seepage zone developed spontaneously, creating an extra dimension in habitat diversity.

Other lessons learned

There is a general positive attitude of the conservationist as well as recreationist target groups, thanks to positive developments of the salt marsh and bird communities and the improved landscape and accessibility of the area (formerly being a restricted military zone).

Some details of the disused marine base and the heavy equipment that was necessary to restore the area.

Small remnant of the original salt marsh (left) and the salt marsh raised with sludge from the fairway of the river IJzer (right) before the start of the restoration works.

Future points of attention for sustainable results

- Avoidance of "over"- and "undergrazing": implementation of a periodical grazing management with accurate grazer densities. Grazing in winter and late summer is possibly the best choice to protect sensitive plant species and breeding birds. It remains to be studied whether other grazers than sheep (cattle) would be better suited for control of *Elymus athericus* and other rough graminoid encroachment.
- Increasing the superficies of fresh-salt ecotone by removal of a remaining strip with raised ground.
- The increase of ruderal, grassy, bramble (*Rubus caesius*) and scrub vegetation threatens biodiversity; regular control of both is important.
- Coastal erosion of dunes, beach and artificial structures and the reducing extent of the elevated parts of the beach.
- Intertidal erosion caused by dredging works and shipping traffic.
- Local sand accumulation (instead of silt) at high-water level.
- Recreational pressure (mainly on the beach but also by low flying helicopter traffic above the restored salt marshes).
- Flood mark pollution by anthropogenic waste and large amounts of organic material.

Public support

The area is – especially in summer – frequently visited by schools, groups of naturalists, recreational users, hikers and bikers. Educational panels and observation hides were put in place. In the future an educational tidal pond will provide close access for wheelchair users to the salt marsh environment.

References

Deboeuf C. & Herrier J.-L. (2002); Herrier J.-L. & Thomas K. (1995); Herrier,J.-L. & Van Nieuwenhuyse, H. (2005); Herrier J.-L., Killemaes I. & Noels C. (2005); Herrier J.-L., Van Nieuwenhuyse H., Deboeuf C., Deruyter S. & Leten M. (2005); Hoffmann M. et al. (2005); Hoffmann M. (2004).

Aerial photo of a part of the restored salt marsh area after 4 years of spontaneous succession (2006). Note the part of the original salt marsh that was never raised in the upper left corner.

After the restoration works the numbers of Pied Avocet in the area increased to 5-15 breeding pairs.

Salicornia and other annuals colonizing mud and sand on the newly created salt marsh.

4. Baai van Heist (Knokke-Heist)

Tanja Milotic (INBO), Maurice Hoffmann (INBO), Jean-Louis Herrier (ANB) & Sam Provoost (INBO)

Natura 2000 area: yes

Management authorities: Agency for Nature and Forests, Flemish Waterways Administration

Ecosystem type

Sequence of sea, tidal sand beach, salt marsh and (embryonic) dunes in the coastal dunes ecoregion (c. 52ha).

Restoration measures, objectives and results

Starting conditions	
The nature reserve is partly surrounded by anthropogenic structures: to the south by a stone seawall and residential area and to the west by the groyne of the port of Zeebrugge. This groyne unintentionally causes 'spontaneous' beach expansion and the development of a green beach.	
Restoration measures	
1999-2007	- Removal of non-native woody species (e.g. poplar, tamarisk, etc.) that were once planted as brushwood in the dunes and of the exotic halophytic shrub *Bacharis halimifolia* in the salt marsh. - Pest control of the exotic *Melilotus albus* which spread quickly in the dune habitats since 1998 and caused nutrient enrichment in these environments. - Mowing of *Elymus athericus* and other rough graminoid encroachment to maintain the halo-tolerant vegetations of the transitional zones between salt marshes and dunes (since 2006).
Objectives	**Management measures**
Development of tidal wet beach, salt marsh on a 'green beach', embryonic dune and open mobile dune habitats. Breeding and foraging site for coastal bird species.	- Controlling visitor access (especially during the breeding-season) by means of appropriate information panels, communication and intensive wardening. - Washed organic material remains at the tidal mark in order to enrich the characteristic pioneer fauna and flora. Large anthropogenic waste is collected and removed twice a month (except in the breeding season).

Evaluation

Species/communities

- The wet unvegetated beach is a habitat to migrating and wintering birds such as *Charadrius hiaticula*, *Calidris alpina* and *Calidris alba*, several fish species and crustaceans. Occasionally, Common Seals (*Phoca vitulina*) are observed.
- The dry beach above the tidemark and the dunes provide nesting opportunities for birds such as *Sterna albifrons*, *Charadrius alexandrinus*, *Charadrius hiaticula*, *Haematopus ostralegus*, *Tringa totanus*, *Tadorna tadorna*, *Galerida cristata* etc.
- In the intertidal zone mud flat and salt marsh habitats exist with low halophytic pioneer vegetations (mainly *Suaeda maritima* and *Salicornia europaea* s.s.).
- More inland a beach-land contact zone with developing embryonic dunes can be found. In this dynamic zone *Honckenya peploides* is a common sand fixation plant and forms embryonic dunes with *Elymus farctus* and *Ammophila arenaria*. The site is rich in plant species characteristic for embryonic dunes and the salt-fresh contact zone such as *Parapholis strigosa*, *Sagina maritima*, *Cakile maritima*, *Polygonum raii*, *Atriplex littoralis* and *A. glabriuscula*.

Abiotic conditions

As a result of its recent history, the area is highly dynamic. In the northern corner of the beach strong erosion took place in the period 1986-1990. After a period of accretion (1998-2005) strong erosion occurred in the north-western corner of the beach (2005-2008), while a sand bank is steadily growing in the shallows in front of the beach. This sand bank is immerged every high spring-tide. The central beach part is the most dynamic zone. The level has risen and a 'bay' has developed in the past decades. The former central depression at the beach is almost completely filled with sediment originating from hydrodynamic and aeolian processes. In the natural embryonic dunes in front of the sea dike and harbour groyne sand fixation occurs. *Elymus farctus* primarily fixates the sand and later in this process embryonic dunes are formed. Especially interesting are the halotolerant vegetations of the numerous tidal gullies in between the embryonic dunes. The occurrence of *Ammophila arenaria* at some of the embryonic dunes indicates the presence of a freshwater environment. In these areas, a direct evolution from *E. farctus* vegetation to 'grey dune' vegetation occurs.

Aerial photo of the Baai van Heist (July 2006).

