

30 YEARS OF RIVER RESTORATION

BRINGING THE RIVER MEUSE ALIVE!



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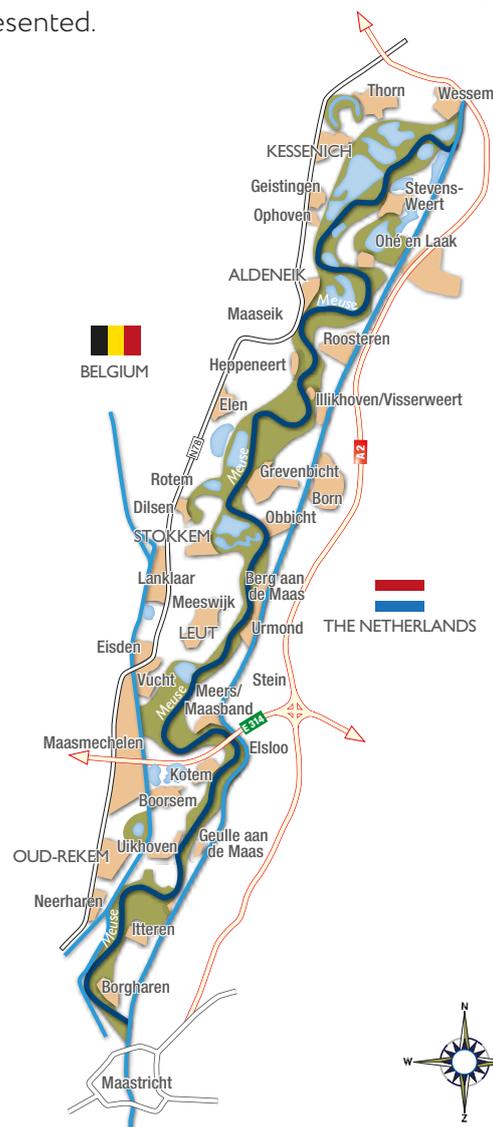
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INTRODUCTION

In this decade of ecosystem restoration, showing good examples of how restoration can work is of utmost importance. Ever since Roman times, rivers in central Europe have been managed for navigation, for flood control and for agricultural use of floodplains, causing strong ecological and ecosystem consequences. The major human interventions of straightening, damming and embankments have transformed fluvial processes, and strongly affected river ecosystems and their biodiversity. The River Meuse is no exception, and it became a major transportation route with the first industrial revolution. Only one river stretch escaped the heavy impoundment, the 60 km of the river along the Dutch-Belgian border. Thanks to its high slope, centuries of straightening and canalisation were abandoned and lateral canals took over the navigation route: the Albert canal from Liège straight to Antwerp, and the Juliana canal on the Dutch side. This offered a window of opportunity for restoring the unique ecosystem of a large gravel river, of which unfortunately hardly anything was left.

This brochure describes the ecological results of the nature restoration project that started thirty years ago on the banks of the River Meuse at the border between Belgium and the Netherlands. Today, with the large floodplain restored, the river is the heart of the cross-border Meuse Valley River Park in the Belgian and Dutch provinces of Limburg. An extensive ecological monitoring programme was developed in a cooperation between more than ten partners from the Netherlands and Flanders. The study focused on the restored natural areas in the southern part of the River Park, which have been created with riverbed

widening and floodplain lowering. Developments in the water as well as on land were examined. In addition to recently completed areas, some 30-year-old nature restoration sites were also investigated. Not only the ecological results, but also a view on the economic benefits and the way inhabitants evaluate their transformed region is presented.



THE RIVER RESTORATION PROJECT OF THE BORDER MEUSE; ENGAGED FOR THE WIN-WIN.

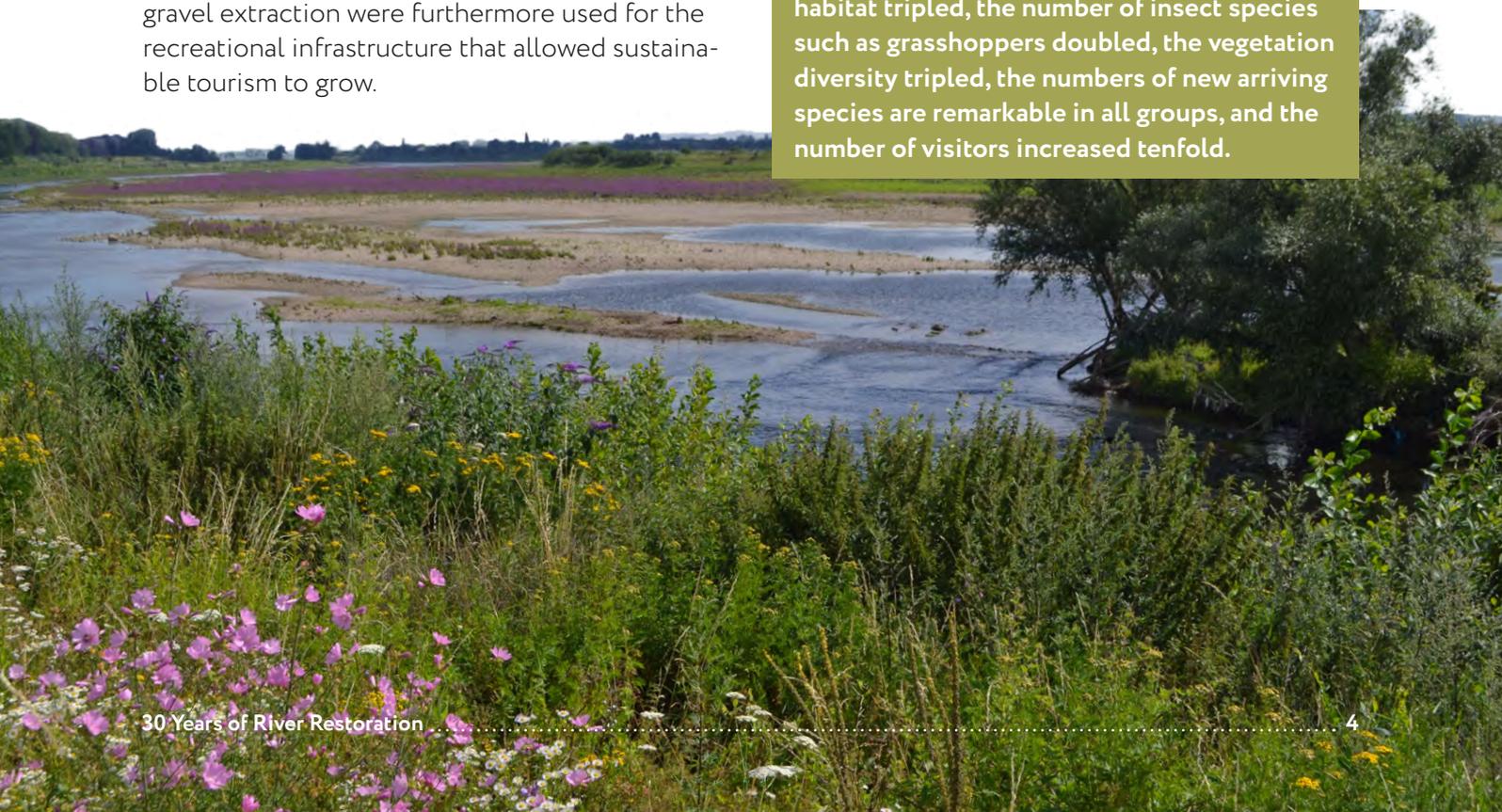
Some 30 years ago, national-level gravel extraction targets were identified and co-developed in coalition with a nature restoration plan. The Meuse River restoration project was born, and in the following years it was completed with additional flood protection goals. The idea for large-scale river restoration was inspired by the WWF 'black stork plan' of 1986 that envisaged restoring robust natural areas along the large rivers in the lowlands. The 'Green for Gravel' plan was established in 1990 and was the start of a long process of investigations, designing and deciding plans, but also of starting with pilots for the restoration and regaining of natural areas and processes in and around the river, managed by WWFs Ark Nature organisation.

The gravel extraction coalition made it possible to obtain budget neutrality in the project. And thanks to this coalition, it is the only large river restoration programme globally that was not withdrawn due to the global crisis in 2008 – as was the case e.g. for plans for the Missouri (USA), Murray-Darling (Australia), Elbe (Germany) and Rhine (Germany-Netherlands). The concept is a nature-based solution, since the gravel extraction follows the geomorphological contours and landforms. Extraction depth is determined by the river incision in its gravel bed. Economic benefits of gravel extraction were furthermore used for the recreational infrastructure that allowed sustainable tourism to grow.

