Starting conditions	
In the 1960s and 1970s part of the area, with large abundance of *Equisetum fluviatile* and *Menyanthes trifoliata,* was used as a dump site for domestic waste.	
Restoration measures	
2005	About 0.4ha (6,000m^3) of waste was removed from the area down to the original peat soil.
Objectives	**Management measures**
Mesotrophic transition mire	Spontaneous succession at first with cutting and removal of the marsh vegetation in dry summers.

Evaluation

Species/communities

As a result of peat compaction and the meticulous removal of domestic waste shallow water was created. This was mainly colonised from the seed bank by *Typha latifolia* and *Juncus effusus*. On the drier parts only few relic species from the original vegetation immediately reappeared: e.g. *Carex disticha, Apium nodiflorum, Eleocharis uniglumis* and *Sparganium emersum*. From the adjacent area other target species already colonised the site: e.g. *Hottonia palustris*, *Pedicularis palustris,* etc.

Other lessons learned

Mowing is not possible every year. As a result the dominance of tall marshland herbs is not broken, but they contribute to a fast terrestrialisation of the shallow water, which may speed up the process of restoration of mesotrophic transition mire.

Future points of attention for sustainable results

Invasion by *Phragmites australis* is a threat as long as mowing is not possible every year.

Removal of an old domestic waste dump site and restoration of an old meander of the former Zuidleie. 3 years later the site looks natural again and lowland peat formation has restarted.

Starting conditions	
An old meander of the Zuidleie was partly terrestrialised.	
Restoration measures	
2000-2005	The meander was excavated and restored over a distance of 800m.
Objectives	**Management measures**
Mesotrophic water community	Cyclical dredging every 10-20 years

Evaluation

Species/communities

From a viable seed bank some target species reappeared: e.g. *Potamogeton lucens, Hottonia palustris* and *Sagittaria sagittifolia.* Relic populations of e.g. *Nuphar lutea, Utricularia australis* and *Riccia fluitans* increased considerably.

Future points of attention for sustainable results

Input of eutrophic water from adjacent intensive agriculture.

Pedicularis palustris was reintroduced with great success with seeds from a threatened, neighbouring population.

12. Vallei van de Zuidleie: Gevaerts-Noord (Beernem)

Kris Decleer (INBO)

Natura 2000 area: no

Management authority: Natuurpunt

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

Ecosystem type

Wooded pasture on wet and dry, nutrient-poor sandy and loamy sand soil in the ecoregion of Pleistocene river valleys (c. 7.5ha)

Restoration measures, objectives and results

Starting conditions	
Maize fields and manured agricultural grasslands along an ancient, ecologically valuable embankment of the canal Gent-Brugge.	
Restoration measures	
1995-1998	About 40cm of the toplayer was removed in a 20-60m wide and 1,500m long strip along the embankment. Gentle transitions in topography, humidity and soil types (pure sand, loamy sand, sandy loam) are present.
Objectives	**Management measures**
Wooded pasture landscape with expansion of the nutrient-poor grasslands and scrubs on the canal embankment to the former agricultural land; creation of transition zones to temporarily inundated zones with pioneer vegetations.	Seasonal extensive grazing by cattle (June-November), supported by additional cyclic scrub removal to maintain vegetation structure diversity.

Sloppy topsoil removal resulted in pioneer vegetations with lots of ruderals.

Evaluation

Species/communities:

- The first years the dry parts of the site were mainly colonised by ruderal species such as *Trifolium repens, Rumex obtusifolius, Holcus lanatus* and *Matricaria* spec. This was probably due to the fact that top soil removal was done with a bulldozer and as a result a lot of the top soil including the weed seeds was spilled in the area. Also willows colonised the area immediately.
- In the wet, temporarily inundated parts *Juncus effusus* became the dominant species. It came as a complete surprise that also more interesting, up to now persisting species germinated from a seed bank (which was not expected at first), such as *Carex nigra, Juncus acutiflorus, Lythrum portula, Ranunculus aquatilis, Scirpus lacustris* and even *Scirpus fluitans*.
- Supported by the management regime vegetation succession evolved positively during the past 10 years: the pioneer vegetation gradually changed to a very diverse mosaic of species-rich vegetation types. A lot of target species that colonised the restoration zone most probably originate from the neighbouring canal embankment. On the dryer parts scrub vegetation of *Cytisus scoparius*, brambles, *Ulex europaeus* and different species of young trees are eye-catching. In the Broom understorey a large population of its parasite *Orobanche rapum-genistae* occurs. In the more open, nutrient-poor zones with larger grazing pressure different notable species are present: *Jasione montana, Ornithopus perpusillus, Trifolium subterraneum, T. striatum, T. arvense, Veronica officinalis, Hieracium pilosella, Parentucellia viscosa*, with pioneer lichens such as *Cladonia* spec. and *Peltigera* spec. and mosses such as *Tortula ruralis*. On more nutrient-rich spots also *Arrhenaterion* species established. On the more humid places locally *Dactylorhiza maculata*, *D. fistulosa* and *Salix repens* appeared.
- The faunistic interest of the restoration site is mainly restricted to some characteristic invertebrates, such as colonies of solitary bees and wasps, *Cicindela campestris, Coenonympha pamphilus* and *Zygaena trifolii* and small reptiles such as *Anguis fragilis* and *Lacerta vivipara*.
- Locally spontaneous succession is allowed, resulting in tall willow scrub which will probably evolve to a Common oak-Birch forest type.

Ten years later a very nice wooded pasture landscape had developed with lots of flowering Broom in spring and many rare target species of both wet and dry, low productive soils.

Abiotic conditions

About 1ha of the area is inundated most of the time, due to the presence of a pseudo groundwater table.

Other lessons learned

- The adjacent canal embankment favoured the colonisation rate of the area by target species.
- Despite the fact that the restoration works were executed more or less careless and with less suitable machinery, such as a bulldozer which also causes soil compaction, the results in the long term were not bad.

Future points of attention for sustainable results

- Grazing by cattle is not sufficient to keep the bramble scrub and willow encroachment at an acceptable level. Additional cutting of these invasive plants is necessary. In the forthcoming years the cattle will be experimentally assisted by some donkeys.
- The area did not receive any legal protection on the spatial planning and zoning maps so far.

Public support

The nature reserve is managed in agreement with the Flemish Waterways Administration, but has no official status and is therefore insufficiently protected. The area is threatened by widening of the canal. In the beginning there was an argument with the municipality to limit free access to the area to walkers only.

Trifolium subterraneum

Jassione montana

Summer grazing by Galloway cattle .

Dactylorhiza maculata

13. Lake Kraenepoel (Aalter)

Luc Denys (INBO)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Supporting authorities: EU (LIFE), municipality of Aalter

Ecosystem type

Very shallow, man-made softwater lake (22ha) with a sandy bottom in the ecoregion of Pleistocene river valleys

Restoration measures, objectives and results

Starting conditions

This circumneutral to slightly acid softwater lake presumably originates from the 16th century and was traditionally used for extensive pisciculture. It used to be famous for *Littorelletea* species and a rich desmid flora (up to 177 taxa in the 1930s). The lake degraded due to eutrophication in the second half of the 20th c., mainly due to pollution of the rivulet supplying water to the lake. At the point of restoration, the lake was divided in two parts by a dam:

- a hypertrophic southern part receiving water from the rivulet, with turbid conditions and without aquatic vegetation; fish biomass of 385kg/ha in 1999, mostly Bream;
- a northern part with some submerged vegetation of tolerant species (*Ceratophyllum demersum*, *Elatine hexandra*, *Potamogeton pectinatus*, *P. pusillus*, *Myriophyllum spicatum*, *Nymphaea alba*); fish biomass only 37kg/ha in 1999.

Restoration measures

2000	– Diversion of the polluted rivulet; draining of both parts and removal of all fish; dredging of the northern part with 24.600m^3 of sediment removed; repair of the separating dam; partial clearing of overhanging trees; creation of gradually sloping shorelines in places.
2001	– Natural refilling of both parts and stocking of northern part with juvenile Pike.
2002	– Drawdown and dredging of southern part followed by natural refilling in 2003.
2004	– Fencing of reed fringes to prevent grazing by geese.

Objectives	Management measures
Nutrient-poor structurally diverse lake with special focus on *Littorelletea* species.	– Yearly mowing of the dam and recurrent cutting back of trees and shrubs along the banks. – The intention is to re-install traditional drawdown management of the entire lake (probably every 5 years) with removal of planktivorous fish.

Evaluation

Species/communities

- Submerse vegetation cover increased in the northern part from less than 40 to c. 70% and from zero to c. 60% in the southern part. Rapid and sustained increase of *Elatine hexandra* and *Eleocharis acicularis* occurred from the seed bank. *Hypericum elodes* and some charophytes (*Nitella flexilis*, *N. translucens* and *Chara globularis*) also reappeared. Initially strong expansion of *Juncus bulbosus* was noticed, but its population declined 3-4 years after refilling and is now restricted to parts of the shore. Strong development of the filamentous alga *Oedogonium* in the first year. Establishment and short-lived expansion of *Pilularia globulifera*, a species not previously recorded from the site. No reappearance of more demanding target species that were formerly present, such as *Eleocharis multicaulis*, *Littorella uniflora*, *Lobelia dortmanna*, *Luronium natans* or *Myriophyllum alterniflorum*. Numerous seedlings of *Nymphaea alba*, *Potamogeton natans* and *Scirpus lacustris* arose from the seed bank but nearly all were eaten by water fowl.

- Initially, the diversity of desmids increased slowly, but it rose markedly since 2004 and now includes well over 50 taxa, including progressively more taxa of mesotrophic vegetation-rich conditions (e.g. *Euastrum denticulatum*, *Micrasterias papillifera* and *Pleurotaenium trabecula*).
- In both parts, diatom communities recovered to some extent and now include taxa characteristic of pre-deterioration conditions (*Achnanthidium minutissimum*, *Encyonopsis minuta*, *Fragilariforma exigua*, etc.) but also indicators of high organic loading (*Craticula molestiformis*, *Gomphonema parvulum*, etc.). The most notable changes occurred in the southern part, where the assemblage of hypertrophic phytoplankton-dominated hard water disappeared entirely.
- Species richness of cladoceran zooplankton increased and species composition also showed a partial recovery to that of 1930's. In line with the increased development of vegetation and reduced fish predation, the community became dominated by larger (*Diaphanosoma*, large *Daphnia*, *Simocephalus vetulus*), instead of small-sized species (*Bosmina*, *Ceriodaphnia pulchella*, small *Daphnia*).
- Perch and Pike became the predominant fish.
- Overall, a partial recovery of species diversity and composition was achieved, but it is highly unlikely that biodiversity levels similar to those prevailing prior to WW II can ever be obtained, among others due to lack of viable propagules *in situ* and isolation relative to possible founder populations. Nevertheless, structural diversity has improved, and a switch from plankton to macrophyte dominance was accomplished in the southern part.