Autumn impression of *Salicornia* vegetation and embryonic dune formation in the Baai van Heist.

A new bird hide will enable the public to witness and enjoy the positive effects of limiting public access to this beach area: the breeding bird populations of *Sterna albifrons* and *Charadrius alexandrinus* peaked at 83 and 30 pairs respectively.

Other lessons learned

- Limiting visitor access to a suitable beach area can have spectacular positive results in terms of breeding of coastal bird species and development of vegetation.
- In 2006 the Belgian Federal government designated the shallows in front of the beach nature reserve as a Marine reserve. Both Flemish Regional beach-reserve and Federal marine reserve constitute together the first integral coastal reserve along the Belgian coast.

Future points of attention for sustainable results

- Because of the highly dynamic nature of the reserve, the tidal mark will possibly shift to lower or higher zones. As a consequence the footpaths could be interfering with the nature conservation goals. In this case these paths should be relocated.

Public support

The ecological (mostly avifaunal) interest versus the recreational aspect is an important conflict issue in this area and is a real challenge to the managers.

References

Herrier J.-L. & Thomas K. (1995); Herrier J.-L., Belpaeme K. & Remans K. (2004); Cosyns E., Provoost S. & Leten M (2002); Herrier J.-L. (2002).

5. Zwinduinen and –polders (Knokke-Heist)

Tanja Milotic (INBO), Maurice Hoffmann (INBO), Hannah Van Nieuwenhuyse (ANB), Evy Dewulf (ANB), Jean-Louis Herrier (ANB) & Sam Provoost (INBO)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Supporting authorities: EU (LIFE)

Ecosystem type

White and grey dunes, dune grasslands and transitions to salt marsh and polders in the coastal dunes ecoregion (c. 222ha).

Restoration measures, objectives and results

Starting conditions

During the 20th century the main part of the area was seriously affected by human activities: afforestation by exotic tree species (*Populus x canadensis*, *Pinus pinaster*, *Salix alba*); parcelling; the construction of a golf course, a horse racing track, a swimming pool and a small airport; the building of bunkers, concrete roads and other infrastructure during World War I and II. As a consequence habitats were fragmented and scrub encroachment took place. In the humid meadows of the transitional zone between dunes and polders excessive manuring and use of pesticides led to a strong loss of biodiversity.

Restoration measures

2004	– Demolition of a former swimming pool (21,000m³ of construction material) and creation of 3ha of wet dune slacks, white and grey dunes (displacement of 12,000m³ soil).
2006-2010 (LIFE nature project ZENO)	– Removal of maple trees and pines and cutting of *Hippophae rhamnoides-Salix* spec. scrub, in order to create a half-open landscape with alternating wood, scrub, dune grassland and rough vegetation (c. 24ha, of which 5ha already executed). – Following the removal of trees and scrub, local sod-cutting will take place in order to create nutrient-poor environments (c. 13ha of which 4ha already executed). – Local excavation works (still in the planning phase) in order to: ● create temporarily to permanently moist habitats; ● create new brook profiles; ● clear, deepen and create new freshwater ponds – Demolition of rigid constructions and infrastructure (concrete roads, bunkers and war debris) and clearing of remnants of the airport and the former horse racing track (c. 1.5ha). – Possible construction of a brackish-salt water inlet

Objectives	Management measures
The preservation and reconstruction of the characteristic mosaic of different dune habitats and the transitional communities to salt marsh and polders.	– Year-round and seasonal extensive grazing by cattle, sheep, Shetland ponies and goats. – Yearly mowing and haying of grasslands – Coppicing

Evaluation

Species/communities

As most of the restoration works have not been finished yet, no conclusions can be drawn about the results of the restoration measures. The following target habitats are distinguished in the nature reserve:
– Open mobile dune (EU-habitat 2120) with *Ammophila arenaria*, *Festuca juncifolia* or *Carex arenaria* as sand fixating plant species;

- Calcareous moss dune (EU-habitat 2130) with *Phleum arenarium* and *Tortula ruralis* var. *ruraliformis* as characterizing species;
- Dry dune grassland (EU-habitat 2130) with *Galium verum*, *Ranunculus bulbosus*, *Thymus pulegioides, Orobanche caryophyllacea*, *Rhinantus minor*, *Vicia lathyroides* etc.;
- Moist dune slacks (EU-habitat 2170) with *Salix repens* var. *argentea*, *Sagina nodosa*, *Gentianella amarella*, *Centaurium littorale*, *Centaurium pulchellum*, *Carex flacca*, *Carex scandinavica* etc.;
- Wet nutrient-poor grasslands (EU-habitat 2190) with e.g. *Carex nigra*, *Carex distans*, *Lychnis flos-cuculi*, *Odontites verna*, *Ophioglossum vulgare* etc.;
- Dune brook with *Mentha aquatica*, *Apium nodiflorum* etc.;
- Dune pool with fresh water and surrounding reed and swamp vegetations. Characeae are oligotrophic water indicating taxa;
- Scrub and fringe vegetation (EU-habitat 2160) with *Hippophae rhamnoides*;

In 2004 a disused swimming pool site was transformed into the original dune grasslands, dune slacks and a large dune pond. Two years later the newly created pond already showed an interesting water and bank flora and aquatic fauna.

Removal of invasive scrub and sod cutting works for the restoration of moist dune slacks.

- Dune forest (EU-habitat 2180) with alder, birch and willow trees in the marshy environments and birch and oak trees in dry, mesophytic conditions;
- Salt marsh (EU-habitat 1330) with *Oenanthe lachenalii*, *Scirpus maritimus*, *Glaux maritima*, *Triglochin palustris* etc.

Abiotic conditions

The site came into being during the 19th century as a broad tidal beach plain that was part of the sea-inlet of The Zwin, which was itself part of the estuary of the river Schelde. In front of this broad beach-plain foredunes started to develop. From the second half of the 19th century on a dike isolated the beach-plain from the sea. Nowadays the site consists of dunes and especially a large transitional area between dunes and polders with gradients from sandy soils to clayish soils and from fresh groundwater to salt groundwater.

Future points of attention for sustainable results

- Scrub expansion, increase of rugged areas and grassing reduce biodiversity.
- The appropriate nature management type should be chosen.
- The presence and encroachment of non-native species reduces biodiversity.
- War-related debris and other unwanted hard structures impede sand-drift.
- The recreational pressure should be lowered, guided and supervised.

One of the target species that successfully colonised the moist dune slacks is *Gentianella uliginosa*. Jimmy, the labour horse, and children of a neighbouring school are assisting with the necessary mowing management.