The project addresses the drivers of biodiversity loss; former uncontrolled gravel mining resulting in large gravel pits and flood protection management that constrained the natural river system. Its execution started in 2008, and is now not only the largest river restoration project globally – a large river over 50km 'fully' restored, but also a new hotspot for biodiversity and centrepiece for nature restoration in the whole of Belgium and The Netherlands.

It offers a showcase of nature restoration benefits in attracting over 2 million visitors a year, with a regional economy turning to this new source of income. The project not only has a documented economic added-value, it is also highly accepted in the region. A survey in spring 2021 revealed a 90% high positive valuation for the large river restoration, with 87% of the respondents taking profit of the new area for walking and biking. Furthermore, with the recent unprecedented flood event of July 2021, the combination of river bed widening and nature restoration proved successful in reaching the flood protection targets, keeping the villages safe and dry. In this brochure you will discover that:

Over the last 10 years, the natural area doubled, the area of Natura2000 protected habitat tripled, the number of insect species such as grasshoppers doubled, the vegetation diversity tripled, the numbers of new arriving species are remarkable in all groups, and the number of visitors increased tenfold.





RESTORING THE RIVER

THE RESTORATION PLAN AND ITS MEASURES

The Border Meuse is the only gravel river in the low countries. Because it is a rain-fed river, the discharges can fluctuate greatly: low discharges of 10 m³/s occur during long dry periods, but during an extreme high water, 3,000 m³/s can roar through the Border Meuse. Under such conditions, the river is able to transport large quantities of gravel and sand. Thanks to the river slope of approximately 0.5 m/km and the absence of weirs, the Border Meuse shows higher stream velocities than other sections of the Meuse.

The project area is the 50-km-long, unimpeded section of the Border Meuse on the Belgian-Dutch border between Maastricht and Maaseik. The elaboration of the plan received an enormous impulse from the two extreme flood events in the Meuse River in 1993 and 1995. The planned river widening could after all increase flood safety, and so it was decided to draw up a plan for the two riverbanks that included a third win-win with the flood protection, after nature restoration and gravel mining. This cross-border plan also included opportunities for recreation and tourism. In the plan, a joint objective was

formulated for the development of approximately 3,000 ha of river nature. This target was - in agreement by all partners - to become a self-regulating ecosystem with restored river processes and high-quality habitat for key species, and strong ecological connections.

In 1990, ARK/WWF also started the first nature restoration pilot areas on both sides of the border. A pilot project for river widening was carried out in 2000 near Meers. Finally, in 2008 the large-scale implementation of the Border Meuse project was embarked on. It is a revolutionary project in the scale of construction works over the width of the floodplain for 50 km, in which flood protection, nature restoration and gravel extraction go hand in hand. The work will be completed in around 2027. Since 2017 Flemish and Dutch partners have been working together under the name of River Park Meuse Valley. This is to strengthen the landscape around the river ecologically and in terms of landscape and heritage value, as well as to put it on the tourist maps in a way that is tailor-made for the area.

ALREADY NEW CHALLENGES AHEAD

The ravaging flood event in the Meuse basin of July 2021 was a stress test of the flood security goal achievement with the project. Where it had a devastating effect upstream, and posed severe threats downstream, in the project area the widened river bed provided the necessary capacity for this unprecedented flood event.

However, things were close. This highest ever flood level caused no real threats for the restored river stretch, while the flood events of 1993 and 1995 still caused large flooding problems in the area, and were at the origin of integrating the flood protection as objective in the river restoration project.

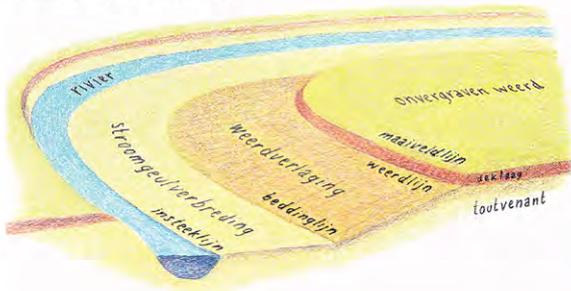


SURVEYED RESTORATION SITES

- Clay shield
- Bed widening
- Floodplain lowering
- Unexcavated natural area



PRINCIPE GRENSMAASPLAN



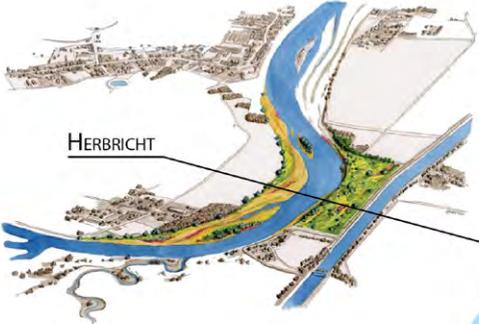
KERKEWEERD



MEERS



GEULLE AAN DE MAAS



HERBRICHT



ITTEREN

HOCHTER BAMPD



BORGHAREN



500 years of attempts to fix the meanders and make the river stretch navigable had reduced the river bed to a narrow fully-embanked channel, with a floodplain under intense agricultural use.

The project's implementation is executed from upstream to downstream. The river widening is carried out through a combination of broadening the stream channel, lowering the floodplain and storage of floodplain top soils in clay shields to protect the groundwater levels. Together with unexcavated parts, thirteen cross-border sub-areas make up the Border Meuse project.



2000



2019



GRAVEL AUGMENTATION AND GRAVEL PIT INTEGRATION

Where possible, gravel was also added to the incised river bed. The gravel augmentation from the Flemish banks amounts some 400,000m³ of gravel.



Existing gravel pits were integrated into the river system by lowering the banks.

Restoration of the gravel pit area on the Flemish side with lowering of the river banks, and guiding the floods through channels and levees.



HYDROMORPHOLOGICAL PROCESSES RESTORED



The project areas show immediate responses of river morphological processes. In this river meander the red colours represent sedimentation of >1m, for one winter season, showing the bar formation. The green colour shows the erosion of new stream channels in the widened flood bed, and the yellow-orange colours show sandy deposition. Gravel islands have formed by sedimentation on both a larger scale and on a micro-scale on the southern stretch. Erosion also operates on large scale within the riverbed, and with more small-scale flood channels through the higher zones.



From the cultural landscape 50 years ago, to the natural landscape today. Same location, from man-made to beaver-made.