Abiotic conditions

In general, clear water conditions (bottom view) have been obtained so far in both parts. Immediately after the first refilling, high concentrations of sulphate, nitrate, ammonium and phosphate and low pH and oxygen values occurred in the southern part due to oxidation/reduction processes and decomposition of organic matter. By 2003, the pH stabilised at c. 6.0 in the northern part and average soluble reactive phosphorus gradually decreased to 18 µg/l in 2006; conductivity dropped from c. 400 µS/cm prior to restoration to c. 120 µS/cm. The initial decrease in N-concentrations that set in the second year after sediment removal was reversed from 2004 onwards, possibly due to some dry summers and high N-deposition. Recently, concentrations of suspended particular matter have started to increase. In deeper parts and along certain shore sections, strong accumulation of organic detritus and leaf litter occurs, mainly originating from surrounding trees.

Removal of eutrophied sludge in Lake Kraenepoel

Other lessons learned

- Due to underestimation of the amount of sediment in the northern part and financial constraints, dredging of the southern part could not be carried out simultaneously as planned.
- Accumulation of organic matter may necessitate repetition of sediment removal. Regular drawdown, mimicking former fishpond management, is considered to decrease accumulation rates.
- In order to preserve the sediment archive for further study and part of the seed bank, organic sediments were not removed in some parts. These were eroded and redistributed soon after refilling, providing a source of organic matter for decomposition.

Future points of attention for sustainable results

- Current nitrogen deposition exceeds critical levels for isoetid vegetations.
- Inflow of nutrient-rich water in periods of excessive rainfall, as took place in 2005, needs to be prevented. Reconnection of the rivulet to the lake has been suggested, but this calls for a substantial improvement of its water quality.
- Soon after completion of the restoration measures, numbers of Canada, Barnacle and Egyptian Geese gathering at the site during winter months increased to several hundreds. This affects the aquatic and shore vegetation and may enhance nutrient availability.
- Due to the proximity of private estates and valued tree lanes, accumulation of leaf litter can only be managed on site.
- The northern part of the lake is still privately owned, complicating further management and necessitating negotiated solutions.

Public support

Removal of fish was poorly prepared and communicated, causing considerable commotion among anglers and local people concerned with animal welfare.

Elatine hexandra

References

Bossuyt B., Van Wichelen J. & Hoffmann M. (2007); Hoste I. & Vanhecke, L. (2002); Louette G., Declerck S., Vandekerkhove J. & De Meester L. (in press); Van Wichelen J. et al. (2007); Van Wichelen J. et al. (2008).

Hypericum elodes

14. Bourgoyen-Ossemeersen (Gent)

Geert Spanoghe (INBO), Bart De Muynck (City of Gent) & Toon Van Coillie (VLM)

Natura 2000 area: no

Management authority: City of Gent, Natuurpunt

Supporting authorities: Agency for Nature and Forests, Flemish Land Agency (land development for nature project)

Ecosystem type

Species-rich floodplain meadows and marshes, partly also groundwater fed, totalling 230ha (ecoregion of Pleistocene river valleys).

Restoration measures, objectives and results

Starting conditions	
After the construction of a major canal around Gent the Bourgoyen-Ossemeersen became isolated from the southern floodplain meadows along the river Leie. The area was drained for more intensive agricultural land use. High winter water levels with vast parts of the area flooded during longer periods were history.	
Restoration measures	
1985-present	A weir was constructed to hold up water levels from rainfall during winter. This resulted in the yearly flooding of the lowest meadows (c. 100ha) in the central and western parts from the end of October until March.
Objectives	**Management measures**
Species-rich wet meadows with breeding meadow birds.	- Mowing and grazing after breeding season. - Banning of pasture.

Evaluation

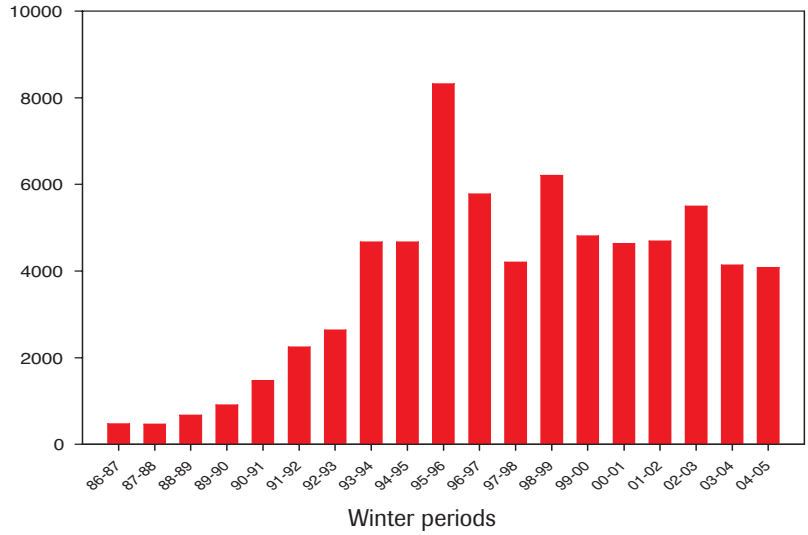
Species/communities:

- After many years of management species rich meadows dominate with abundance of target species as *Rhinantus angustifolius, Myosurus minimus, Veronica scutellata, Eleocharis palustris, Odontites vernus, Scutellaria galericulata* etc.
- The reserve has become one of the main wintering areas for ducks and waders in Flanders (proposed Ramsar site). Species as *Anas penelope*, *Anas clypeata*, *Anas crecca*, *Philomachus pugnax* and *Vanellus vanellus* are abundant. Breeding numbers of *Limosa limosa*, *Vanellus vanellus*, *Anas clypeata* and *Aythya fuligula* all increased.

The c. 100ha of flooded grasslands attract high numbers of wintering ducks and waders, qualifying the Bourgoyen-Ossemeersen as Ramsar site.

Future points of attention for sustainable results

- Cyclical dredging will be necessary to maintain open water communities in the ditches.
- The invasion of willows in the ditches and lowest meadows after dry summers is problematic for both plant communities, wintering and breeding birds.
- Eradication of breeding Canada Geese (*Branta canadensis*) still needs future attention.



Evolution in the maximum counts of wintering Wigeon (*Anas penelope*) in the Bourgoyen-Ossemeersen since the raising of the water table during winter.

Spring impression of the floodplain grasslands, with local patches of *Rhinantus angustifolius.*

Starting conditions	
14ha of the area was raised with sandy and partly polluted soil in the 1960s, during the construction of a major canal around Gent.	
Restoration measures	
2004-2007	The raised soil was removed up to the original peaty soil surface and the historical network of ditches was recreated (210,000m³ of soil relocation). New weirs were constructed to enable water level menagement.
Objectives	**Management measures**
Restoration of historical speciesrich (peaty) meadows with development of local marshy areas and open water.	Seasonal high water level (winter), possibility for grazing and mowing in summer if not too wet.

Evaluation

Species/communities

- In the pioneer stage the open water is dominated by Charophytes. A thorough inventory is scheduled in 2009.
- The marshy parts are dominated by *Salix* spec., *Lythrum salicaria*, *Mentha aquatica*, *Lycopus europaeus*, *Phragmites australis* and *Iris pseudacorus*.
- From early spring on, when water levels are lowered in the surrounding meadows, the area is the main attraction for all species of waterbirds as open water with mudflats is available into the summer. This resulted in much higher breeding numbers of all species of duck (mainly *Anas clypeata* and *Anas strepera*) and *Tachybaptus ruficollis*. *Phalacrocorax carbo* colonised the area with 0 tot 132 nests in 4 years. *Anas querquedula* returned to the area after a non-breeding period of 10 years and also *Sterna hirundo* and *Charadrius dubius* have bred. Migrating waders have increased tenfold.

Future points of attention for sustainable results

- *Salix* spec. invades the areas from seeds on exposed mudflats in June-July. During the summer of 2007 high water levels halted a further expansion but this will probably reoccur in the future. Mechanical removal of these young trees is hardly possible.
- Holding higher water levels in the summer with intensive mowing in surrounding meadows in drier periods may create a bigger water body with development of mudflats in the transition zone to the meadows. Controlled invasion of reedbeds in high water zones may attract lost breeding birds such as *Ixobrychus minutus* and *Locustella luscinioides,* while mowing may halt expansion of trees to the transition zone.

Public support

Lying next to a major city the area has thousands of visitors each year (3000+ on best days). With a new footpath along the longest side of this new restoration area with large numbers of waterbirds, both breeding and wintering, the public greatly enjoys the walk along this side of the reserve.

Over a total length of 2km 17,000m^3 of partly polluted sludge was removed in the canal "Loopgracht".

Roosting Cormorants near the newly created open water and marshland zone.

15. Damvallei (Destelbergen, Laarne)

Tom De Beelde, Frederik Hendrickx & Dirk Bogaert (Natuurpunt)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: EU (LIFE), province of Oost-Vlaanderen, municipalities of Destelbergen and Laarne

Ecosystem type

Eu-/mesotrophic lowland fen area formed within a fossil Holocene meander of the river Schelde (ecoregion of Pleistocene river valleys).

Restoration measures, objectives and results

Starting conditions	
Peat digging in the terrestrialised meander of the Schelde around the end of the 18th century created about 45 ponds, hosting important *Hydrocharition* and *Magnopotamion* vegetations. During the last decennia their ecological value strongly deteriorated due to their exploitation as fish ponds with high densities of planktivorous and benthivorous fish.	
Restoration measures	
2003-2008	After a physicochemical study restoration measures were taken, including removal of these adverse fish populations, introduction of Pike, removal of woody bank vegetation and reintroduction of native populations of the "flagship" species *Stratiotes aloides*.
Objectives	**Management measures**
Restoration of mesotrophic aquatic communities, with special focus on *Hydrocharition*, *Magnopotamion* and *Characeae* vegetations and expansion of suitable habitat for fish species like *Cobitis taenia* and *Rhodeus sericeus.*	None, unless monitoring results suggest otherwise

Evaluation

Species/communities

The reduction of benthi- and planktivorous fish populations resulted in a steady increase in water transparency, followed by an abundant presence of macrophytes (*Potamogeton crispus* and *Ceratophyllum demersum*) in the ponds. For some ponds, formerly extinct plant species reappeared (e.g. *Potamogeton natans, Sparganium emersum*). Within a period of five years population densities of the formerly dominant fish species *Rutilus rutilus, Abramis bramis* and *Cyprinus carpio* remained low, while densities of *Esox lucius* strongly increased.

Reintroduction of *Stratiotes aloides* appears to be very successful but only when reintroduced in specific cages, which indicates the predicted suitable water quality for this species. The less successful reintroduction of non-caged plants points to the presence of mechanic disturbance, likely predation by *Fulica atra* or the exotic species *Branta canadensis*. The latter is present in large numbers and has a very negative impact on the restoration of aquatic and other Natura 2000 habitats, especially the expansion of several target species.

The area is a regional hotspot for dragonflies. After restoration the numbers of some threatened species increased considerably (e.g. *Coenagrion pulchellum, Erythromma najas, Cordulia aenea*). Previously extinct and threatened species such as *Aeshna isosceles* and *Brachytron pratense* are occasionally observed. Whether they have already established a breeding population remains unsure though.

Abiotic conditions

An extensive physicochemical study was carried out to investigate whether the abiotic conditions allow successful pond restoration and to test the effects of changing water quality. Sediment, sediment pore water, surface water as well as ground water was sampled and all relevant chemical parameters were determined. Results of this study demonstrated that the area has very high natural concentrations of most nutrients, especially phosphate. However, overall nutrient availability is only determined by the phosphate fraction that is not complexed with iron molecules. Nutrient leaching from agricultural neighbouring areas lowers the iron availability and may as such result in eutrophication.