Newly created drinking pool in the northern, grazed part of the area.

- The agricultural background of the area results in several separate parcels, herbicide use by tenants etc.
- The percolation of water towards the polders, and with this the expansion of arid zones, reduces habitat diversity.
- The lowering of the groundwater level by the drainage of the building pits of swimming pools, underground car parks in the neighbouring suburban area, etc. cause serious disturbance of the hydrology in the region.

Public support

The attention for recreational joint use is just as important as the restoration of the biodiversity and natural processes. Information sessions, information boards, the website, press releases about the works, consultations with the local authorities etc. are necessary to prevent a lack of comprehension. Only that way a social basis can be created and respect and positive reactions of the public, local inhabitants and local authorities can be received. The daily presence of the warden in the project area is very important to give possible information and instructions to visitors.

References

Herrier J.-L., Killemaes I. & Noels C. (2005); Herrier, J.-L. Van Nieuwenhuyse, H., Deboeuf, C., Deruyter, S. and Leten, M. (2005); Dewulf E., Van Nieuwenhuyse H., Herrier J.-L. & Lozie P. (2008); Agency for Nature and Forests (2008).

www.lifenatuurzeno.be

6. Uitkerkse Polder (Blankenberge, Zuienkerke, De Haan)

Stefan Versweyveld (Natuurpunt)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: EU (LIFE); province of West-Vlaanderen; city of Blankenberge; Flemish Land Agency, Agency for Nature and Forests (land development for nature project).

Ecosystem type

Complex of non-intertidal Atlantic salt meadows with salt pioneer vegetations and a rich avifauna in the Polders and tidal Schelde ecoregion

Restoration measures, objectives and results

Starting conditions	
225ha of valuable ancient polder grasslands with abundant salt meadow relics and important meadow bird populations were destroyed due to intensification of agriculture by draining, heavy fertilization, microrelief destruction (190ha) and transformation into arable fields (35ha).	
Restoration measures	
1999-2008	In a ten year period the historical micro-topography, ditch pattern and degraded pools were restored and new pools and depressions were created.
Objectives	**Management measures**
Large scale restoration of salt meadows, with Salicornia- and Glauco-Puccinellietalia-vegetations and their associated breeding birds.	Extensive grazing in co-operation with local farmers.

More than 55 local farmers are currently involved in the management of the nature reserve.

Evaluation

Species/communities

- After decades of decline (since the sixties) the breeding populations of the target bird species are again increasing: *Recuvirostra avocetta, Charadrius dubius, Limosa limosa, Tringa totanus, Anas querquedula* and *Anas platyrhynchos*. For some species the increase was spectacular: the breeding population of *Recuvirostra avocetta* rose from a mere 4 pairs in 1999 to +180 pairs in 2007.
- During migration, the numbers and the species of migrants increased as well: *Philomachus pugnax, Tringa glareola, Tringa nebularia, Tringa erythropus, Actitis hypoleucos, Gallinago gallinago, Platalea leucorodia, Pluvialis apricarius, Philomachus pugnax* and *Limosa lapponica*.
- The restored salt meadows proved to be a very suitable habitat for wintering geese, especially *Anser brachyrhynchus* (+ 8,500 wintering birds from Svalbard) and *Anser albifrons* (+10,000 wintering birds) and in growing number also *Branta leucopsis*.
- From the seed bank and neighbouring, untouched parts several target plant species re-colonized the restored parts. In the lowest areas, species are typical for salt pioneer vegetations: *Salicornia europaea, Sueda maritima, Spergularia media, Parapholis strigosa, Puccinellia fasciculata* and *P. capillaris*. In the slightly higher areas, species are characteristic for Atlantic salt meadows: *Aster tripolium, Glaux maritima, Juncus gerardii, Puccinellia distans, P. maritima, Spergularia marina, Scirpus maritimus, Plantago maritima*, *Triglochin maritima* and *Oenanthe lachenalii*.

Abiotic conditions

Due to intensive fertilization in the years before the restoration, the soil contained high concentrations of nutrients, causing problems with thistles (*Cirsium arvense*). After 5 years without fertilization, the nutrient concentrations decreased significantly.

Other lessons learned

- When planning the restoration works, it is necessary to pay sufficient attention to potential archaeological values. The area turned out to be inhabited for more than 2000 years. During restoration works tracks of ancient human occupation can easily get destroyed.
- Restoration of the salt meadows needs to be executed in a very precise way. An experienced crane operator is necessary to avoid that the seed bank gets lost.

Future points of attention for sustainable results

- Eutrophication of surface and ground water and disturbance of birds due to intensive agricultural activities adjacent to the nature reserve
- Excessive drainage in the area surrounding the nature reserve, affecting the water levels inside the Uitkerkse Polder.
- Continuation of the grazing management with local farmers.

Public support

- The Uitkerkse Polder is nowadays one of the most popular nature reserves along the Flemish coast with more than 150,000 visitors a year. Several visitor facilities are present: hides, information panels, footpaths, cycle-tracks and a visitor centre.
- The nature reserve is strongly supported by the city council of Blankenberge, because of the opportunities for eco-tourism.
- At present, more than 55 farmers are involved in the management of the nature reserve.

Thanks to the restoration works the Uitkerkse Polder has become a birdwatcher's paradise. It is one of the strongholds in Flanders for breeding meadow birds such as *Limosa limosa* and wintering waterfowl such as *Anser brachyrhynchus*.

Large parts of the ancient polder grasslands with salt meadow relics in the Uitkerkse Polder were raised and levelled for agricultural purpose. The aim is to gradually restore the historical micro-topography and ditch pattern of this unique landscape. At some places new pools and depressions with both salt or brackish water were created as well.

7. Meetkerkse Moeren (Zuienkerke, Jabbeke, Brugge)

Joy Laquière & Carole Ampe (VLM)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Supporting authorities: Flemish Land Agency (land development for nature project)

Ecosystem type

Groundwater fed, species-rich fen meadow area (425ha) in the transition zone between the coastal Polders ecoregion and the higher sandy soils of the ecoregion of Pleistocene river valleys.