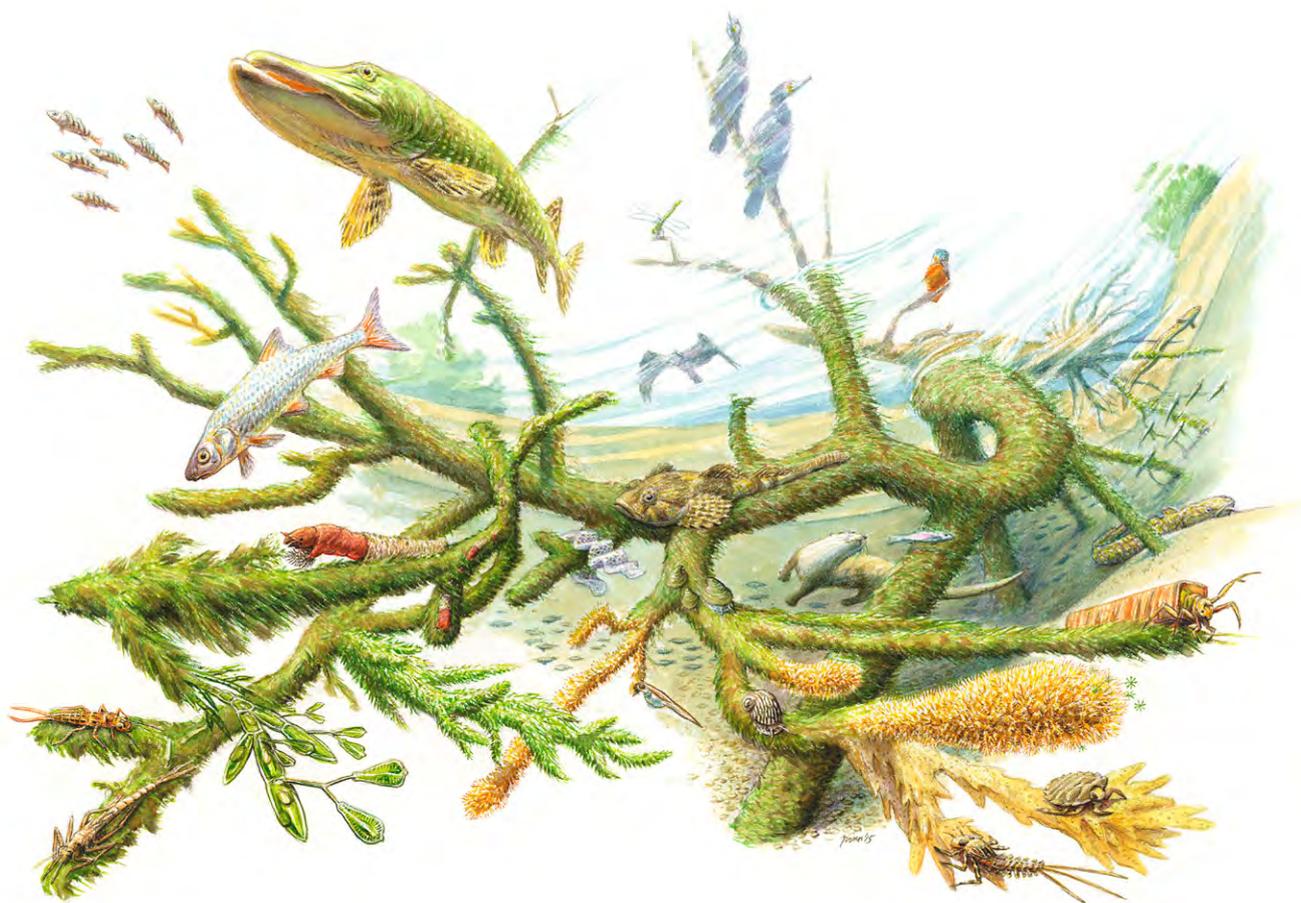
SIX KEYS TO ECOLOGICAL SUCCESS

A monitoring method MaasinBeeld 'Meuse in sight' was developed to measure the evolution of habitats and species throughout the area, by detailed surveys of restoration sites, with a fixed protocol and tailored standard lists. Characteristic species for the river valley that also enable

indication for the present NATURA2000 habitat types are systematically surveyed in the restoration project sites. With a 10-year interval period, this monitoring allows us to keep track of the development of species and their habitats in the area.

For the results, we identified Six Keys to Success:

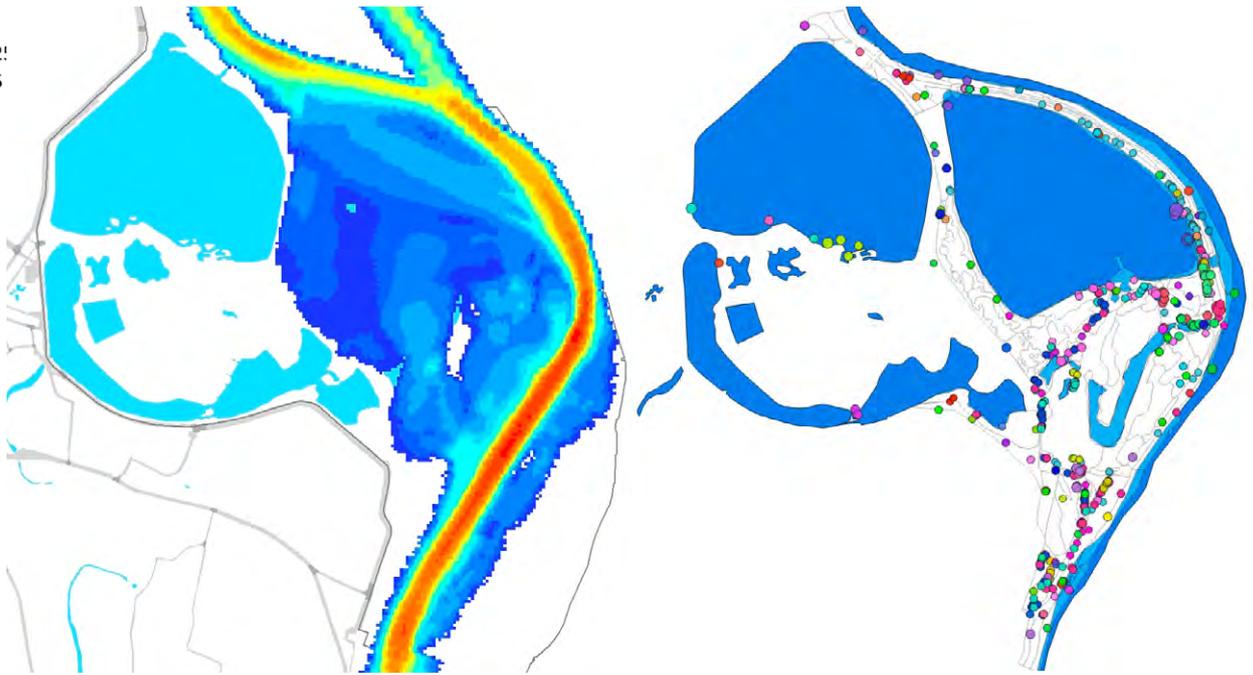
1. FLOW AND FLOOD DYNAMICS



The river flow is at the origin of all life in the valley, and the disturbance caused by regular flood events is the creating force to all the landforms and habitat in the valley. This can be symbolised by the dead wood from a tree eroded from the riverbank, which not only will diversify stream patterns and substrates, but also offer life to an entire community under water of fish, invertebrates, aquatic mosses and algae.

The now extensive underwater vegetation of Loddon pondweed and dead wood is home to, among others, black flies and chironomid midges, some of which were named as target species at the start of the project. The improved water quality and, in particular, the increase in freshwater mussels are undoubtedly at the origin of the strong increase in shellfish-eating winter water birds, such as the goosander, smew and common goldeneye.