Other lessons learned

- Effects of pond restoration may greatly fluctuate between years and ponds.
- Hydrological isolation appears to be a prerequisite for successful restoration.
- Reintroduction of *Stratiotes aloides* is probably only successful if the species is released in large numbers to reduce individual plant predation pressure by waterfowl.

Future points of attention for sustainable results

- The large numbers of *Branta canadensis* are a treat to sustainable results and need a persistent management plan to remove the whole population. The Flemish government should take a coordinating and implementing role in collaboration with necessary partners.
- Removal of planktivorous and benthivorous fish species probably needs to be continued, for example once every five years as a cyclical management measure. Close monitoring of the evolution of every pond will be necessary.

Public support

Communication towards several stakeholders is an important part of the restoration project (information activities to local government, guided visits, etc.). This was especially important for the replacement of local angling clubs to artificial ponds.

References

De Beelde T., Smolders F., Hendrickx F. & Bogaert D. (2007).

In the peat ponds of the Damvallei carps and other benthivorous or planktivorous fish were removed in collaboration with local fish clubs. Afterwards Pike was restocked and locally *Stratiotes aloides* was reintroduced in the hope that the typical pond communities would be re-established.

Starting conditions

Poplar plantations and abandonment or intensification of agriculture practice were responsible for the deterioration and disappearance of species-rich alluvial and groundwater fed grassland types throughout the valley. Until around 1950 these grasslands were well known for their large numbers of rare species such as *Orchis morio, Silaum silaus, Briza media, Succisa pratensis* and *Dactylorhiza fistulosa*.

Restoration measures

2003-2008	– Removal of c.15ha of poplar stands. – Restoration of c.15ha old abandoned grassland and transition mire by tree and scrub removal. – Removal of waste material and nutrient enriched top layer of the soil on c. 1ha. – Restoration of the original hydrology by dredging c. 500m of silted ditches.

Objectives	Management measures
Restoration of structure-rich alder forest, transition mire and *Arrhenatherion*, *Eu-molinion* and *Nardetalia* grasslands.	Mowing once or twice each year.

Poplar plantations and invasive willow scrub were cleared for the restoration of low productive wet grasslands and transition mire. On the soft, peaty soil special machinery is used for the mowing and removal of the cut material.

Evaluation

Species/communities

Although the restoration project is not finished yet, the first results of restoration measures indicate a successful recovery of the originally present habitats and many of the target species:

- *Menyanthes trifoliata*: strong increase of the relict population;
- *Pedicularis palustris*: after an exponential increase, several populations disappeared (now only a few left);
- *Dactylorhiza fistulosa* and *Dactylorhiza maculata/fuchsia*: both species colonised new places;
- *Potamogeton natans, Hydrocharis morsus-ranae, Myriophyllum spicatum, Groenlandia densa*: after dredging the ditches, these species colonised the new open water habitats; the last record of *Groenlandia densa* dates from the beginning of the 20th century;
- *Potentilla anglica/erecta*: locally disappeared, but also increase of the population in other places;
- *Ranunculus lingua* and *Valeriana dioica*: very strong population increase of both species;
- *Silaum silaus*: local, small population status-quo;
- *Rhinanthus angustifolius*: exponential expansion throughout the whole project area;
- *Senecio aquaticus*: small variations yearly;
- Reappearance of many rare and threatened species from the seed bank: e.g. *Carex caryophyllea, Carex demissa, Carex flacca, Carex panicea, Carex vulpina, Polygala vulgaris, Cuscuta epithymum, Luzula multiflora, Potentilla erecta* and *Viola canina*.

Other lessons learned

- Restoration of grasslands from former poplar stands or abandoned grassland appears to be much more successful compared to restoration of intensively used agricultural grasslands.
- A second mowing in September gives better results for the development of the target grassland types and is necessary for many target species.

Future points of attention for sustainable results

Ensure long term management of grasslands by setting up suitable haying equipment is of great importance to maintain these habitats. Within the LIFE-project, a specific low pressure 'soft track' device was purchased.

Public support

Successful collaboration with local farmers could be achieved for sustainable grassland management in the driest parts of the area.

Menyanthes trifoliata is one of the target species in the restoration of few meadows and transition mire in the Damvallei

16. Heidebos (Wachtebeke, Moerbeke)

Jan Van Uytvanck (INBO) & Gert Ducheyne (Natuurpunt)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: Province of Oost-Vlaanderen, Agency for Nature and Forests

Ecosystem type

Dry woodland-heathland complex on sandy inland dunes in the ecoregion of Pleistocene river valleys (c. 250ha).

Restoration measures, objectives and results

Starting conditions	
± 50ha of former ungrazed heathland were planted with or invaded by the invasive *Prunus serotina* during the past decades. In the same period forest management included monocultures of *Pinus nigra laricio* (3ha) and *Picea abies* (5ha).	
Restoration measures	
1996-2008	Active control of *P. serotina* and phased logging of the coniferous stands are up to now important conversion measures. A small Galloway cattle herd was introduced in the area (90ha).
Objectives	**Management measures**
Restoration of dry heathland and Birch-Oak woodland with typical bird communities.	- Cutting of trees and manual removal of seedlings of *P. serotina*. - Year-round grazing management (± 0.1 AU $ha^{-1}y^{-1}$).

Evaluation

Species/communities

- Mainly regeneration and increase of dry heathland and dry oligotrophic grasslands with an increase of the common but typical species *Calluna vulgaris*, *Carex pilulifera, Jasione montana* and *Ornithopus perpusillus. Filago minima* and *Juncus squarrosus* are newly established species. The previously disappeared bird species of open woodland types *Caprimulgus europaeus* and *Anthus trivialis* breed again. Population size of the thermophilous heathland grasshoppers *Chortippus mollis* and *Myrmeleotettix maculatus* increased.
- Natural regeneration in logged woodlands has started with *Quercus robur, Betula pendula, Frangula alnus* and *Sorbus aucuparia*.

Abiotic conditions

Unchanged, however more open, thermophilous conditions were created.

Other lessons learned

Grazing by large herbivores could not really “follow” the newly created open landscape types after logging and conversion. So, species-rich short grazed grassland types may come under pressure with encroachment of shrubs and trees. Probably the collapse of the rabbit population during the past decade could not be compensated by the introduction of the cattle herd. An increase of grazing pressure and the introduction of other herbivores, such as horses or goats, with a different foraging behaviour and diet (including wood) will be needed.

Future points of attention for sustainable results

Prunus serotina control needs long term planning and a persistent effort.

Public support

In the beginning, local inhabitants feared new restrictions in accessibility and actively objected to the creation of a nature reserve on the former inaccessible hunting ground; ten years later some inhabitants fear too large crowds during the weekend.

Pine plantations are successfully transformed in open Birch-Oak woodland with dry heathland and inland dune vegetations.

Thanks to the transformation measures the Nightjar breeds again in the area.

Persistent eradication of invasive *Prunus serotina* is essential to provide opportunities for the target heathland and dry grassland communities.

Starting conditions	
Arable land and intensively used grasslands	
Restoration measures	
1997	± 10ha of former agricultural land (without top soil removal) were included in a grazing block of ± 90ha with adjacent woodland and heathland, which is year-round grazed by a small Galloway cattle herd year-round.

Objectives	Management measures
Development of a mosaic with oligotrophic dry grassland, heathland and Birch-Oak woodland.	Year-round grazing management (± 0.1 AU $ha^{-1}y^{-1}$).

Evaluation

Species/communities

On former arable land, mainly open woodland with *Betula pendula* and dry grassland species (see above) developed. Development on former grassland is much slower, where the grassland sward inhibits the establishment of tree and scrub species. Furthermore, *Senecio jacobea* behaved as an invasive species on former agricultural land.

Abiotic conditions

Nutrient levels of nitrogen in the topsoil decreased very fast on former arable land in the first years after abandonment; this was not the case in grassland. Phosphorus levels remained high in both grassland and arable land. Nutrient limitation should focus on nitrogen to create low productive grasslands. Year-round grazing may fail in reaching this aim.

Spontaneous succession under extensive grazing management on former arable land without topsoil removal provides faster and better results than the same treatment on former agricultural grassland.

17. Stropersbos (Stekene, Sint-Gillis-Waas)

Inge Vermeulen (VLM)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Supporting authorities: EU (LIFE); Flemish Land Agency (land development for nature project); municipalities of Stekene and Sint-Gillis-Waas

Ecosystem type

Alluvial forest, inland dunes and heath (c. 100ha) in the sandy district of the northern part of the province of Oost-Vlaanderen (ecoregion of Pleistocene river valleys).

Restoration measures, objectives and results

Starting conditions	
Coniferous plantations on former heathland and inland dunes.	
Restoration measures	
2004-2005 2007-2008	Following some experiments in 2004-2005 a total surface of 17.5ha of coniferous plantation was logged in 2007-2008. All top soil was removed. The sites where chosen because they were adjacent to remnants of still existing heath and inland dune vegetations with target species such as the Field Cricket (*Gryllus campestris*). In 2009 the water level of the area shall be restored to its historic level.
Objectives	**Management measures**
Restoration of mosaics of wet and dry heathland, *Corynephorus* and *Agrostis* grasslands, *Nardus* grassland and transition communities to (mixed) deciduous forest and scrub.	A combination of year-round or seasonal natural grazing by sheep and horses, locally supported by additional mowing and cutting back of unwanted scrub development.

Evaluation

Species/communities

A few months after the deforestation *Calluna vulgaris*, *Carex pilulifera* and *Juncus squarrosus* already regenerated from a viable seed bank and breeding of *Lullula arborea* was observed. Thorough evaluation will only be possible after the completion of the restoration works by the end of 2008.

Future points of attention for sustainable results

The area will need close monitoring to respond to excessive growth of young trees such as birch, ferns (*Pteridium aquilinum*) and Blackberry. The management will need constant fine-tuning.

Ongoing or future restoration measures in the area

- 90ha of mainly degraded or even disappeared mesotrophic alder swamp forest will be restored by reinstalling the original hydrological conditions as much as possible. An ecohydrological model will be used to build 39 ground dams in 2008-2009 in strategic places in the artificial network of ditches in order to raise the level of the ground water up to the root zone of the trees. An intensive monitoring campaign is programmed for the period 2009-2014.

- Over a period of 27 years an area of 90ha with mainly monotonous coniferous forest plantations will be converted to acidophilous oak wood with an increase of forest structure diversity and active removal of exotic invasive species such as *Prunus serotina*.
- A surface of 45ha of former intensive agricultural land will be converted into wooded pasture with a mosaic of open and closed habitats in a ratio of about 25/75. At the same time the increase of the surface of deciduous forest is a compensation measure for the loss of forest due to restoration of open habitats elsewhere in the project area.
- About 8km of woodland alleys in the area will be widened to increase sunlight and to stimulate the development of species-rich woodland edges and grassland verges. The woodland edges will be managed as coppice and cut every five years; the grassland verges will be grazed by sheep or mowed once or twice a year.