Restoration measures, objectives and results

Starting conditions	
For decades the ecological values degraded due to the intensification of agricultural use. Despite the nature destination on spatial planning maps, a powerful pump station was built in 1986 and since then the area suffered form desiccation, eutrophication and loss of the traditional mowing management regime.	
Restoration measures	
2002-2003	A sod cutting experiment was set up to investigate the restoration potentials from the seed bank in different grassland types. On 8 plots of 400m² (one of 100m²) the nutrient-rich topsoil was removed (5 to 10cm). The plots were connected with existing shallow field drains in the grassland. Application of this type of measures and other restoration measures are currently still under investigation.
Objectives	**Management measures**
Restoration of low productive fen meadow community	Mowing 2x per year or mowing followed by grazing

Evaluation

Species/communities

Despite intensive agricultural use for about 20 years, in the different grasslands the peat soil still yielded a viable seed bank with some surprising results. Different target species reappeared, including an extinct species for Belgium: *Viola persicifolia*. Other interesting species were: *Carex distans, C. oederi* ssp. *oederi, C. oederi ssp. oedocarpa, C. panicea, Hydrocotyle vulgaris, Juncus gerardii, Luzula multiflora, Potentilla erecta, Ranunculus flammula, Salix repens, Samolus valerandi* and *Trifolium fragiferum*. There was a large variation between the plots: the number of target species varied between 1 and 24.

Abiotic conditions

The soil properties on the 8 plots after sod removal were similar: they are located on a sandy soil with an OC-content between 3.5 and 6.1%; former agricultural fields (2 plots) are excluded. In 2 plots calcareous gyttja has been observed, in 2 other plots remnants of the podzol Bh horizon occurred.
Not surprisingly, the sod cutting plots with the lowest values for OC, N and P and the plots on the formerly less intensively used grasslands, showed the best results. The plot with the lowest pH (pH H_2O of 6.1) showed the largest number of target species and valuable indicators for acid to weakly acid soils. On the plots with the presence of calcareous gyttja, hence higher pH levels, most of these valuable species did not appear. Possibly the seed bank is better preserved in a more acid soil.

Future points of attention for sustainable results

Ensuring a higher level of the water table will be a key factor in the future of the restoration project

Ongoing or future restoration measures in the area

The results of the experiment are very encouraging to upscale the restoration efforts in the nearby future. Other restoration measures for the area are currently still under investigation as well.

Public support

Although most of the local farmers (still) object to the restoration project, it is the intention of the management authority to encourage participation of local farmers in the mowing and grazing management of the area.

References

Laquière J. & Ampe C. (2008)

Experimental top soil removal of intensively used agricultural grasslands in the Meetkerkse Moeren yielded unexpected results. *Viola persicifolia* had not been seen in Flanders for more than 130 years until it reappeared here from a seed bank. It proves the value of an experimental approach and close monitoring to enable appropriate planning of a large-scale restoration project.

8. Lake Blankaart (Diksmuide)

Kris Decleer & Luc Denys (INBO)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: EU (INTERREG), Agency for Nature and Forests, province of West-Vlaanderen

Ecosystem type

Shallow eutrophic freshwater lake of 30ha created by late-medieval peat cutting, surrounded by 40ha of marshland, in the floodplain of the river IJzer in the Polders and tidal Schelde ecoregion. Six rivulets enter the lake, which flows into the river IJzer.

Restoration measures, objectives and results

Starting conditions

The shallow eutrophic lake with abundant aquatic vegetation and extensive reed belts and mats of floating vegetation was affected by a 4 year long water level rise of c. 1m during World War I. After 1945 ecological degradation was induced by severe pollution and increased sediment load of the inflowing water due to catchment development (3,670ha, mainly with intensive agriculture) and since the 1960s by lowering of the regional water level due to pumping. Water level changes also increased due to occasional floodings of the river IJzer. By the 1980s, all water plants had disappeared and silting up caused large parts of the lake to fall dry during some summers. The reedmarsh fringing the lake died back or became invaded by willows and ruderal species such as *Urtica dioica* and *Calystegia sepium*.

Restoration measures

1994-1995	– 250.000m^3 of sludge was dredged from the lake up to an average depth of 1-1.5m. – Sedimentation basins were constructed on the 2 most important inflowing rivulets. – Experimentally, benthivorous and planktivorous fish were removed from a part of the lake in 1999, with re-stocking of 15,000 young pikes.

Objectives	Management measures
Restoration of a eutrophic lake with abundant submerged and floating vegetation and a species-rich reedmarsh.	– Occasional cutting of the reed marsh. – Water-level management (suboptimal due to compromise with agricultural demands)

As a result of the lowering of the water table in its surroundings the reedmarsh of lake Blankaart (background) has been invaded by *Urtica dioica* and willow scrub (foreground).

In the 1980s lake Blankaart completely silted up with sediment from field erosion in the catchment area of its inflowing rivulets and periodically dried out, with massive fish mortality as a result.

Evaluation

Species/communities

The measures did not have the pursued results. The water in the lake remained turbid and no recovery of water plants occurred. The concentrations of green algae and cyanobacteria remained extremely high (up to 60,000 cells/ml). Overall initial fish biomass (mainly Carp, Bream and Roach) was estimated at 110 kg/ha, with almost no Pike or Perch. In the part of the lake, where fish were removed experimentally, the fish biomass was estimated at 472 kg/ha and only 60% of the benthivorous and planktivorous fish could be removed. Despite introduction of large numbers of Pike and separation from the rest of the lake by a small-meshed net, no improvement in the ecological condition of this part of the lake could be observed. Recovery of target plant species in the marsh after willow cutting and mowing management is in most cases only temporarily.

Abiotic conditions

A study in 2002-2004 revealed that the inflow of nutrients and sediment from the surrounding agricultural land remained extremely high (erosion and nutrient run-off). For the year 2002 the annual input of nitrates was estimated at 424 tons, orthophosphate at 9 tons and suspended matter at 4,737 tons (resulting in peaks up to 400 mg/l). The sediment traps were only able to limit the amount of sand transported into the lake. Smaller particles, with high loads of adsorbed phosphate, are not retained by the traps and silting up proceeded after dredging. In order to meet agricultural needs, water levels in the lake could not be restored sufficiently to allow substantial improvement of the ecological quality of the reed marsh. The project is considered a failure due to the lack of an integrated approach.

An attempt in 1994-1995 to restore the lake ecosystem (once full of submerged and floating macrophytes) by large-scale dredging (left) and the building of sediment traps on some of the inflowing rivulets (right), failed. The lake remains hypertrophic as a result of still ongoing nutrient and sediment inflow from the surrounding agriculture. Measures at the source of the problems are needed.