Stream velocity in m/s

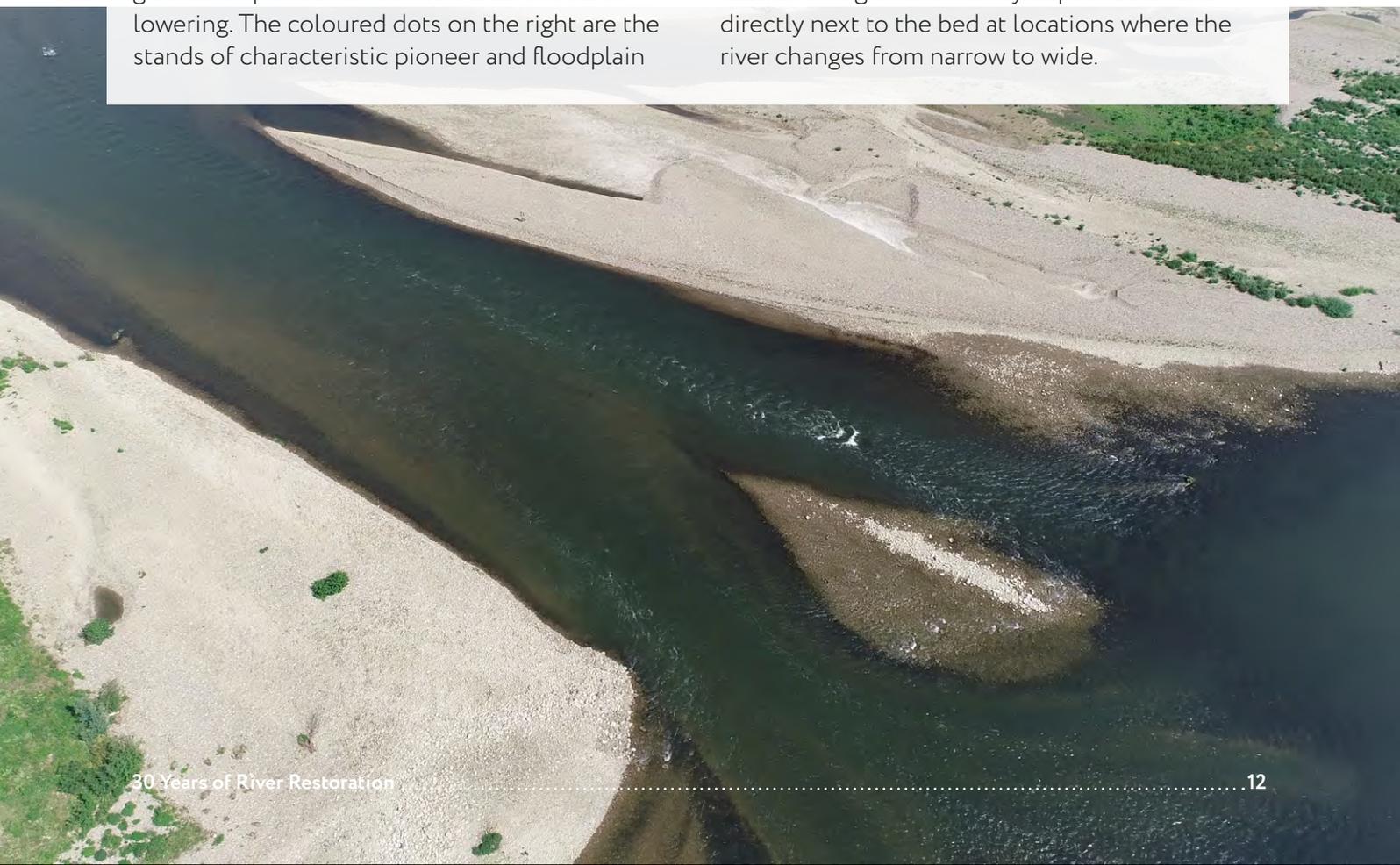


The lowering of the riverbanks and embankments caused a strong change in the flood dynamics in all the sites, with the desired effects on the establishment of characteristic species.

Hotspots for the settlement of characteristic species occur at flow 'hotspots'. The establishment of characteristic species clearly follows the flood flow paths through the area. Here, the presence of the characteristic flood meadow grassland species can be seen after the bank lowering. The coloured dots on the right are the stands of characteristic pioneer and floodplain

meadow species. The characteristic species are clearly established in the most dynamic zones in the area and have also benefited from the change of substrate through gravel and sand deposition instead of the nutrient-rich loam.

The recovery of river dynamics is occurring as predicted, with major changes in the zones of river bed widening. Erosion and sedimentation create natural bedforms of gravel bars and islands. The gravel is mainly deposited in and directly next to the bed at locations where the river changes from narrow to wide.





Dynamics bring dead wood into the river, and fresh sediment - essential elements for further improving the quality of the area.

The characteristic tree species of the gravel bed, purple willow and black poplar, play a crucial role in the formation and gradual raising with sand and gravel of the islands within the bed.



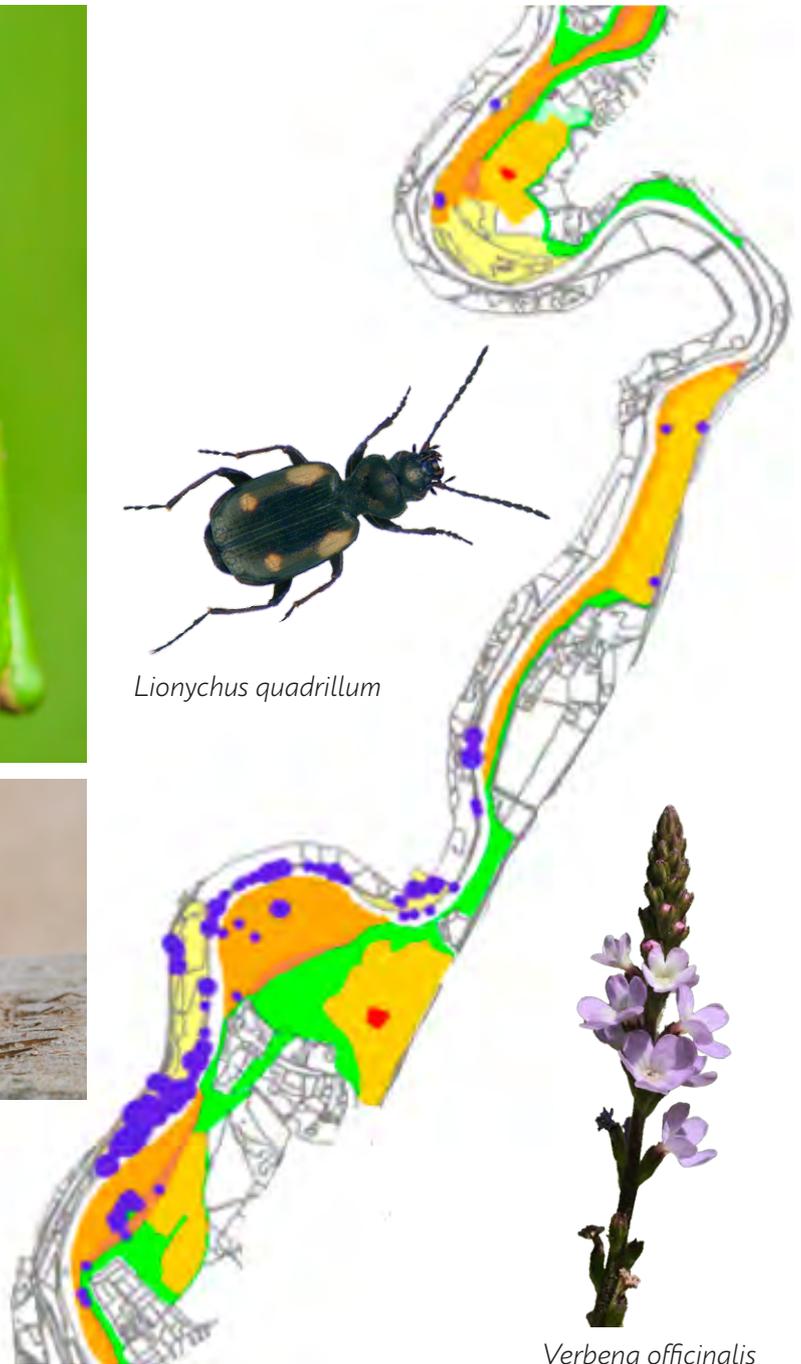
Purple willow shows the start of the bar formation in the river bed.

2. CONNECTIVITY



With the reopening of the Rhine and Meuse delta to the North Sea, the populations of Atlantic salmon, sea trout and other migratory fishes have greatly benefited. The inset photographs show the most recent newly recolonised burbot and spirlin. The restored connectivity along the river allows for migration and colonisation for a wide range of species in both aquatic and terrestrial groups.

It is at the heart of the appearance of the (shifting) mosaic in the river landscape: together with habitats, species travel through the area in waves. For most species of plants and insects, this dispersal along the river works from upstream to downstream, as we can illustrate for specific species in the riverbed and on the banks. Also for this reason, it is favourable that the project was carried out from upstream to downstream.



Lionychus quadrillum

Verbena officinalis

The terrestrial plant *verbena officinalis* gradually moves down the river – in pace with the downstream progression of the river restoration; currently with high densities on upstream river banks, and only a few colonisations further downstream.

Also, flying and swimming insects, such as the riparian ground beetles (*lionychus quadrillum*) follow the river bank restoration immediately.

For non-flying animals such as amphibians, reptiles and mammals, the actual linking up of nature areas in the River Park is of great importance. For critical species especially, infrastructure, intensive agricultural areas and buildings can be major barriers to their spread. There are no major obstacles in the Meuse valley itself, but the connec-

tions to high ground are obstructed on both sides by canals and busy roads. Nevertheless, there are positive examples, including the previously reported settlement of the badger and the wild boar. Illustrative of the improved connections is the increase in two rare amphibians: the tree frog on the Flemish side and the natterjack toad on the Dutch side.