Public support

Thanks to an intensive information campaign people understand why so many coniferous plantations are deforested and that this is done with respect for the already present valuable species and habitats.

Stropersbos is one of the last strongholds of *Gryllus campestris* in the western part of Flanders. It is a target species for the restoration project.

Experimental plot dominated by *Calluna* after 3 years of succession without management, following the clearcutting of a conifer plantation with topsoil removal in 2004-2005.

18. Gulke Putten (Wingene)

Eckhart Kuijken (Ghent University, INBO) & Christine Verscheure (Natuurpunt)

Natura 2000 area: Yes

Management authority: Natuurpunt

Supporting authorities: EU (LIFE), Ministry of Defence, Flemish government

Ecosystem type

Relict landscape of the late medieval heathlands, representing the *intermediate Atlantic heath systems* on acid sandy soils with local seepage. The small core area with species-rich vegetations is dominated by *Erica tetralix*, *Molinia caerulea*, *Sphagnum* spec., many *Carex* species such as *C. binervis* and on drier parts *Calluna vulgaris* and *Nardus* grasslands are important. Other parts of this reserve are former heathlands under coppice woods and young forest (basically *Querco-Betuletum*, but with many exotic species); grassland zones were partly abandoned, partly intensively manured by agriculture. Recently some mixed wood plantations on former heath have been included in the reserve which thus represents a varied mosaic with historical landscape patterns. The area is located in the Cuesta ecoregion of the Flemish sandy area (c. 100ha).

Restoration measures, objectives and results

Restoration measures	
1969-1975 until present	– Within the Radio Sending Station at Wingene, established in 1923, an agreement was reached in 1969 to manage a unique relict parcel (1.25ha) of wet 'Atlantic' heathland as a nature reserve. Cyclic small scaled sod-cutting is done to maintain pioneer vegetations. – Also 14.5ha of coppice woods in drier types of former heath (*Calluna, Molinia*) became part of the reserve. Parts of these woods have been transformed into the original heathland by logging and local sod-cutting. – Many woody parcels are separated by alleys or corridors of nutrient-poor grasslands which were mown annually in view of the dense antennae park and especially to prevent burning risks. In 1975-1980 most sending installations were abandoned and since then the mowing management was continued for conservation. Strips of c. 5m on both sides of the alleys were clear-cut to reduce shadow. On wet spots local sod-cutting is executed to restore wet heathland pioneer vegetation. In the coppice woodland invasive exotic tree species are eradicated.

Objectives	Management measures
Conservation and expansion of species-rich wet heathland and *Nardus* grassland; development of *Querco-Betuletum* forest	- Mowing of the nutrient-poor grasslands and parts of the Erica-heathland in July-September. - Cyclic removal of scrub re-growth in the heathland every 2-5 years. - Local cyclic cutting of coppice wood. - Natural succession of parts of the woodland towards older mixed forest types.

Evaluation

The continued 'intensive care' of the wet heathland parcel in the seepage zone is successful. In spite of the surrounding intensive agriculture, several rare species survive such as *Narthecium ossifragum, Carex binervis, Pedicularis sylvatica, Lycopodiella inundatum, Eriophorum polystachion, Eleocharis multicaulis, Drosera rotundifolia* and *D. intermedia*, etc. Patches of stagnant rain water cause a local deterioration of the *Sphagnum* layer (replaced by *Carex panicea*). Small natural windbreaks stimulate occurrence of special insects. Some rare species (*Rhynchospora alba*) have returned, probably not permanently, but *Viola lactea* has disappeared. A permanent problem is the high nitrate levels of seepage water (from agricultural zones on the top of the cuesta) and the intensive atmospheric deposition causing acidification and fertilisation.

Thanks to the mowing regime all open areas and corridors developed to species-rich acid grasslands (*Nardo-Galion*) with abundant *Dactylorhiza maculata, Succisa pratensis, Polygala serpyllifolia, Potentilla erecta, Nardus stricta, Sieglingia precumbens, Calluna vulgaris* etc.; this is also the habitat of *Botrichium lunaria*. Exceptionally high numbers of fungi with 14 *Hygrocybe* species occur and relict populations of rare butterflies such as *Pyrgus malvae* and *Callophris rubi* survive as well. *Lacerta vivipara* is still common. Most of the *Nardus* grasslands in the alleys react positively when shadow of surrounding trees, coppice and shrub is removed; this also has positive effects on their use as corridors for butterflies. Sod-cutting of *Molinia* dominated grasslands is most successful with restoration of pioneer vegetations of *Drosera, Lycopodiella inundatum, Polygala serpyllifolia*, etc.
The heathland patches in the former woodland have also ornithological interest (a.o. *Anthus trivialis* breeding).

Public support

As public access to the Radio Sending Station is not allowed, guided visits are organised by Natuurpunt. Parts of the newly acquired woodlands are opened for visitors along alleys (sign-posted trails), which increase the public and political support for this nature reserve with international protection status.

References

Stieperaere H., Verscheure C. & Kuijken E. (2005).

General view of the Gulke Putten nature reserve within the domain of the Radio Sending Station (white building), with wooded area, heathland relicts and grasslands; far left is 30ha of forest acquired by Natuurpunt as extension of the reserve. Corridors of the former antenna park need cutting down of trees and coppice to prevent shadow and to maintain *Nardus* grassland strips. Small-scale restoration of heath in clear-felled areas is successful, especially after removal of the thick humus layer or sod-cutting.

Annually volunteers realise small scale sod-cutting in a wet heathland parcel (*Ericetum* with *Narthecium ossifragum, Pedicularis sylvatica, Eriophorum vaginatum* etc.) to prevent overgrowing by *Molinia, Betula, Salix,* etc.

Regrowth of pioneers on wet sandy soil, such as *Drosera rotundifolia, D. intermedia, Lycopodiella inundatum, Pedicularis sylvatica* and *Sphagnum* spec.

Starting conditions	
In 1998 new concessions gradually enlarged the managed area of the Radio Sending Station to 16.5ha and in 2001 to 69ha. These zones also include different habitat types, mainly species-poor *Lolium-Holcus* grasslands that were intensively used and over-manured by agriculture until 2001 (ca 30ha for silage).	
Restoration measures	
1998 until present	– Intensive mowing aims at the restoration of flower-rich meadows (*Lychnis flos-cuculi, Cardamine pratensis, Ranunculus flammula, Dactylorhiza maculata, Juncus acutiflorus*, etc.). – Some 20ha were abandoned after sheep grazing stopped in the 1970s; in former *Agrostis* and *Molinia* dominated grasslands *Querco-Betuletum* elements and shrub of *Salix* spec. and *Rubus* spec. developed (10ha). Here year-round grazing with cattle and local sod-cutting is done to restore the late medieval wastelands ('wooded pastures') with patchy mixture of species-rich grassland, heath and shrub.
Objectives	**Management measures**
Restoration of flower-rich meadows and 'wooded pastures' (mosaic of species-rich grassland, heath and shrub).	- Intensive mowing of former manured grasslands to decrease nutrient levels (2x/y), followed by seasonal grazing from mid-September until early February. - Former sheep pasture: year-round grazing with Galloway cattle (1 on 2ha)

Evaluation

The extension of the nature reserve in the Radio Sending Station from 15 to 69ha prevented further over-manuring of the grasslands, which tend to restore successfully after 7 years of intensive management with drastic removal of nutrients (e.g. return of *Dactylorhiza maculata*).

The permanent grazing with Galloway cattle (18-25 animals on 40ha) has positive effects on opening the *Holcus*-felt layer by trampling, allowing germination of several interesting species from the seed bank (*Scutellaria minor, Calluna vulgaris, Dactylorhiza maculata, Hydrocotyle vulgaris, Illecebrum verticellatum* etc.). Also *Cytisus scoparius* reacted explosively. The vegetation structure changed to a patchy open landscape with mixed grasslands, heath elements, shrub and young trees. The grazing is not yet sufficient to suppress dominance of a closed *Juncus effusus* vegetation; however, along the spontaneous trails some interesting species are probably transported over considerable distance within the poorer *Lolium-Agrostis* grasslands (e.g. *Scutellaria minor, Potentilla erecta* etc.).

Former grasslands under the abandoned antennae developed to *Salix*, *Betula* and *Quercus* shrub; grazing by Galloway cattle caused massive growth of *Cytisus*, resulting in a varied mosaic landscape (cfr. late-medieval 'wastines').

Starting conditions	
Adjacent to the reserve 30ha of mixed forest stands scattered between agricultural land were acquired in 2002. Stands of *Larix, Pinus* and *Populus* have undergrowth of *Rubus* spec. and *Querco-Betuletum* elements. The botanical interest is mainly situated in a small brook with *Apium inundatum* and *Potamogetum polygonifolius*. Also the Fagus-alleys have good potential as a source for the restoration of heath vegetation. Historical maps indicate the presence of the same late medieval wilderness (wooded pastures) and some fishponds.	
Restoration measures	
2006-2008	Parts of these forest stands were logged in 2006 (3x 1ha as a first stage) and sod-cut afterwards (finished in 2008). Restoration of shallow ponds near the brook was started in 2008. In the forest conifers and exotic species have gradually been eliminated.
Objectives	**Management measures**
Restoration of heathland and *Querco-Betuletum* forest	– Eradication of invasive exotic species – Cattle grazing (in the future)

Evaluation

Fast *Calluna vulgaris* germination from the seed bank was observed in the sod-cut area. Also the restoration of ponds on the historical location of former water bodies is hopeful, as rare water vegetation (*Apium inundatum*) occurs in the brook at short distance; this and other aquatic species increased considerably after logging of surrounding trees (light!). Extensive cattle grazing of the forest is planned after revegetation of sod-cut parcels has been stabilised; this will reduce the dominance of *Rubus* undergrowth of former plantations.
This part of the reserve has also ornithological interest (*Strix aluco, Falco subbuteo, Dryocopus martius, Sitta europaea*, etc.).

Left: Clearance of trees and shrub with removal of humus layer and roots: small-scale management by young volunteers in the domain of the Radio Sending Station (2005). Right: Resulting vegetation with restoration of a pool surrounded by *Erica tetralix*, *Calluna vulgaris*, *Juncus* spec., *Carex,* spec. etc. (same spot 2008).

19. Maldegemveld (Maldegem)

Tom De Beelde (Natuurpunt)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: EU (LIFE)

Ecosystem type

Species-rich, intermediate Atlantic heathland system with a temporary high level of ground water in a historical 'wooded pasture' area in the sandy part of Flanders (Cuesta ecoregion, c. 85ha).

Restoration measures, objectives and results

Starting conditions

Since the 17th and 18th century forest plantations, drainage and reclamation for agriculture were responsible for the almost total loss and degradation of the Maldegemveld: a huge dry and wet heathland area, traditionally extensively grazed by cattle and sheep.

Restoration measures

1999-2003	– 16ha of mainly 20-60 year old larch and pine plantations were logged on a site that has been under woodland cover since 1875. Afterwards 8ha of top soil at the site was removed and the area was rewetted by reshaping the network of small ditches. – A former weekend cottage with an artificial fish pond was reshaped into a more natural shallow pool. – More than 5ha of *Pinus sylvestris* plantations were thinned for the creation of open habitats.