Other lessons learned

In this case it is clearly shown that nature restoration is often a complex matter and sound scientific data are to be gathered in advance for an appropriate planning and execution of a restoration project. Restoration can only be effective and sustainable if the spatial scale of the restoration measures is adjusted to the spatial scale of the constraints that have to be solved.

Future points of attention for sustainable results

- A land development for nature project is in preparation to raise the water level of the lake and increase the marsh surface. This will include acquisition of all low-lying agricultural parcels in the surroundings of the lake.
- Actually, there is no policy plan yet to reduce the inflow of nutrients and sediment from the catchment. This is imperative to achieve sustained restoration of the lake, since hydrological isolation is not possible.
- When targets for water levels and water quality of the inflowing rivulets are achieved, internal eutrophication may still be a problem. It will probably be necessary to keep the populations of planktivorous and benthivorous fish at a low level.

Public support

The Blankaart case is a classic example in Flanders of conflicting aims of agricultural and nature conservation policies. It remains a huge challenge to reconcile both in this catchment dominated by intensive agriculture.

References

Muylaert K. et al. (2003)

Nevertheless lake Blankaart is still very important for wintering water birds.

9. Ketenisseschor and Paardeschor (Kallo, Doel)

Bart Vandevoorde & Erika Van den Bergh (INBO)

Natura 2000 area: yes

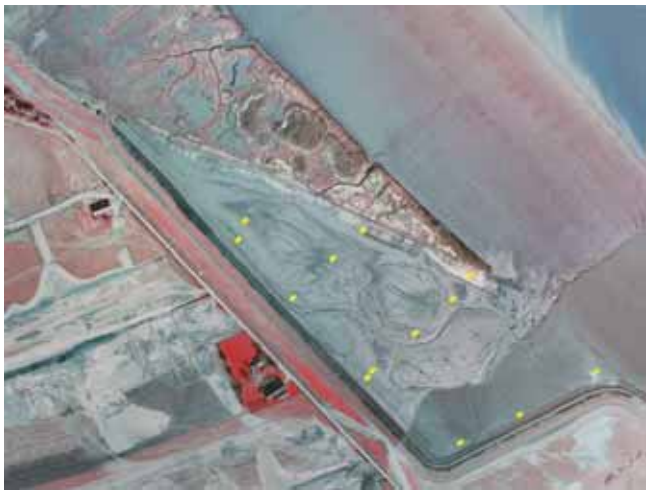
Management authority: Flemish Waterways Administration, Natuurpunt

Ecosystem type

Brackish tidal mudflats and marshes in the Schelde estuary (Polders and tidal Schelde ecoregion)

Restoration measures, objectives and results

Starting conditions	
The Ketenisseschor tidal marsh was embanked in the 19th century and raised in the late 1980s with excavated material from a tunnel, except 25ha of tidal mudflat. The Paardeschor tidal marsh was raised in the 1960s for the construction of the Doel nuclear power plant.	
Restoration measures	
2003	35ha of the Ketenisseschor was restored by lowering the area below mean high water level under a gentle slope from the dike towards the river. This open brackish tidal area was restored to compensate the loss of intertidal area for the North Sea container terminal in the port of Antwerp.
2004	As compensation for the new 'Deurganckdok' dockyard in the port of Antwerp, 12ha of tidal marsh of the Paardeschor was restored by removal of the dumped material. This site resembled more a breached site rather than an open tidal area because part of an existing tidal marsh remained between the river and the restored area.
Objectives	**Management measures**
Restoration of brackish tidal mudflats and marshes	None (spontaneous succession allowing natural dynamics)



Restoration of 12 ha of brackish tidal marsh and mudflats at the Paardeschor along the river Schelde, as a compensation measure for the expansion of the port of Antwerp. On the orthophoto the existing part of the marsh is noticeable in the upper left corner. Yellow dots indicate the monitoring plots.

On the lower, more inundated parts of the restoration zone *Aster tripolium* is the most important pioneer species.

Evaluation

Species/communities

During the first growing season the locations high in the tidal frame were colonised by typical pioneering species of brackish tidal marshes. Stands of *Scirpus maritimus* appeared accompanied by *Aster tripolium*, *Spergularia marina* and *Atriplex prostrata*. Also monospecific stands of high outgrowing *Aster tripolium* occurred on lower more inundated areas. On well-drained and sandy sites along creeks stands of *Aster tripolium* and *Atriplex prostrata* occurred. The lowest parts remained without vegetation or were colonised by large mats of macro-algae, mainly *Vaucheria* spec. on the sheltered parts. Some sandy parts remained supratidal and were covered by several *Chenopodium* spec. and *Atriplex* spec. or by tall herbs like *Calamagrostis epigejos*.
Benthic invertebrates rapidly colonized the restored areas. Only one month after restoration already several taxa were found. The number of taxa quickly increased. Mainly mobile taxa appeared shortly after restoration, particularly *Nereis diversicolor* and *Corophium volutator*. Also several Oligochaeta spec. like *Paranais litoralis* and *Tubificoides heterochaetus* occurred. Less mobile species remained rare. In total about 20 benthic invertebrate taxa were found at the Paardeschor and Ketenisseschor (low species diversity is typical for brackish areas).
At Ketenisseschor a total of 46 water bird species were recorded. After three seasons a wintering pattern started to develop. Ducks, especially *Tadorna tadorna*, were the most abundant species but also waders and geese were numerous. Waders and *Tadorna tadorna* mainly foraged on the wider muddy areas of the restored area, where benthic invertebrates were most abundant. The numbers of roosting birds were also the highest in these areas. The highest numbers of geese, mostly *Anser anser*, were observed in winter. They primarily foraged on the restored areas with *Scirpus maritimus*. The number of breeding waders, particularly *Recurvirostra avosetta* and *Charadrius dubius*, decreased and the numbers of reed birds increased as taller vegetation appeared. Because of the limited inundation time of the mudflat and high abundance of macrobenthic invertebrates the Paardeschor is used for foraging and roosting by waders and ducks like *Tadorna tadorna*, *Anas platyrhynchos*, *Numenius arquata* and *Haematopus ostralegus*. The bare mudflats in the restoration sites are important foraging grounds for young fish such as *Solea solea*, *Platichthys flesus*, *Clupea harengus* and *Dicentrarchus labrax* and support high densities of easily available prey species.