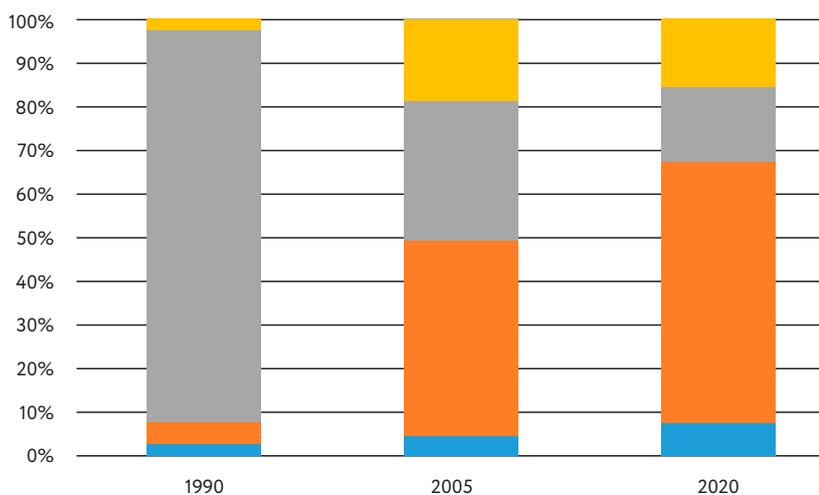
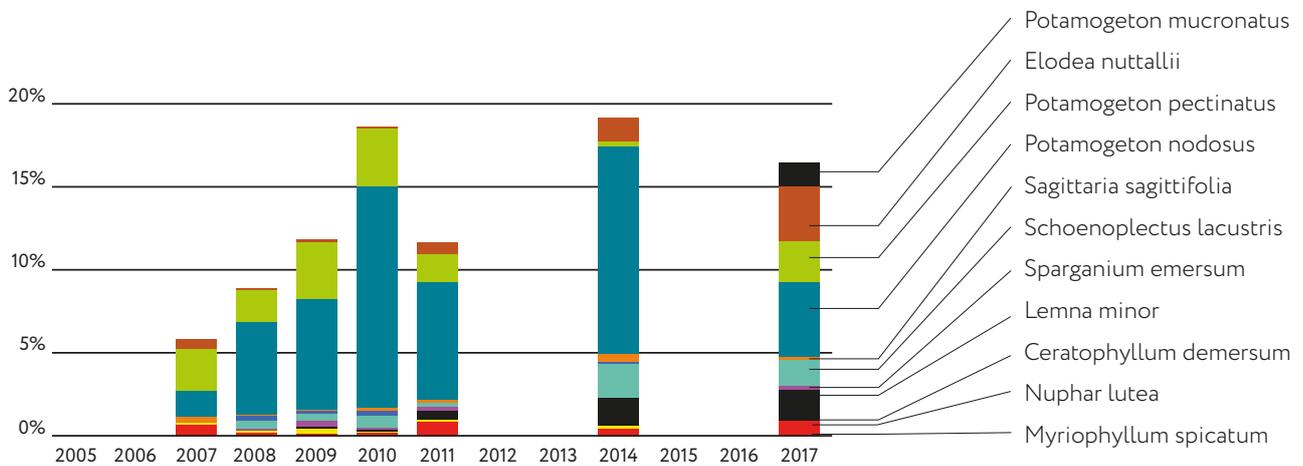
The return of these critical animals and plants was not possible without the presence of source populations or seed banks within the area or beyond. The relics of specific habitats like flood-plain meadows play a major role in the recolonisation of the area. A long list of species that were on the brink of disappearing from the Meuse valley are re-establishing themselves in the new areas.

AQUATIC VEGETATION AND FISH IN THE RIVER BED

The aquatic vegetation of the river bed showed a strong recovery, first in densities, reaching over 15% coverage even 10 years ago. But where in this first period the recovery was mostly in two species (*Potamogeton nodosus* and *P. pectinatus*), nowadays very diverse aquatic vegetation is present with some 10 characteristic species – including *Ranunculus fluitans* - for this large gravel river type.

Whereas in the 1980s and early 1990s the fish community of the Border Meuse in the canalised river bed was dominated by eurytopic fish, mainly stagnant water fish with the common roach and

bream being dominant, since the floods of the mid-1990s and the start of nature restoration in the summer bed, the fish community has also changed to a more typical gravel river community. Gradually, the number of rheophilic fish species has increased: 16 now, compared to 12 a decade ago, and only 4 in the 1980s! Currently the fish community is dominated by characteristic species like the barbel, chub and common nase, and more accidentally sea trout and Atlantic salmon can be spotted. Two protected species, the river lamprey and sea lamprey, are now migrating back from the sea via the Meuse into the Ruhr, but are still rarely detected in the Border Meuse.



- ana-/katadromous fish
- rheophilic fish
- eurytopic fish
- limnophilic fish

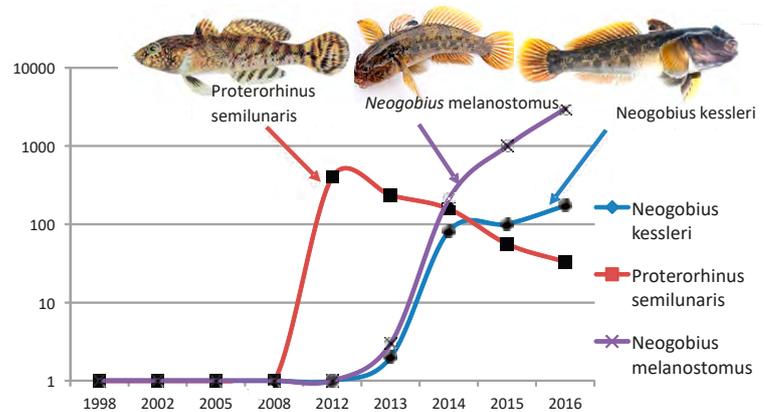
The fish community has in the last decade seen a series of invasions by exotic goby species that arrived with the opening of the Meuse-Rhine and Rhine-Danube canal connections. In recent

years, a decline in these exotic species has been observed, and the indigenous species have reclaimed their place.

LESSONS FROM INVASIONS

Since the opening of the canal connections between the Danube, the Rhine and the Meuse in the 80s, these large rivers have been the scene of consecutive invasions of (mainly Ponto-Kaspian) amphipod (Gammarids) species, a bullhead species and in the last decade also a series of river goby species. All these invasions showed true wave forms, with exponential rise but also a fairly quick withdrawal.

Goby species invasion waves in the Border Meuse (numbers caught at eight 100m sample sites during electrofishing campaigns). The western tubenose goby (Proterorhinus semilunaris) and bighead (Neogobius kessleri) show consecutive waves with the same amplitude. The round goby (N. melanostomus) showed an invasion wave with a tenfold higher amplitude at the peak (data source: Flemish fish Database).



In a large river with such high diversity of niches, and such a strong determining force of the floods, invaders mostly do not get the chance to take control and dominate for long time. This is also observed for plant invaders, both aquatic such as *Elodea nuttallii*, and terrestrial such as *Impatiens glandulifera*. Invasive in many other habitats, these species now are present in the communities in the Border Meuse habitats, without taking a dominant position. For an even stronger and more dynamically-adapted invader – Japanese knotweed – the inevitable invasion is currently taking place, and apart from some larger infestations, large herbivores mostly tend to keep the species under control.

So, in these large and dynamic systems – characterised by mobility and connectivity – newcomers deserve their chance, or at least an evaluation

period. For the *Corbicula* clams that are now very present in the river, discussions are still ongoing regarding its ‘natural’ or ‘invasive’ status, but meanwhile they are more than welcome for their water purification capacities and for being main prey for the now abundant wintering water bird communities.

The colourful vegetation of the river park is composed of species that descended the river, many of them from the more calcareous upstream regions, with some calcareous sediment to accommodate them. This brings exceptional flora to the lowlands of Belgium and the Netherlands. Exotic species that are disputed for their non-autochthonous character by some, but are highly appreciated by most, and are fascinating for their mobility and adaptation, make up the novel communities of the new ecosystem.

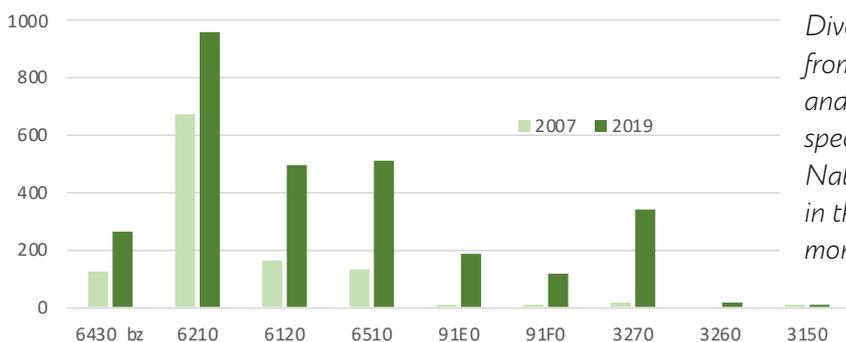


3. SHIFTING MOSAICS

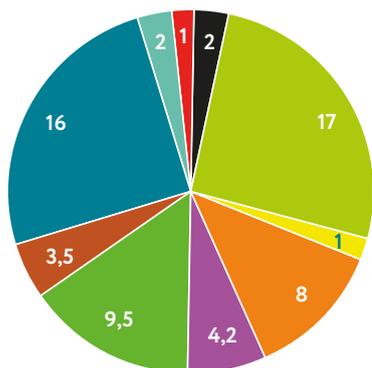


Natural habitats along rivers occur as a shifting landscape mosaic, which, thanks to the resulting variation in the landscape, also benefits high biodiversity. Biodiversity can be measured both in species richness and in the mosaic of habitat. The stands for characteristic Border Meuse species were registered, so that for each area there is an insight into the diversity of these characteristic species and habitats in space and time.