Objectives	Management measures
Restoration of the specific 'intermediate Atlantic type' of Annex I habitats, especially wet heaths with *Erica tetralix*, dry heaths and species-rich *Nardus* grasslands. These habitats are quite exceptional in phytogeographic terms because many typical species are here at the north-eastern border of their geographical distribution.	The restoration site is part of a plot of 33ha with summer grazing by Galloway cattle, thus restoring the traditional 'wooded pasture' practice. Additional mowing may be necessary on an irregular basis to keep a desirable ratio of woodland and open habitats.

An artificial fish pond and dilapidated weekend cottage were transformed into a more natural pool in a more open landscape.

Evaluation

Species/communities

Colonisation of target species from the seed bank proved to be very successful. *Calluna vulgaris* germinated massively and now dominates the dry heathland. Also the locally rare *Ulex europeaus* reappeared. On the more wet and peaty soils colonisation was observed of *Juncus squarrosus, Erica tetralix, Drosera intermedia, D. rotundifolia, Lycopodiella inundata, Eleocharis multicaulis, Potentilla erecta, Carex panicea, C. demissa, C. echinata* and the locally very rare *C. binervis* and *Genista anglica*. *Myrica gale* was found as well. In response to the rewetting of the site, *Sphagnum* mosses are expanding.

The newly shaped pool attracted several notable dragonflies such as *Ischnura pumilio, Lestes barbarus, Lestes virens, Gomphus pulchellus* and *Sympetrum danae*, besides the uncommon newt *Triturus helveticus*. In the newly developed heathland a large population of *Lacerta vivipara* established, while *Lullula arborea* and *Caprimulgus europaeus* are rare breeding birds.

Other lessons learned

- The viability of the seed bank proved to be much larger under forest plantations than under fields in agricultural use. For effective restoration of heathland habitats young and unnatural plantations deserve the first attention to investigate future restoration prospects by deforestation and top soil removal.
- The first years after top soil removal there was massive encroachment of young trees (mainly birch) and bramble scrub. Grazing management could not prevent this process of spontaneous woodland development and was backed up by selective mowing.

Future points of attention for sustainable results

- Atmospheric nitrogen deposition is very high in the region, mainly due to intensive agriculture. It forms a source of eutrophication, endangering the maintenance of the necessary habitat quality.

The results of the restoration project in Maldegemveld had an exemplary function for other projects elsewhere in the region to restore wooded pasture communities on former afforested heathland areas. However, additional cutting of scrub is periodically necessary to keep a desirable ratio of woodland and open habitats.

Larch and pine plantations before the restoration project.

Considering the amount of germination of *Calluna* and other target species the importance of sod cutting (foreground) for the restoration of heathland is obvious, compared to spontaneous succession (background), both under extensive grazing management.

- It is known that acidic soil circumstances may hamper germination of seeds from the seed bank in heathland restoration projects. Small scale liming experiments are actually undertaken to find out whether this could be a useful measure in future top soil removal actions.
- The area is still very small for the conservation of sustainable populations of endangered plants and animals typical for this kind of habitat. Enlargement of the area is crucial to enable the restoration of the natural hydrology of the area as well.
- The further development of the vegetation will be continuously evaluated for the necessity of additional mowing management against too much encroachment of open habitats by trees or bramble scrub.

Public support

In the beginning there were some negative reactions on the deforestation (although unnatural plantations of pinewood) and top soil removal. Eventually the project became a reference for similar heathland restoration projects in other parts of Flanders. After the successful regeneration of heath, visitors are very enthusiastic about the results of this restoration project.

20. Bos t' Ename (Oudenaarde)

Jan Van Uytvanck (INBO) & Guido Tack (Natuurpunt)

Natura 2000 area: yes

Management authorities: Natuurpunt, Flemish Agency for Nature and Forests

Supporting authorities: EU (LIFE)

Ecosystem type

Mosaic of mesophilous ancient forest and former intensively used grassland and arable land on loamy soil in the South-western hills ecoregion (c. 150ha).

Restoration measures, objectives and results

Starting conditions	
The forest site was surrounded by intensively used agricultural land.	
Restoration measures	
2004-2008	From 2004 on c. 25ha of forest is grazed together with adjacent former agricultural, manured grasslands (c. 25ha) and former arable land (c. 15ha) (no topsoil removal). Some smaller parcels develop spontaneously without grazing.
Objectives	**Management measures**
Spontaneous woodland expansion, mainly steered by large herbivores.	Low intensity grazing by a small cattle herd of 10-14 animal units and two Konik horses.

Early succession of former arable land on loamy soil with extensive cattle grazing (right) and without grazing exclosure (left).

Evaluation

Species/communities

Woodland expansion is concentrated on former arable land. Interaction between large herbivore grazing and spontaneous regeneration leads to young open forest types dominated *by Salix caprea* and *Betula pendula* in a grassland matrix. Growth forms of the palatable *Salix caprea* are scrubby and low due to heavy browsing, but more and more trees are growing beyond the browsing line after 4 years. In grassland, woodland regeneration is almost restricted to forest edges. Mainly unpalatable species such as *Alnus glutinosa* and *Populus canescens*. In smaller parts scrub species such as *Rubus* spec. and *Crataegus monogyna* established.

Abiotic conditions

Unchanged

Other lessons learned

Apart from woodland expansion aims, cattle grazing is a good measure to control expanding bramble understorey in forests. In late winter-early spring, the cattle herd forages on bramble understorey in the forest. 4 years of grazing reduced bramble cover by c. 50%. However, large vernal flowering stands of *Hyacinthoides non-scripta* and *Anemone nemoralis* may be negatively influenced by large herbivore activities. Their cover and flowering decreased. Evergreen species such as *Vinca minor* and *Hedera helix* have disappeared from the grazed forest parts. It is suggested that low or moderate grazing pressure should be maintained or that intermittent periods of non-grazing should be provided to maintain ancient forest ground flora.

Public support

Still quite unique for the Flemish nature conservation scene is that the management of the forest is successfully done with strong participation of the surrounding inhabitants, instead of the more traditional collaboration with naturalist volunteers from the NGO Natuurpunt. For instance the wood harvest from the coppicing goes to the local people who are well motivated to help with the management and consider Bos t'Ename as "their forest". This local network provides a very strong public and political support for the increase and the management of the nature reserve.

Woodland colonisation on former agricultural grasslands on loamy soil under extensive grazing goes much slower.

21. Kalmthoutse Heide: Biezenkuilen (Kalmthout)

Geert De Blust (INBO)

Natura 2000 area: yes

Management authority: Agency for Nature and Forests

Ecosystem type

Complex heathland with shifting dunes, dry and wet heath and moorland pools in the Campine Ecoregion (> 1,000ha).

Restoration measures, objectives and results

Starting conditions	
The 'Biezenkuilen', a moorland pool of 3ha, acidified and rich in ammonium and dominated by *Juncus effusus*, had lost its typical vegetation.	
Restoration measures	
1991-1996	After temporary draining of the pool, *Juncus effusus* and accumulated mud was removed.
Objectives	**Management measures**
Restoration of vegetations of oligotrophic lightly buffered pools (*Littorelletalia* communities).	Once-off mowing of *Juncus effusus* immediately after the restoration.

The objectives for the restoration of the Biezenkuilen moorland pool were chosen without prior investigation of the natural abiotic conditions of the site. After the restoration project it became clear that the wrong objectives were chosen.

Despite the restoration works *Juncus effusus* remained the dominant species in large parts of the site.

Evaluation

Species/communities

- Immediately after the cleaning of the moorland pool in 1991, *Juncus effusus* established from seeds all over the moorland pool. Prior to the rise of the water table, *J. effusus* was mown. Afterwards, the species remained only on the higher shore of the pool.
- Target species, such as *Hypericum elodes, Potamogeton polygonifolius* and *Eleocharis multicaulis* germinated the year after the restoration and established at several sites. After 2 to 4 years however, most species disappeared again; except for *E. multicaulis*. 10 years later, overgrown by *J. effusus*, also this species was lost.
- The project was not successful. The main reasons were that not all mud and *Juncus effusus* rhizomes could be removed and that acidification started again because of lack of buffers. Indeed, the pool is situated in an acid cover sand area and is rain fed. The former presence of *Littorelletalia* communities depended on the temporary inflow of surface water coming from a nearby pasture reclaimed in the heathland. Today, that pasture is no longer fertilized or limed.

Abiotic conditions

Before the restoration, pH of the water was very low (4.2.) Immediately after the cleaning pH increased to 5.4 but then dropped again below 5.

Other lessons learned

The main lesson learned was that one has to be very careful in choosing the right reference situation and target and that it is of the utmost importance to have precise knowledge of the environmental conditions during the time the reference communities were present. In this case, the presence of the *Littorelletalia* vegetations was only temporary and coincided with the period that the pool was influenced by the drainage water of the pasture. That water supplied buffers but also nutrients to the pool. A detailed analysis of diatoms collected from two mud cores, proved that before the reclamation of the pasture in 1923, the moorland pool was dystrophic and had no *Littorelletalia* vegetations at all. Some decades after that reclamation, a willow thicket developed between the pasture and the pool, blocking the shallow draining ditches. In the mean time, nutrients had accumulated in the pool that gradually acidified again.

References

Denys L. & De Blust G, (2007).

22. Turnhouts vennengebied: Zwart Water (Turnhout, Merksplas)

Tom Andries (Natuurpunt), Mario De Block (ANB) & Luc Denys (INBO)

Natura 2000 area: yes

Management authority: Natuurpunt (299ha) and Flemish Agency for Nature and Forests (35ha)

Supporting authorities: EU (LIFE), Agency for Nature and Forests and Flemish Land Agency (land development for nature project)

Ecosystem type

The project area mainly consists of wet heathland (21ha) and several moorland pools and is situated in a part of the Campine ecoregion where a clayey substrate underlies the Pleistocene cover sands at shallow depth. Special attention is given to the largest pool, the Zwart Water (5ha).

Restoration measures, objectives and results

Starting conditions	
From the 1960s onwards, *Littorelletalia uniflorae* and heathland communities deteriorated markedly, mainly due to acidification, eutrophication and afforestation.	
Restoration measures	
1987-2002	Since 1987 different actions were undertaken: – 3ha of sod cutting on *Molinia* dominated heathland. – Deforestation of 3.5ha of pine plantations followed by top soil removal, mainly with the intention to restore wind-driven turbulence in the pools and to increase superficial groundwater input. – Liming after sod cutting and top soil removal was carried out (1-1.5 ton/ha). No direct liming of the pond was applied. – Reintroduction of the butterfly *Maculinea alcon*.

Objectives	Management measures
Restoration of wet heathland, *Nardus* grasslands and oligotrophic pools with *Littorelletalia* communities.	Summer grazing by Galloway cattle.