Abiotic conditions

Geomorphological processes in sedimentation or erosion and creek development determine to a greater extent the colonization, stability and succession by plant communities and macrobenthic invertebrates at restored tidal areas and consequently the use by water birds and fish.
Sedimentation/erosion was the overall result of slope, intertidal elevation, width, shelter and soil properties all depending on the initial starting conditions. Areas below mean high water with a gentle slope were subject to net sedimentation where the soil developed from sand to fine sands or silt. The sedimentation rate was directly proportional to shelter (width of the area on open tidal areas and distance from the breach in breached areas). Areas with a steep slope were subject to erosion. A critical overall slope of 2,5% was calculated: above this slope erosion was more likely to happen. Depressions acted as sediment traps and filled relatively quickly. Zones above mean high water level showed very little geomorphologic changes. In most locations organic matter percentage increased but only in the extremely sheltered locations it became comparable to that of existing mudflats. It will take more time to build up comparable soils. Dendritic and sinuous creek systems only developed in zones with net sedimentation. Creek development was found to be directly proportional to the mean width of the area perpendicular to the river. More higher order creeks developed in wider areas. An exponential and inverse relationship between slope and creek development was found. In open realignments separate parallel creek systems developed whilst in a breached situation fewer but bigger systems with higher order creeks developed.

Other lessons learned

- To develop a well functioning tidal area the initial slope, width (or shape) and shelter from strong current are crucial.
- The final design differed significantly from the original plan. The excavated material was used as construction material for dikes. Because the topsoil was not useful for that purpose some areas were not excavated below mean high water level and remained supratidal, a missed opportunity to create more tidal area. In some parts the old dike was also not removed resulting in flat plateaus with a steep slope towards the river, instead of a gentle overall slope from the dike to the river.

Future points of attention for sustainable results

The Schelde estuary is subject to sea level rise and many anthropogenic impacts (harbour expansion, dredging activities, embankments, etc.) destroying or deteriorating intertidal areas and inducing hydrodynamic pressures. The tidal amplitude and tidal energy are increasing, causing erosion and drowning of tidal marshes and mudflats (coastal squeezing) which will have an impact on the sustainability of the restoration measures.

Public support

The managed realignments of the Paardeschor and Ketenisseschor are compensation measures for the loss of intertidal area due to the expansion of the port of Antwerp. With the decisions about the Development outline 2010 for the Schelde estuary and the updated Sigmaplan, the Dutch and Flemish governments are committed to leap forward with the ecological rehabilitation of the Schelde estuary. An important challenge is the creation of tidal wetlands. In order to assess the feasibility and to identify possible problems these small-scale projects are studied in detail. Analysis of their evolution can improve our apprehension of the future plans on a larger scale.

References

Breine J., Van den Bergh E., Stevens M. & Simoens I. (2008); Van den Bergh E. et al. (2005); Van den Neucker T. et al. (2007).

Ketenisseschor: 35ha of brackish tidal marsh and mudflats restored as a compensation measure for the expansion of the port of Antwerp.

10. Lippenbroek and Heusden LO (Hamme, Heusden)

Tom Maris (UA), Bart Vandevoorde (INBO) & Erika Van den Bergh (INBO)

Natura 2000 area: yes

Management authority: Flemish Waterways Administration, Flemish Agency for Nature and Forests

Ecosystem type

Freshwater tidal mudflats and marshes under controlled reduced or natural tide in the Schelde estuary (Polders and tidal Schelde ecoregion)

Restoration measures, objectives and results

Starting conditions	
Along the Schelde dikes protect the surrounding polder areas. Direct contact between the river and its alluvial plain has been lost.	
Restoration measures	
2005-2006	In the freshwater tidal zone pilot projects were executed in the framework of a large flood control project for the Schelde. This was done by dike relocation and inner dike restoration in 2 small, former polder areas with an elevation below mean high water. Lippenbroek (2.5m below mean high water) is turned into a flood control area (FCA) of 10ha by lowering the river dike. Construction of new sluices in this river dike allows a limited amount of estuarine water to flow in during every flood, a system called controlled reduced tide (CRT). At Heusden LO (0.5m below mean high water), the dike was relocated inland, the old dike was levelled to just below mean high water level and breached to mean low water level where the culverts used to be. A tidal marsh of 10ha was created (2006).
Objectives	**Management measures**
Creation of fresh water tidal mudflats and marshes.	None.