Characteristic plant species for the river valley that are at the same time indicator species for the present NATURA2000 habitat types are systematically surveyed in the restoration project sites; all individuals are counted and mapped, to enable the population development to be followed through time and space.



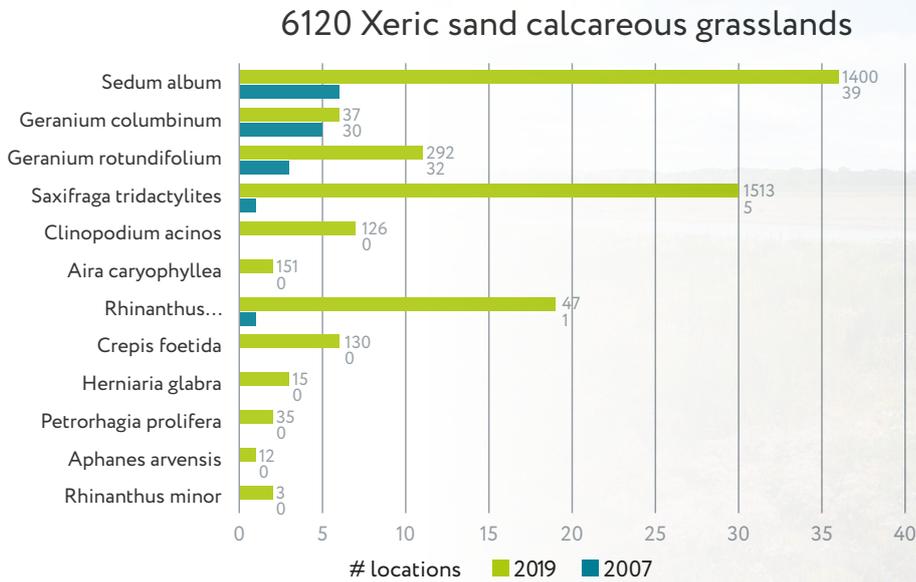
Diversity index – derived from numbers of stands and individuals of indicator species- for the characteristic Natura2000 habitat types in the River Park, for the two monitoring periods.



- W1G 3260 Water courses of *Ranunculus fluitantis*
- P0-P1 3270 River muddy banks with *Chenopodium rubri* and *Bidention*
- 6210 Semi-natural dry calcareous scrubland facies (*Festuco-Brometalia*)
- 6510 Alluvial meadows (*Arrhenatherion*, *Mesobromion*)
- 6120 Xeric sand calcareous grasslands (*Koelerion glaucae*)
- 6430 Riparian tall herb fringe vegetation
- 91E0 Alluvial forests (*Alno-Padion*)
- 91E0* Softwood forests (*Salicion albae*)
- 91F0 Riparian hardwood forests (*Ulmenion minoris*)
- 3270 River mud banks - *Chenopodium rubri* and *Bidention*

The habitats actually present show a good distribution of about a quarter pioneer and water habitats, a quarter grasslands, a quarter fringes and shrubs, and a quarter forest habitats. This distribution is a good approximation of previously

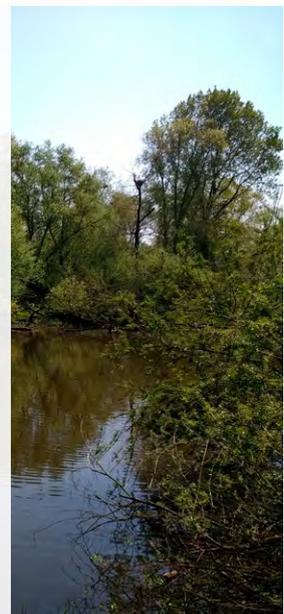
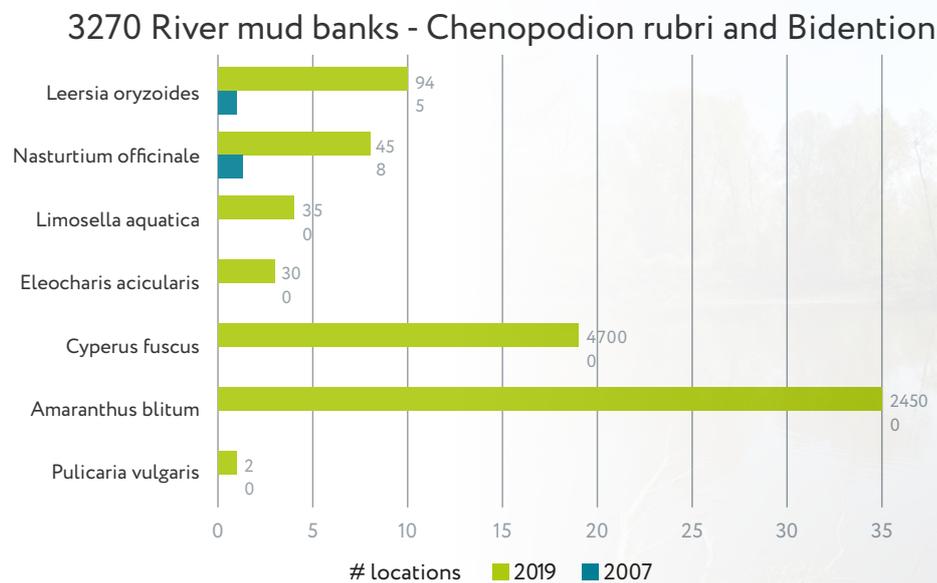
described ecological targets for habitats. All the more so because the distribution of low and high elevation environments and habitats is also well equilibrated across the area.



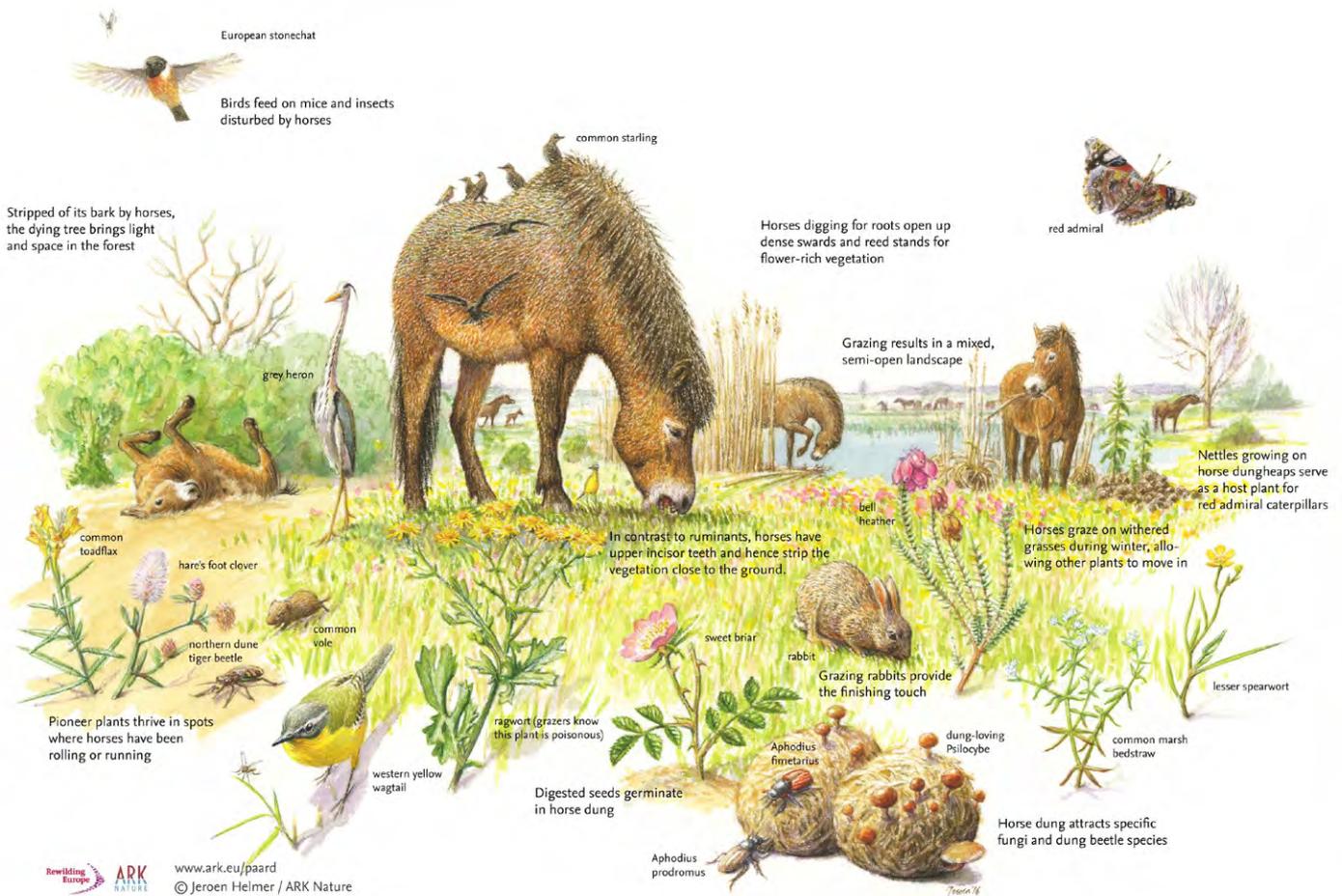
The characteristic indicator species for specific habitat types can be used to show the evolution for the different habitat types. For the evolution of xeric and sandy calcareous grasslands, we observe the arrival and strong development of a wide range of characteristic species, both in numbers of stands and in individuals of the species. The characteristic species of the river mud banks mostly arrived the last decade; the more regular species of this habitat, such as *Chenopodium* and *Bidens*, were already present, but the more specific species are only recently established.