Evaluation

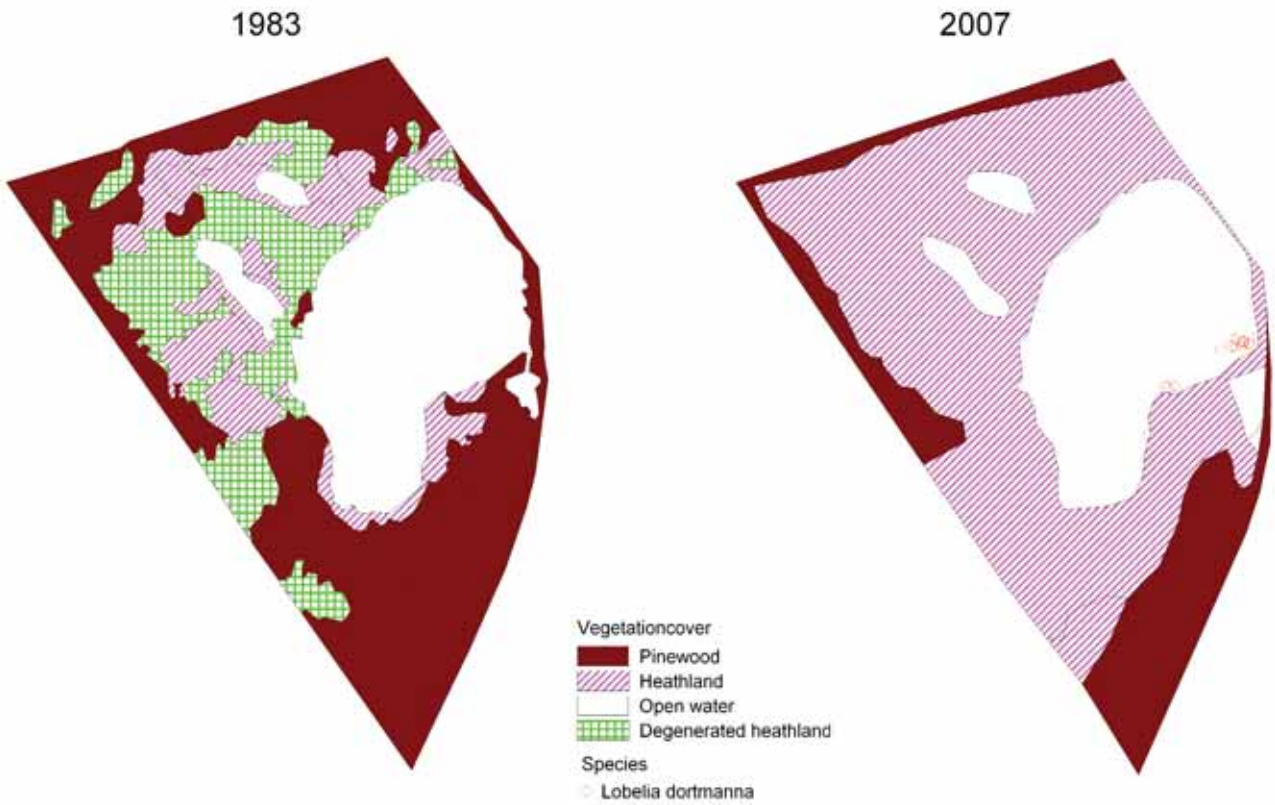
Species/communities

- Wet heathland and *Nardetalia* communities responded well to the measures with expansion of several target species (*Erica tetralix, Scirpus cespitosus, Gentiana pneumonanthe, Polygala serpyllifolia, Calluna vulgaris, Narthecium ossifragum, Rhynchospora alba, R. fusca* and *Eriophorum angustifolium*). The reintroduction of *Maculinea alcon* was successful.
- Species of buffered soft water (i.c. *Luronium natans, Sparganium angustifolium, Littorella uniflora, Eleocharis multicaulis* and *Hypericum elodes*) increased in the moorland pools. The small relic population of *Lobelia dortmanna* in the Zwart Water (0 to 20 plants per year between 1979 and 1999) also appears to grow (52 plants in 2007).

Abiotic conditions

- The successful germination of many target species after sod cutting indicates that liming increased the buffer capacity of the soil sufficiently to avoid ammonium toxicity.
- After clear cutting of the surrounding pinewood, the surface of bare sand providing suitable conditions for the establishment of *Littorelletalia* vegetations increased in the Zwart Water. Its pH rose to 4.7, and the bicarbonate concentration reaches 18mg/l.

Panoramic view (2005) of the central part of the Turnhouts Vennengebied, with the Zwart Water in the foreground. The eutrophied and slightly acidified Grote Klotteraard (background) is one of the other moorland pools to be restered in the next years, favouring *Littorelletalia* vegetations. Intensive agriculture in the surroundings may be a threat to achieve sustainable results in the long run.



Vegetation maps of the 'Zwart Water' in 1983 (Stieperaere & De Blust) and 2007. The occurrence of *Lobelia dortmanna* is shown; it only occurs in the north-eastern part of the pool where bare sand is present.

Other lessons learned

- Some grazing exclosures had to be made to prevent the grazing of *Gentiana pneumonanthe* and *Narthecium ossifragum*.
- Initial access of Galloways to the Zwart Water caused eutrophication and local damage to the vegetation and consequently had to be prevented.

Future points of attention for sustainable results

As the area is surrounded by intensive agriculture, atmospheric nitrogen deposition causing enrichment and acidification is still going on.

Ongoing and future restoration measures in the surrounding area

In the context of the LIFE project 'Large-scale Habitat Restoration in 'Turnhouts Vennengebied' (Life 06 NAT/B/000084) and the land development for nature project, moorland and heath restoration in the surroundings of Zwart Water are further investigated and effectuated. This already resulted in the recovery of about 30ha of mesotrophic *Alnus* woodland and oligotrophic pools with *Rhynchospora alba*. In 2007, measures were taken to restore 11ha of wet heath around the fens Zandven and Koeven.

The agenda for the coming years is set on the restoration of other ponds, fens and heaths in the area. The (a)biotic changes have been studied over several years in selected areas. Together with accurate geomorphological information, studies on hydrology, diatoms and seed banks and a geo-archaeological prospection, these data provide a solid basis for selecting appropriate measures, including the creation of buffer zones, deforestation, sod cutting, top-soil removal in former farmland, dredging of ponds and liming of infiltration zones.

Public support

Organising guided tours, implementing a network of volunteers and especially giving responsibility to local volunteers are key factors.

Temporary working lawn created with sod-cut material, near Zandven, in the centre of the Turnhouts Vennengebied (2008).

Maculinea alcon was successfully reintroduced. Locally, host plants for the caterpillars, *Gentiana pneumonanthe*, are protected from cattle grazing by exclosures.

Lobelia dortmanna responded very well to the increased wind dynamics on the pool, as a result of cutting down pinewood plantations surrounding the pool. Also, the surrounding heathland was limed to buffer the pool since 2000.

23. Olens Broek-Langendonk (Olen, Herentals)

Eddy Vercammen (ANB) & Geert De Blust (INBO)

Natura2000: Yes

Management authority: Agency for Nature and Forests

Ecosystem type

Complex brook valley of the Kleine Nete with mesotrophic fens, heathland and small-scaled agricultural land in the Campine ecoregion (c. 100ha).

Restoration measures, objectives and results

Starting conditions	
Peat diggings and wet meadows in the brook valley were threatened by desiccation and succession, increasing the dominance of species such as *Juncus effusus*, birch and willow thicket.	
Restoration measures	
1996-2008	Since 1996, 10ha of meadows, reed beds and ponds have been gradually restored by scrub removal, sod-cutting, raising the water level and resuming the mowing management.
Objectives	**Management measures**
Wet meadows with *Caricetalia nigrae* vegetations, reedbeds and wet tall herb vegetations.	- Ponds: periodical mowing of the banks. - Meadows: mowing twice a year. - Reedbeds and wet tall herb vegetation: cyclic removal of scrub encroachment.

Restoration of wet meadows with *Juncus filiformis, Carex rostrata* and *Carex lasiocarpa* in former peat diggings.

Wahlenbergia hederacea recolonised the site from the seed bank after local sod-cutting in 2000

Evaluation

Species/communities

- Immediately after the cleaning of the revegetated peat diggings and the clearing of the former meadows followed by the re-establishment of the traditional mowing regime, target species reappeared and spread considerably (e.g. *Carex lasiocarpa*, *C. rostrata*, *C. echinata, C. vesicaria* and *C. nigra*). *Wahlenbergia hederacea*, which was believed to be extinct in 1995, recolonised the site from the seed bank after local sod-cutting in 2000. Other interesting rare species include *Oenanthe fistulosa, Veronica scutellata, Rhinanthus angustifolius, Viola palustris, Comarum palustre* and *Lysimachia thyrsiflora*.
- Today reed marsh bird species such as *Acrocephalus scirpaceus, A. palustris, Luscinia svecica, Emberiza schoeniclus, Rallus aquaticus* and *Anas crecca* breed again in the area.

Abiotic conditions

Canalization and deepening of the brook in 1972 had a major impact on the hydrology in the valley. Therefore mitigating measures were implemented from 1996 onwards. First, weirs were installed to prevent the loss of surface and rain water. In 2006 a pumping-engine supplied water from the river to a number of ditches resulting in a decrease of the draining of the adjacent meadows. Today, formerly cut-off meanders are reintegrated in the river system and the water level in the river is raised by 50cm.

Other lessons learned

- Quite often, *Juncus effusus* becomes dominant the year after removing the top soil of former agricultural land. Mowing this sward late in the vegetation season, often done by hand, at the start or just before the winter inundations, led to a considerable decrease of the rush and a quick re-establishment of the species rich fen vegetations.
- An isolated meander that was cleaned in 2003, was invaded by *Azolla filiculoides* hindering the development of other aquatic vegetations. This species quickly spread in other eutrophic environments too. However, in most cases the plant disappeared again after 2 to 4 years.

Public support

Different actions were undertaken to ensure public support:

- Public acceptance was increased by providing a permanent nature trail;
- By spreading the restoration measures in time and space, opposition was anticipated;
- Stakeholders are involved in the practical management of the alder woods and the meadows are, as far as possible, managed by farmers and locals on the basis of management agreements.

Starting conditions	
The formerly open gradient from valley to higher land became wooded in the course of the years. Old grassland was turned into large scale corn fields.	
Restoration measures	
1996-2008	Starting from the woodland, c. 7ha of heathland and a number of levelled heathland pools and a sand dune elevation were restored. 4ha of maize fields were restored to small-scaled grassland, partly by removing 20-30cm of the top soil.
Objectives	**Management measures**
Dry and wet heath with oligo- to mesotrophic pools, acid grassland, *Myrica* shrub. Species rich grassland with cattle pools and hedgerows	Depending on the vegetation mowing every 1 to 2 years (heathland vegetations) or mowing followed by grazing by horses and sheep.

Evaluation

Species/communities

- Dry heath dominated by *Calluna vulgaris* developed quickly after deforestation and removal of the litter layer. Target species appeared such as *Genista anglica, Cuscuta epithymum* and *Filago minima*.
- After sod cutting, wet heath with *Erica tetralix, Lycopodiella inundatum, Drosera intermedia, Myrica gale* and *Sphagnum* species re-established.
- In the newly restored moorland pools typical species of nutrient-poor, slightly buffered water appeared: *Hypericum elodes, Pilularia globulifera, Scirpus fluitans, Potamogeton polygonifolius*.
- Clearing the woods and restoring the small-scaled agricultural landscape was also favourable for birds. The number of heathland and farmland birds (for instance *Anthus trivialis, Saxicola torquata, Acrocephalus palustris* and *Hippolais icterina*) increased steadily.
- Development of the grassland on former corn fields occurs slowly. However, the number of plant species increases considerably.