Evaluation

Species/communities

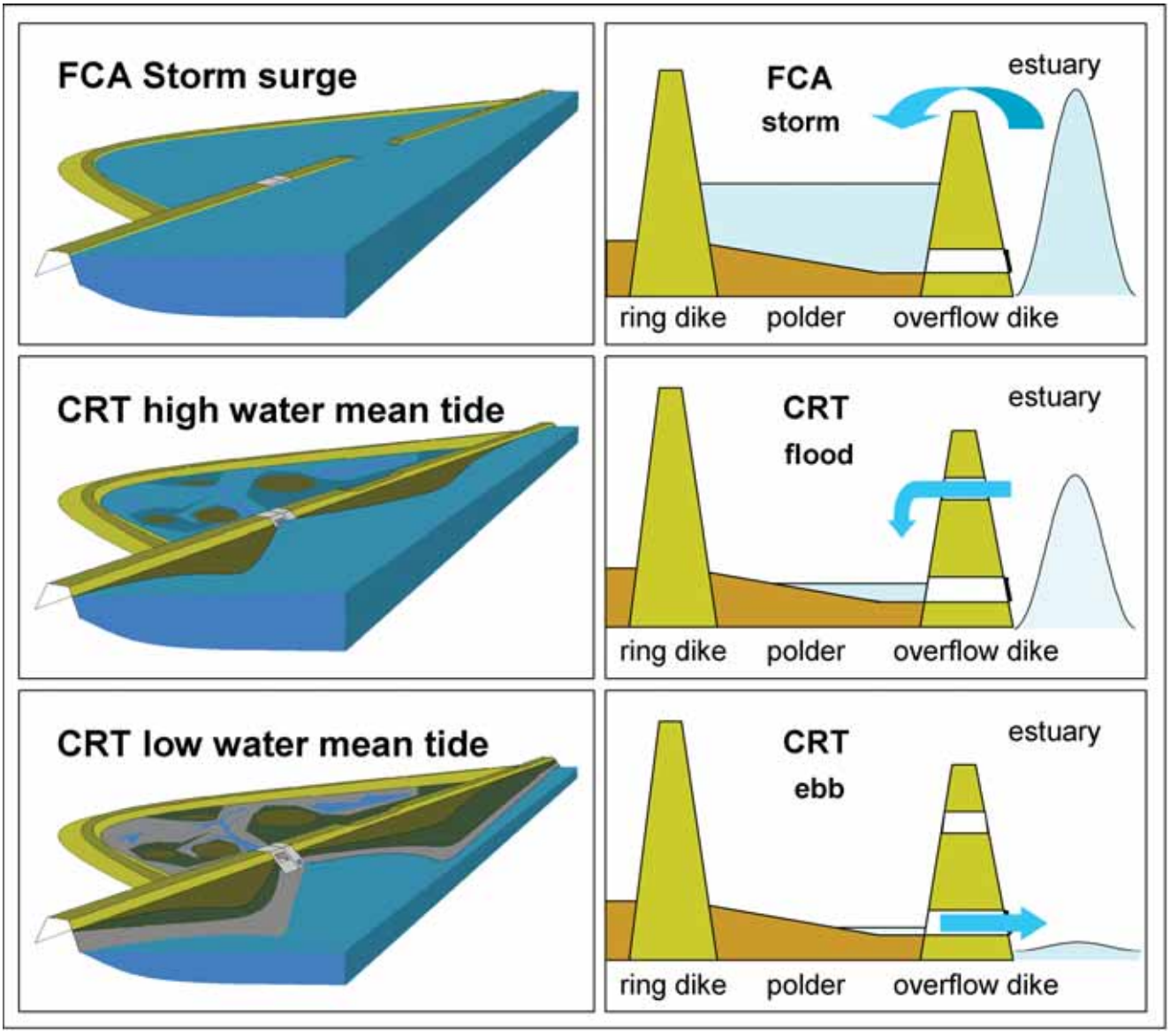
Vegetation development showed a clear shift from terrestrial species towards estuarine and wetland species. The lowest parts in Heusden LO, more than 0.6m below mean high water level remained unvegetated or were scarcely colonised by *Polygonum hydropiper*. Vast stands of species-rich and highly covering pioneer vegetations developed higher up between -0.6m and mean high water level. The most abundant species were *Polygonum hydropiper*, *Lythrum salicaria*, *Alisma plantago-aquatica* and *Lycopus europaeus*. Above mean high water level a mixed pioneer vegetation of estuarine and non-estuarine pioneer species developed. Even some species of earlier vegetations remained.
Likewise terrestrial macrobenthic species were replaced by aquatic and estuarine species. High densities were especially observed on parts with high sedimentation rates. In Heusden LO the first year after restoration a species rich (24 spec.) benthic community developed. 13 species of Oligochaeta were recorded but also Hirudinea, Diptera and Gastropoda. The high species diversity is probably related to the high topographic heterogeneity of the site.
Permanent pools in Heusden LO function as spawning and nursing habitat for tolerant fish species such as *Carassius auratus gibelio* and *Pseudorasbora parva*.
The CRT sluice system in Lippenbroek seems to allow fish migration between the FCA and the Schelde.

Abiotic conditions

Creating good tidal conditions is a key factor for tidal marsh restoration, because hydrodynamics are the main driving force behind several physical, chemical and biological processes in tidal areas. Inundation frequency and height in natural marshes are determined by local elevation relative to the tide.

In Lippenbroek, tidal regime is detached from site elevation. Despite its low elevation the sluice system allowed for a wide range of inundation frequencies, very similar to the natural patterns in the adjacent tidal marsh. We could measure big differences between spring tide high water and neap tide high water. Sedimentation rates were very high (up to 14cm/year) at the lowest points, because of higher inundation frequencies. The highest points have very low sedimentation rates (a few mm/year), leading to a flattening of the area. To preserve water storage capacity, sedimentation rates can be limited by reducing the inundation height (and thus the imported sediment mass). Erosion was measured in the thalway of the main channel (a former polder ditch). Lateral sedimentation and erosion patterns were observed, turning the symmetric ditch into an asymmetric creek.
Also in Heusden LO high sedimentation rates, up to 12cm/year, were observed at the lowest points; at the higher parts the sedimentation rate is obviously lower. High sedimentation rates were probably caused by the asymmetric tide in this part of the Schelde estuary and the sheltered nature of the site. The deposed sediment is mainly silt to very fine sand. The lowest parts are permanently inundated or waterlogged, caused by the poor drainage of the site.

The FCA-CRT system of Lippenbroek has significant impact on water quality. High inlet sluices act as important aerator of the inflow. Therefore, oxygen concentrations within the CRT were always above 60% saturation. Due to surface aerations and primary production, oversaturation was often measured. For ammonia and nitrate, the polder acts as a sink. For silica, the polder is a sink when silica is abundantly available in the estuary, but becomes a source when concentrations are limiting. Thus, the CRT in Lippenbroek acts as buffer and regulator in the silica cycle (similar to natural marshes).



Schematic representation of the functioning of a flood control area (FCA) with controlled reduced tide (CRT).

Detail of the inlet sluices in the dike during flood when water is entering the FCA-CRT Lippensbroek.

Other lessons learned

- The final design in Heusden LO differed significantly from the original plan. For example the old dike was not lowered to mean low water level as planned but rather to mean high water level. Initially the site only inundated at spring tides and it was not drained at low tide. Later two breaches to mean low water level were added where the old sluices used to be, connecting to ditches. It then had every aspect of a breached site with a strongly accentuated spring tide/neap tide differentiation in the inundation regime. Nevertheless, some low parts remain inundated at low tide.
- The southern part of Heusden LO, where the sand stock for the dike construction works was, was not completely removed and remained supratidal.
- The new inland dike is not fortified with riprap stones, and the topography of the restored site was not altered, resulting in a site with a great variety of habitats as permanent pools, mudflats and typical tidal marsh vegetation. The vegetation gradient from low marsh to supratidal can develop due to the absence of fortifications in the supratidal zone.

Aerial view of the 10ha large FCA-CRT Lippensbroek during ebb.

Part of Heusden LO (10ha) during flood in winter (Feb. 2007) and the same area covered by pioneer vegetation of *Polygonum hydropiper* and *Lythrum salicaria* in summer (Aug. 2007).

Future points of attention for sustainable results

Recently the area was colonised by *Hydrocotyle ranunculoides*, an invasive species. Chances are that this species will soon invade the complete tidal area.

Public support

The managed realignment of Heusden LO was originally designed, but afterwards rejected as compensation measure for the loss of intertidal area at the Deurganck dock in the port of Antwerp. On the other hand Lippenbroek is a pilot project to test the hydraulic effectiveness, ecological evolution and geomorphological changes of flood control areas with a controlled reduced tide (FCA-CRT). With the decisions about the Development outline 2010 and the updated Sigmaplan, the Dutch and Flemish governments are committed to leap forward with the ecological rehabilitation of the Schelde-estuary. An important challenge is the creation of tidal wetlands, partly as FCA. In order to assess the feasibility and to identify possible problems these small scale projects are studied in detail. Analysis of their evolution can improve our apprehension of the larger scale future plans.