For insects we observed an increase in butterflies over the 30 years from 25 to 32 species, in grasshoppers from 11 to 25 species, and in dragonflies from 21 to 37 species. Protected species such as *Gomphus flavipes* are also inventoried and mapped over the entire area.

For the dragonflies, as well as for the macroinvertebrate community in general, the low flow conditions are still critical, and with numerous upstream dams, the fluctuations and hydropoising problems seem to hamper the successful settling of the typical species in this group.



4. REWILDING & NATURAL GRAZING



Rewilding can be defined as restoration that promotes self-regulating ecosystems through restoring ecosystem processes – both physical and biotic - while reducing human control.

From the start of the project, natural grazing has been one of the pillars of the River Park. While, in the beginning, the focus was mainly on horses and cattle, in recent years the role of other species has also strongly increased: for example, beaver, roe deer and wild boar. The herds of horses and cattle not only play an important ecological role by developing a varied landscape, they have also become emblematic attractions of the River Park. The effects of grazing were not directly investigated, but many species that are found appear to be indirectly linked to this process. In contrast to river dynamics, grazing is often a more subtle force. It not only leads to the creation of a finely-meshed mosaic landscape, but also provides “fine tuning” of the biotic processes. Think

of the dispersal of plant seeds, hairs and manure, the creation of open spaces through bull pits, horse’s sand baths and wild boar digging places, the accumulation of beaver wood etc.





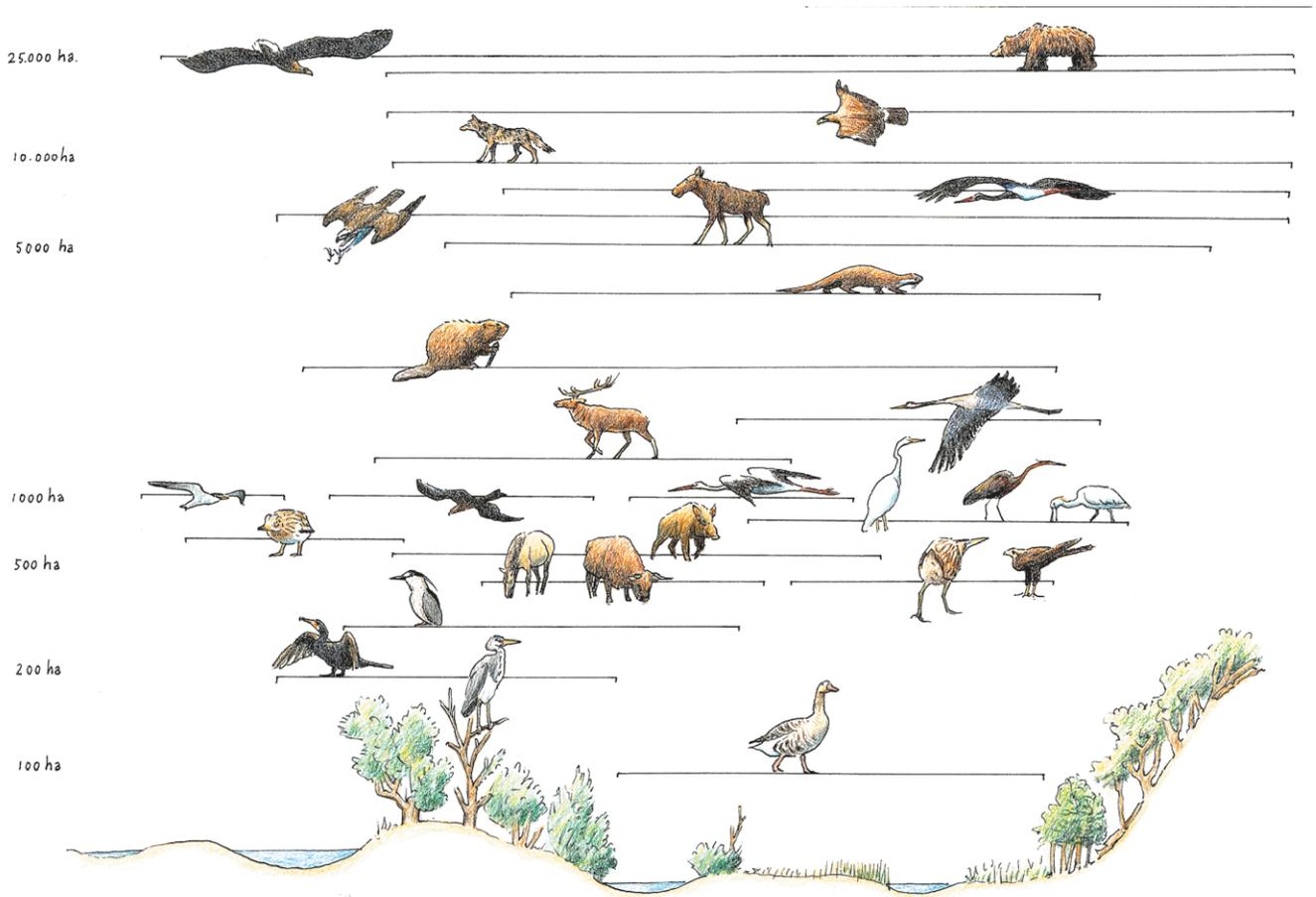
Here are some examples of species that have benefited from grazing. In recent years, the first breeding cases of the red-backed shrike have been observed in the River Park. This species likes to nest in thorny bushes that are ignored by the grazers and forages on all kinds of large insects that often live on open sandy and gravelly soils. Think, for example, of the large populations of blue-winged grasshoppers.



In spring, the oil beetle (*Meloe proscarabaeus*) is now a common sight in the natural sites, especially in the dry floodplain meadows. The larvae of this striking species live in nests of solitary bees. This group of insects benefits from the micro-dynamics of open soil and the small steep walls created by large grazers and wild boars. Numerous plant species also germinate in these new open spaces.



5. NATURAL AREA



This illustration of the habitat area for small viable populations of key target species depicted 30 years ago shows that the actual 1,500 ha of natural area offers a viable habitat for the beaver, common tern, black kite and wild boar. These species indeed have become re-established, and with the continuing increase of area, the River Park is gradually increasing the figure.