A former agricultural grassland (2004) was restored into the original heathland pool and sand dune elevations (2008).

Abiotic conditions

Species-rich acid grasslands are vulnerable for excessive acidification. Immissions from a nearby factory made it necessary to lime some of the reclaimed heathland parcels (Dolomite limestone, 1500kg/ha).

Other lessons learned

The historical landscape was used as the reference. Detailed studies of soil profiles are necessary in order to locate the former moorland pools, the former low dunes once used to level the pools and the buried seed banks. Restoring the old dune elevation with the original sand does not ensure re-establishment of the vegetation from the seed bank. So, freshly cut heather was spread.

4ha of maize fields (2003) were transformed into small-scale grasslands (2007) with ponds.

24. Buitengoor-Meergoor (Mol)

Mario De Block (ANB), Daniël Sanders (VLM) & Joost Dewyspelaere (Natuurpunt)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: Agency for Nature and Forests, Flemish Land Agency (land development for nature project)

Ecosystem type

A unique complex of wet and dry heathland, bogs and mires and marshy woodlands in the Campine ecoregion (90ha), with intrusion of lime, provided by superficial infiltration of eutrophic surface water from an irrigation ditch, connected to a nearby canal (dating from the mid-19th century and diverting lime-rich water from the Meuse basin to the river Schelde). The area is very famous for its large number of red list species: calcicolous or rich fen vegetations intersperse with oligotrophic and ombrotrophic vegetations, depending on horizontal (acidic to lime-rich circumstances) and vertical (hummocks/depressions) variations. *Caricion davallianae*, *Caricion nigrae*, *Junco-Molinion* and *Eu-Molinion* vegetations, with all possible transitions, are typical for a large part of the area.

Restoration measures, objectives and results:

Restoration measures	
2004-2005	The restoration measures were focussed on: - Prevention of occasional flooding with eutrophied water from the canal (by construction of a water distribution device on the irrigation ditch) and removal of 0.75ha of eutrophied top soil in the occasionally flooded zone. - Removal of about 4ha of scrub (willows, birch, *Myrica gale*) and monospecific *Molinia* vegetation with top soil removal in favour of *Caricion davallianae* communities and their gradients to alkaline fen and transition mire. - Logging and top soil removal of about 4ha of *Pinus sylvestris* plantations on higher grounds and filling up of artificial drainage ditches with sod-cut material. - Installation of weirs to allow for proper water level management. - Dredging of some old peat-cuttings or digging of new pools, re-allowing natural succession and improving conditions for amphibians and a rich dragonfly fauna (Meergoor). - Reshaping banks of ditches and of the Vleminksloop with more gradual slopes over some 1500m. - Building about 2km of new public tracks through the area to avoid damage by visitors to vulnerable habitats and to prevent access of motorized vehicles from a nearby recreational area. - Neutralizing a fish migration barrier in the Vleminksloop by installing a boulder construction. - About 900m^3 of soil material from the restoration works was re-used to reshape the banks of a sand quarry in the vicinity of the area.

Objectives	Management measures
Enlarging and improving the quality of oligotrophic waters with *Littorelletalia uniflorae* communities, water courses with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation, wet and dry heaths, *Nardus* grassland, transition mires and quaking bogs, *Rhynchosporion* vegetations, calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*, alkaline fens and mesotrophic alder forests.	No management; local scrub removal and sod-cutting; summer grazing by Galloway cattle (Meergoor).

Evaluation

Species/communities

The restoration works are especially important for the increase and quality improvement of the present *Caricion davallianae*, *Caricion nigrae*, *Junco-Molinion* and *Eu-Molinion* communities and their transitions to bogs and wet heath. It is hoped that the works will be beneficial for rare, typical plant species, such as *Carex dioica, Juncus alpino-articulatus* subsp*. arthrophyllus, Eleocharis quinqueflora, Hammarbya paludosa, Dactylorhiza sphagnicola* and *Utricularia intermedia,* amongst the more than 360 other vascular plant species that have been observed in the area, next to about 220 species of bryophytes, 244 spider species, 14 red list dragonflies and 5 red list butterflies.
Because the measures were taken only very recently and succession is slow in nutrient-poor conditions, only some preliminary results can be presented:

- The germination of *Carex dioica* and *Eleocharis quinqueflora* illustrates the development of typical calcicole *Caricion davallianae* vegetations dependent on nutrient-poor, neutral to alkaline conditions.
- *Scorpidium* mosses pioneer stands of fen brown-moss communities.
- Locally abundant germination of *Equisetum variegatum* (only location in Belgium outside the coastal region), *Pilularia globulifera* and *Cladium mariscus.*
- *Calluna vulgaris* and *Erica tetralix* rapidly re-colonised target stands of dry and wet heathland.
- *Lycopodiella inundata*, *Rhynchospora alba*, *Rhynchospora fusca*, *Drosera rotundifolia* and *Drosera intermedia* abundantly germinate, showing evidence of successful pioneering phases of lowland heathland and *Rhynchosporion*.
- Target areas for wet heathland and *Eu-Molinion* vegetations show a increase of *Gentiana pneumonanthe*, *Centaurium erythraea*, *Narthecium ossifragum* and *Anagallis tenella.*
- Abundant occurrence of *Eleocharis acicularis* and return of *Hydrocharis morsus-ranae* were observed after removing trees and shrubs down the shores of the Rosse Put (Meergoor).
- Aberrant species like *Berula erecta*, *Carex pseudocyperus*, *Lycopus europaeus* and *Iris pseudacorus* almost integrally disappeared from the formerly eutrophied zones in the Buitengoor.

Recent investigations on water macrofauna underlined the specific richness of the area in terms of gradients in transition mires and lagg fen shorelines, also at the central sod-cut area of the Buitengoor. Species like the caddisfly *Hagenella clathrata*, the dragonfly *Somatochlora arctica* and the dytiscid beetle *Nartus grapii* are illustrative to that. The Scarce Blue-tailed Damselfly (*Ishnura pumilio*) is a typical species inhabiting newly sod-cut zones.

Newly developing lagg fen vegetation

A newly created fen

Water level management, a core measure to preserve the ecological values of Buitengoor-Meergoor

Cladium mariscus is a very rare plant in Flanders. The largest population is found in the Buitengoor.

Abiotic conditions

The hydrology of the area is extremely delicate with influx of both superficial, nutrient-poor, slightly acidic groundwater (with high Al-concentrations) and deeper, more alkaline, iron-rich groundwater. The irrigation ditch from the canal brings lime and nutrients into the area. Phosphates, however, get fixed by aluminium hydroxides (with precipitation of P-Al complexes) and Fe^{2+} ions (with precipitation of iron phosphates), and nitrogen most probably gets denitrificated. The main goal of the project was to maintain the N and P limitation to the habitats of the area, while securing the right hydrological balance between the different hydrological factors defining the local ecosystem, with an emphasis on the increase of groundwater pressure within the Buitengoor. There is evidence that the latter already increased quite rapidly at the northern and eastern border zones. As a result of the sod-cutting, the influx of groundwater mixed with surface water towards the central zone of the Buitengoor was improved.

Other lessons learned / Comments concerning the measures

- Different ways of sod-cutting were applied. Dependent on the specific and local vulnerability of the soil, for instance tree roots were either removed or left in situ. In order to prevent soil compaction, low-pressure vehicles were used and sod-cut material was used to create temporary working lawns. In the alder forest trees were removed by horses.
- The project instigated the already long-term, small-scale management that secures the rich variety of habitats present in the reserve. This type of management, paralleled with multidisciplinary monitoring, is a core prerequisite to the maintenance of the vulnerable and rare habitat types.
- A flexible attitude of the contractor proved to be crucial for the optimal exertion of the works.

Future points of attention for sustainable results

- Apt water table management, by use of the newly placed weirs and the canal water distribution device, will be crucial to reach the goals set for vegetations which are highly dependent on the right hydrological balances. Further investigation of abiotic processes and eventual shifts in these are planned in the nearby future. An ecologically improved management of the Vleminksloop (mainly by turning down the sludge removal frequency) should be installed.
- The newly installed extensive grazing should be further monitored. While the Galloways seem to successfully browse *Molinia*, introduction of a few horses is still in consideration.
- Small-scale mowing activities and tree and brush removal, with a wide group of volunteers, remains an essential prerequisite to successfully maintain the dense patchwork of habitats.

Public support

Considerate communication with any partner throughout the project, including the directors of the adjacent recreation parks, co-defined the success of the project

References

Boeye D., Clement L. & Verheyen R.F. (1994); Maelfait, J.P. et al. (1993).

25. Vallei van de Kalsterloop: Langdonken (Herselt, Aarschot)

Lon Lommaert (INBO)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: EU (LIFE), Flemish government, municipality of Herselt

Ecosystem type

Groundwater-fed depression in a valley on the transition of the sandy Campine area and the more loamy Hageland region (Campine ecoregion, c. 170ha).

Restoration measures, objectives and results

Starting conditions	
About 7ha of wet heathland with variation in structure and topography was destroyed around 1955 for farming purposes.	
Restoration measures	
1998-2000	About 20 to 50cm of the topsoil that was used for farming practice was removed down to the undisturbed soil layer. Consequently the groundwater level now temporarily exceeds the surface by 1 to 30cm during winter. A former cattle pond was restored to hold water throughout the year.
Objectives	**Management measures**
Restoration of wet heath and pioneer vegetations.	Mowing in late summer once a year to keep production at low level and to prevent tree growth.

Evaluation

Species/communities

- After 10 years of colonisation about 90% of the surface is covered with species of wet heath and pioneer vegetation of oligotrophic and mesotrophic riparian habitat; about 10% is still open ground. *Pilularia globulifera, Calluna vulgaris, Carex viridula, C. pilulifera, C. panicea, C. pallescens, Veronica scutellata, V. officinalis, Hypericum humifusum, Luzula multiflora, Potentilla erecta* appeared frequently and reacted to small differences in topography. Because of their very frequent and scattered appearance from the very first beginning, germination from the seed bank is assumed. Later on flooding events may have enhanced seed dispersal. *Lycopodium inundatum, Erica tetralix, Gnaphalium sylvaticum* started with very few plants but have now colonized larger areas. *Gnaphalium luteoalbum* and *Juncus tenageia* were very rare from the beginning and disappeared after one or two years.
- At first species like *Potentilla anglica, Carex hirta, Alopecurus geniculatus* and *A. pratensis* were common where the excavator had lost some ground, but these vegetations disappeared after one or two mowing seasons.
- Dragonflies colonized immediately with viable colonies of *Sympetrum pedemontanum, Gomphus pulchellus, Cordulia aenea, Ischnura pumilio, Lestes dryas* and *L. barbarus*.
- Breeding of *Gallinago gallinago, Charadrius dubius, Anthus trivialis* and *Falco subbuteo* was observed.

Abiotic conditions

- Nitrogen-limited growing conditions makes mowing once a year necessary.
- The fluctuating water tables, especially in parts that are flooded for more than half a year, are crucial to maintain the typical pioneer vegetations for a longer time.
- Places where the excavator did not reach the original and undisturbed soil layer yield more grassland species. Only where the upper layer was removed more rigorously, colonisation occurred by heathland species.
- The soil still had buffer capacity against phosphate saturation. Locally phosphate is immobilized by iron-rich seepage water.