References

Breine J., Van den Bergh E., Stevens M., & Simoens I. (2008); Cox, T. et al. (2006); Maris T. et al. (2007); Maris, T. et al. (2008); Maris, T., Cox, T., Van Damme, S. & Meire, P. (Red.) (2007); Van den Neucker T. et al. (2007).

Detail of the breach to mean low water level in Heusden LO where an old sluice used to be.

11. Vallei van de Zuidleie: Leiemeersen (Oostkamp)

Kris Decleer (INBO)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: Flemish Waterways Administration, province of West-Vlaanderen, Regional Landscape Houtland

Ecosystem type

Groundwater fed, species rich fen meadow and marsh relic (13ha) in the ecoregion of Pleistocene river valleys

Restoration measures, objectives and results

Starting conditions	
4ha of the area was raised with polluted and nutrient-rich sludge in the 1960s.	
Restoration measures	
1992-1994; 2002	About 20,000m³ of sludge was removed down to the original peaty soil surface. Locally, small ponds were created.
Objectives	**Management measures**
Restoration of low productive fen meadow community and mesotrophic transition mire	Mowing 1x-2x per year

Evaluation

Species/communities

- After about 40 years being covered by a thick sludge layer the peat soil still yielded a viable seed bank. Different target species were able to recolonize the area: e.g. *Carex panicea, C. pallescens, C. viridula, C. demissa, C. flacca, C. nigra, C. acuta, C. vesicaria, C. disticha, Juncus acutiflorus, J. subnodulosus, Ranunculus flammula, Senecio aquaticus, Lotus pedunculatus, Potentilla erecta, Veronica scutellata, Scirpus sylvaticus, Lychnis flos-cuculi, Stellaria palustris, Sium latifolium* and *Eleocharis uniglumis.*
- From a neighbouring, untouched part of the fen meadow area different target species were able to colonize the restoration area, most probably as a result of inundations or with mowing machines: e.g. *Dactylorhiza fistulosa, Caltha palustris, Pedicularis palustris, Rhinanthus angustifolius, Equisetum fluviatile, Cirsium palustre* and *Menyanthes trifoliata*. For to the same reason colonisation by a large population of the Large Marsh Grasshopper (*Stethophyma grossum*) was possible.
- Other target species colonised the restoration area for uncertain or unknown reasons: e.g. *Dactylorhiza praetermissa, D. maculata, Epipactis palustris, Triglochin palustris* and *Peucedanum palustre.*
- Open water was colonised by pioneer species such as *Potamogeton crispus*, *P. pusillus* and *Ranunculus peltatus*. Later on these species disappeared in favour of target species such as *Nuphar lutea*, *Utricularia australis*, *Sagittaria sagittifolia* and *Wolffia arrhiza*, but also reed is invading.

Abiotic conditions

- In the beginning the ponds suffered from high sulphate concentrations (up to 800 mg/l), which caused temporary die back of submerged waterplants due to periodic hydrogen sulphide intoxication. After about 10 years normal background concentrations of sulphate were observed.
- The peat soil was hard and compacted in the first year after removal of the sludge. Gradually, the peat became spongy again and slightly raised.

Other lessons learned

- Removal of the sludge layer needs to be executed in a very precise way. An experienced crane operator is necessary to avoid that nutrient-rich sludge remnants stay behind or that the top layer of the peat soil with the seed bank gets lost. In the latter case, moreover, local waterlogged depressions in the area hamper an efficient mowing management.
- The mowing management is of major importance. Plant production in the early succession stages of most of the restoration area was very large due to dominance of species such as *Juncus effusus, Glyceria fluitans, Holcus mollis, Alopecurus geniculatus, Typha latifolia* and *Salix alba*. This dominance was largely broken within 5 years of consequent mowing management.

Future points of attention for sustainable results

- Eutrophication of surface and groundwater due to intensive agricultural activities adjacent to the nature reserve.
- Natural drainage of the area depends on the water levels in the adjacent canal Gent-Brugge which are kept high for shipping. As a consequence, periodically, water levels in the nature reserve are too high, disturbing the natural groundwater discharge and nutrient availability and hampering an efficient mowing management.
- A less intensive mowing management would improve the diversity in vegetation structure for the benefit of faunistic interests.

Public support

Local farmers initially objected to the restoration project. Currently the area is a major point of attraction each spring, when hundreds of visitors and schools enjoy the extremely flower-rich meadows.

Removal of the sludge down to the original peat soil.

15 years later: successful restoration of the original low productive fen meadow community and mesotrophic transition mire. Typical in spring are the thousands of *Dactylorhiza fistulosa*.

Detail of *Dactyorhiza fistulosa.*

Starting conditions	
Around 1850 about 1.5ha of the area was raised with excess soil from the excavation of the adjacent canal Gent-Brugge.	
Restoration measures	
2001-2006	About 6,000m³ of soil was removed. The original peat soil appeared to be disturbed or absent. As a result a shallow water area was formed. Locally small ponds were created. Part of the excavated material was rich in subfossil water molluscs and part of these ancient water bottom layers of the canal were left behind in the excavated area in the hope they still contained a viable seed bank.
Objectives	**Management measures**
Spontaneous succession of mesotrophic open water, reedmarsh and alder carr.	None.

Evaluation

Species/communities

- After about 150 years seeds of different target species, most of them absent in the surroundings, were still able to germinate from a seed bank: e.g. *Nymphaea alba, Potamogeton natans, Potamogeton lucens, Potamogeton crispus, Potamogeton pusillus, Zannichellia palustris, Scirpus lacustris, Sagittaria sagittifolia* and *Typha angustifolia*.
- In the pioneer stage the open water was dominated by Charophytes, but they disappeared again as reed gradually colonised the shallow water.
- Before the restoration measures only 5 species of dragonflies were known from the area. Up to now 24 species have been recorded, a high number for the region.

Future points of attention for sustainable results

- Cyclical dredging will be necessary to maintain open water communities.
- Locally, the invasion of the alien duckweed *Lemna minuta* may become a problem to maintain aquatic species diversity.

Apparently seeds of *Nymphaea alba* may survive for about 150 years or more in the seed bank if the conditions are right.