Other lessons learned

- In large-scale projects the creation of a suitable abiotic starting situation is more important than trying to maximize the release of the seed bank. For a lot of plant species only a few successful hits on the seed bank are sufficient to colonize the whole spot if the neighbouring area is in a suitable abiotic condition.
- Because of the advantage for mowing practice it is recommended to have a starting situation without micro-relief. Variation in vegetation can result and appear effectively from the mesogradient that exists in the project .
- Disturbance or compaction of the soil was minimized by the working method: at first a heavy 40-ton excavator that could reach 12m worked backwards and deposited the soil on a long pile on one side, as far as possible. Then the excavator did the same on the other side. Afterwards the pile was removed by trucks and the excavator driving on top of the pile.
- As transport of the soil is expensive, the price can be reduced by an immediate transport to the destination place. The combination of a restoration project with a commercial ground-demanding project provides a financial opportunity and is more easily accepted by the public.

Topsoil removal of a former agricultural grassland was very successful, with nice gradients in humidity and nutrient contents (impression after 10 years of mowing management). The idea for topsoil removal arose by accident, after a pile of dumped mowing material was removed and the presence of a promising seed bank was revealed.

Starting conditions	
Large parts of the area were planted with *Populus canadensis* and *Pinus sylvestris* or were colonised by young *Salix*-woods.	
Restoration measures	
2003-2006	About 20 ha were deforested; the stumps were milled and the nutrient-rich soil was removed. On some artificial ponds the banks were levelled to a very low-sloping profile, more like a natural depression. Small canals that drained the site were filled.
Objectives	**Management measures**
Regeneration of oligo- to mesotrophic water communities, pioneering vegetation and wet heathland.	Mowing to prevent scrub and woodland development and maintain pioneer vegetations.

Evaluation

Species/communities

- Target species of the *Littorellion* plant community colonised the site, partly from the present relic population, partly from the seed bank: *Apium inundatum, Baldelia ranunculoides, Carex lasiocarpa, Eleocharis multicaulis, Hypericum elodes, Isolepis fluitans, Deschampsia setacea, Luronium natans, Pilularia pilulifera, Potamogeton gramineus, P. polygonifolius, Ranunculus ololeucos* and *Utricularia australis.*
- On some higher sandy places, countless plants of *Juncus tenageia* appeared but after 1 to 5 year they disappeared almost completely after stabilisation of the vegetation development. In transitional places between wet heathland and *Littorellion* *Anagallis tenella, Scutellaria minor* and *Cirsium dissectum* were able to settle (the first two species most probably from the seed bank, the latter from a neighbouring place).
- Shortly following the restoration efforts five charophyte species were found. Most remarkable is *Nitella confervacea*, a rare species in Europe and previously observed only once in Belgium as far back as the mid 1920s.
- The number of dragonflies amounts to 36 species, making the area an important dragonfly site in Flanders. During spring of 2006 thousands of *Sympecma fusca* were seen. *Orthetrum brunneum, Ceriagrion tenellum* and *Sympetrum depressiusculum* are other uncommon species in Flanders. The measures were beneficial for *Triturus cristatus*, already present on the site; the grasshopper *Stethophyma grossum* became numerous in places with rather rough vegetation.

Poplar and pine plantations and young *Salix* woods were logged and the litter layer was removed in favour of wet heathland and *Littorellion* communities. The old, parallel drainage channels in the area can be recognised by their more productive vegetation.

Thanks to the restoration works the Langdonken became the most important area for *Luronium natans* (Annex 2 species Habitats Directive) in Flanders.

Abiotic conditions

Although most water bodies are, at least in winter, in direct contact with each other, differences in the local chemistry are observed. These differences are reflected in a number of vegetation types and have partly a natural cause (e.g. contribution of rainwater versus groundwater) and partly an anthropogenic cause (e.g. impact of neighbouring agriculture and waste water from urbanisation).

Other lessons learned

- Due to the large-scale deforestation, the evapotranspiration declined and resulted in structurally higher water tables, especially in summer. This complicated the project operations in the last phase.
- Potential nuisance species like *Juncus bulbosus* and *Phragmites australis* colonised immediately (*J. bulbosus* very abundantly from the seed bank, *P. australis* from present roots) but their dominance decreased by first-year mowing.
- Non-native geese (*Alopochen aegyptianum* and *Branta canadensis*) use the place for breeding (5 to 8 pairs) and nightly roosting (10 to 30 birds). They have a noticeable impact on vegetation development and on cohabitation with native duck species. The problem of non-native geese is approached with local hunters but suffers from the lack of legal regulation.
- Restoration measures seem to be more successful when the project starts from a relatively undisturbed and non-fertilized wooded area than from arable land (see subproject above).
- To minimize the efforts (and the price), the different actions (cutting trees, removing the tree-trunks and the branches, milling the stumps and removing the nutrient-rich upper layer) preferably follow each other in one single operation. Vegetation development between these actions hampers the next action and gives worse results.

Future points of attention for sustainable results

There is a lack of instruments to minimise the effects of diffuse pollution (e.g. nitrogen deposition or ground water contamination), so selection of a project or location has to take into account these aspects in order to obtain sustainable results.

References

Andries, T. (2007); De Becker P., Denys L., Packet J. & Batelaan O. (2007); Denys L. & Packet J. (in press).

26. Hageven (Neerpelt, Lommel)

Joost Dewyspelaere & Gaby Bollen (Natuurpunt)

Natura 2000 area: yes

Management authority: Natuurpunt

Supporting authorities: EU (LIFE), province of Limburg, the Flemish government, Natuurmonumenten (a Dutch NGO)

Ecosystem type

Mosaic of dry and wet heathland, reed marsh, pine forest, different types of broad-leaved forest and flood meadows along the river Dommel in the Campine ecoregion (> 200ha).

Restoration measures, objectives and results

Starting conditions	
Former dry and wet heath was levelled at the end of the 1950s and turned into arable land.	
Restoration measures	
Ca. 1985	About 10ha of maize fields surrounded by wet and dry heaths were restored in four different ways: – Extensive grazing only, without sowing in of grass mixture. – Sowing in of grass mixture and extensive grazing. – Sowing in of grass mixture with initial fertilization and extensive grazing. – Removal of 30cm of topsoil, with extensive grazing.

Objectives	Management measures
Restoration of dry heath and dry, poor grasslands.	Extensive grazing.

After more than 10 years the results of top soil removal on former maize fields were still disappointing. It became clear that the digging had not been done deep enough to remove all of the residual phosphor from the area. In 2006-2007 the same restoration zones were dug out deeper in the hope of better results.

Evaluation

Species/communities

Restoration of heath and dry, poor grassland turns out to be a lengthy process. After more than 20 years, mainly common species of *Festuco-Thymetum serpylli* and *Thero-Airion* vegetations have settled more or less permanently (*Agrostis capillaris, A. vinealis, Aira caryophyllea, A. praecox, Festuca filiformis, Rumex acetosella, Luzula campestris, Veronica officinalis*). Invertebrate fauna recover very slowly or not at all, except for pioneer species with good dispersion capacity (some ground beetles, e.g.). The best results were achieved in the levelled zone, with occasional presence of species like *Calluna vulgaris, Juncus squarrosus* and *Spergula morisonii*. Topsoil removal was successful in particularly in the wet parts of the area, attracting priority species like *Gentiana pneumonanthe* and *Drosera rotundifolia*, in addition to various rare ground beetles with good pioneer capacity. In none of the test areas a true recovery of a nutrient-poor original situation turned out to be possible, due to high residual amounts of phosphor. Effects of fertilization are still visible even after 20 years from interference indicators like *Juncus effusus, Cirsium arvense, Poa annua* and *Urtica dioica*. This renders the grounds vulnerable to atmospheric nitrogen deposition, which in turn may benefit competitive species like *Phragmites australis, Lotus pedunculatus* and *Holcus mollis*. Vegetation structure turned out to be considerably more diverse in the test areas that were not sown in, as a result of growth of mainly *Betula pendula, Rhamnus frangula* and *Salix aurita*.

Abiotic conditions

Extractable phosphor turned out to be five times higher than in a reference area for dry, never reclaimed heath, even for the area with topsoil removal. This means that digging had not been done at a deep enough level to remove all of the residual phosphor from the area. The level of nitrogen was the lowest in the levelled area and the highest in the parcel that had been fertilized initially. In the levelled part, a gradient appeared from permanently wet to dry.

References

Van Uytvanck J. & Decleer K. (2004)

Starting conditions	
A mosaic of fens, wet heath and land dunes (c. 50ha) was drained around 1959, leveled and partly turned into arable land. Parts that could not be cultivated became afforested, were planted with Scots Pine, or became overgrown by *Molinea*.	
Restoration measures	
2006-2007	– 6 fens (with a total surface of c. 30ha) were restored on the basis of an aerial photograph from 1936. Digging was done down to just below the mean lowest groundwater level. Around the fens a wide strip was sod-cut and limed, both on dry and wet soil. Any *Molinia* herbage was flailed before that. – The fields with insufficiently deep topsoil removal around 1985 (see higher), were dug out deeper on the basis of nutrient analysis of local soil cores. – The excavated soil was used to restore the former relief on surrounding former fields. – Sapling growth of Birch was removed (c. 3ha). – A small woodland of Scots Pine (c. 1ha) was cut down, after which flailing and sod-cutting were possible.
Objectives	**Management measures**
Restoration of fens, wet and dry heaths, and sand drifts with special attention for gradients from wet to dry. One important priority species is the butterfly *Maculinea alcon*, which lives on *Gentiana pneumonanthe* and is increasing in the area.	Extensive grazing by Galloway cattle. Additional mechanical management, including mowing and saving of open habitat in land dunes by means of a specifically designed machinery.

Evaluation

Species/communities

One year after restoration a number of species typical of the target habitats have grown from the seed bank (*Luronium natans, Utricularia minor, Eleocharis multicaulis, Littorella uniflora*). Breeding birds of open heath, such as *Anthus pratensis* and *Vanellus vanellus*, reappeared in 2008 already.

Abiotic conditions

As a result of the project, the historical landscape was restored as fully as possible in its abiotic aspects. Restoration of moors and filling of drainage ditches have led to an unexpectedly strong rising of the groundwater level. On the deforested and sod-cut land dunes and the raised former fields small sand drifts occur to a lesser extent. This is hopeful for the preservation of open sand dunes in the area in the long term.

Large-scale sod-cutting and fens restored on the basis of aerial photographs from the year 1936.

Other lessons learned

- The thorough preparation by a consultant bureau, particularly towards the hydrological aspects and their relation to former land use, was essential to the success of the restoration works.
- The fields were superficially but strongly polluted by heavy metals (former non-ferro factory at less than 2km). The restoration works have prevented the outcrop of polluted soils that would hinder the management (such as grazing).

Future points of attention for sustainable results

The results will be monitored closely with regard to any necessary adjustments for optimal results.

Public support

There was a lot of press coverage at the start of the works, in the presence of the local deputy of environment. Further communication efforts include guided walks and publication of information leaflets.

Littorella uniflora, one of the target species of fen restoration in the Hageven.