With some 1,500 ha of relatively wild nature, the Meuse Valley River Park is a growing nature core on the Dutch and Flemish sides of the river. It is not only the passing migratory birds that notice this. In the core area for nature that is gradually being created, river nature is developing where species such as the common tern, common sandpiper, black kite and beaver feel at home. This necessary space for undisturbed foraging and resting away from footpaths enabled the settlement of the originally projected ecosystem and food web, in accordance with the spatial habitat requirements of the critical target species. With the connection to neighbouring national parks, the red deer, crane, black stork, wolf and otter have also come into view in the Meuse valley. For

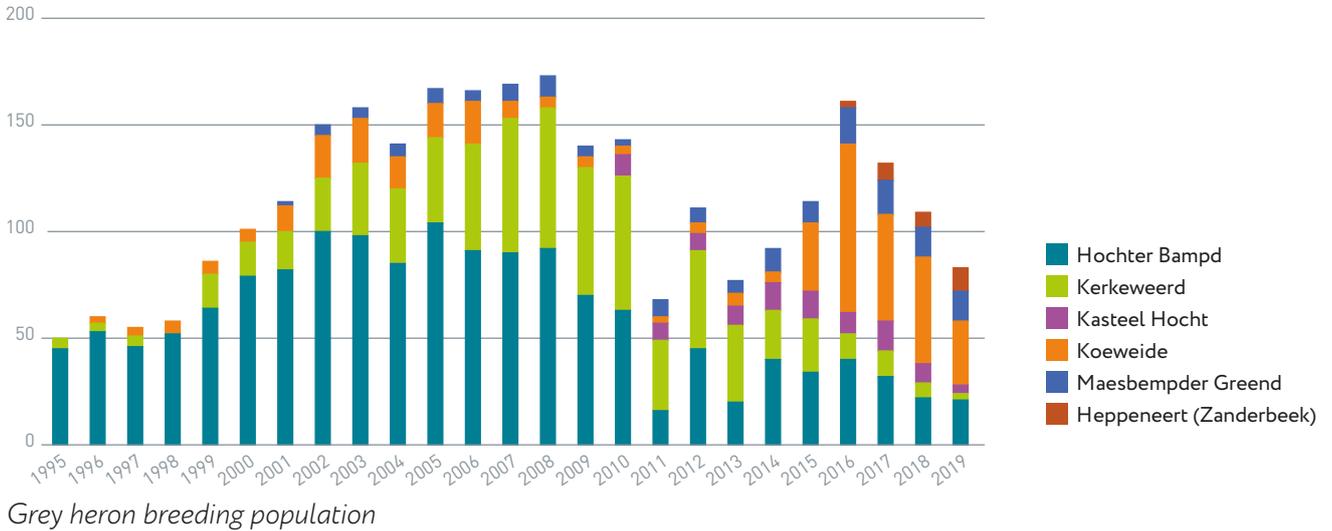


the future, expansion and connection to surrounding natural areas are possible, which makes it possible to aim for ospreys and white-tailed eagles in the area. The establishment and increase of some characteristic mammals (beavers, badgers and wild boar) and colony birds (the cormorant and grey heron) shows how species have profited from the growing area of the River Park. A key observation is the strong positive relationship between habitat area and species richness evolving.

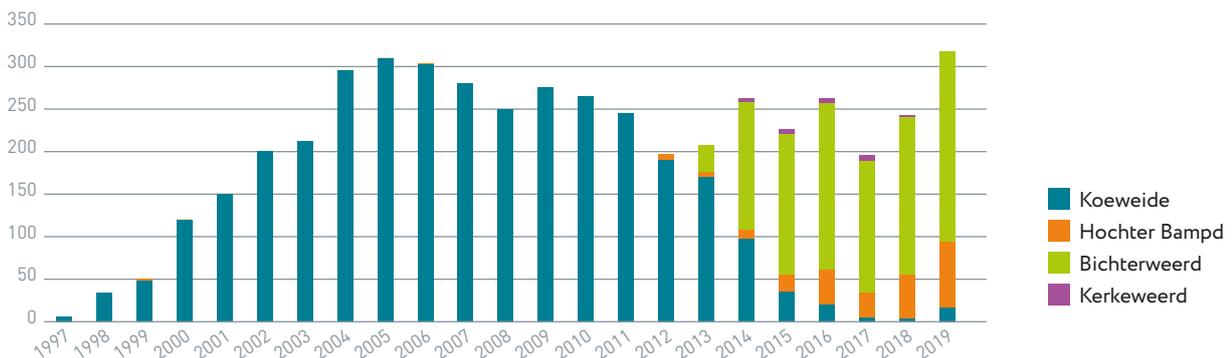
COLONIAL BREEDING BIRDS

The grey heron was the first colonial waterbird to recover in the area, exactly 30 years ago in 1991, with fast-growing colonies, first in one site, then expanding over the valley with a more diverse

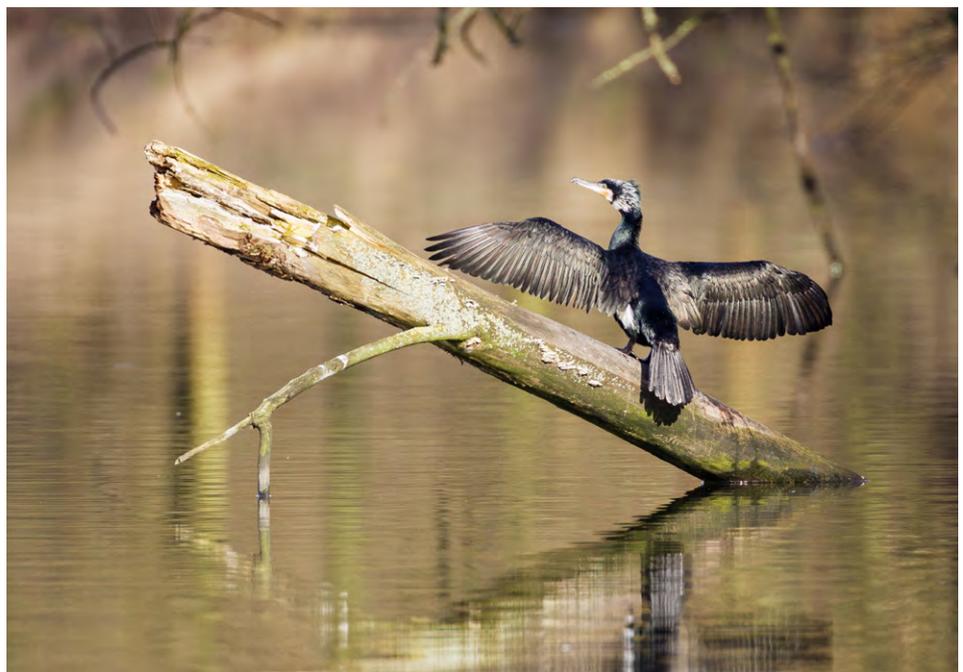
coverage of colonies over the area. The common cormorant followed ten years later, and shows the same image of a first strong settlement, followed by spreading over the valley.



Grey heron breeding population



Great cormorant breeding population



RESTORATION OF KEY SPECIES: REINTRODUCTION OF THE BEAVER AND BLACK POPLAR



With the Beaver also the opportunities for the European otter in the area improve



For the beaver, of which a few individuals arrived from the nearby Ruhr population, active reintroduction was carried out to strengthen the isolated specimens present. And the reinforcement worked very well. With only 5 beavers in 2008, the population now counts nearly 100 individuals and some 30 territories.

The Beaver a keystone species

black kite

When there is a lot of rain, beaver dams hold back the water in natural valleys. Thus there will be less flooding downstream.

Large grazers eat from twigs of the felled trees, the stumps regrowth, and the meadows that arise after departure of the beavers

Drowned trees are loved by woodpeckers and bats, and they serve as a lookout for birds of prey

kingfisher

middle spotted woodpecker

Martens find shelter in beaver burrows and profit, like kingfishers, from the temporarily ice-free state of beaver pools.

otter

Beaver pools filter the water

little grebe

young salmon

tree frog

skull cap

fish, amphibians, dragonflies, marsh plants, and water birds thrive in beaver pools

common frog

bandied damselfly

grass snake

ARK NATURE

Beaver territories in 2020



Another key species of the gravel river ecosystem is the black poplar, which, just like the beaver, needed a reintroduction in the area. Intensive research on the species revealed the success in its restoration even with strong pollen pressure of cultivars and hybridisation risks. The native *Populus nigra* appeared to reduce the spread of the exotic poplar species. Although significant gene flow from exotic poplars is observed in European floodplains, restoration programmes of the native *P. nigra* can vigorously outcompete the exotic gene flows and strongly reduce the impact of exotic *Populus* taxa on the softwood riparian forest development (Vanden Broeck et al. 2021).

The reintroduction of the black poplar was executed with plantings at the margin of the bank lowering, so that new seeding could immediately take place.



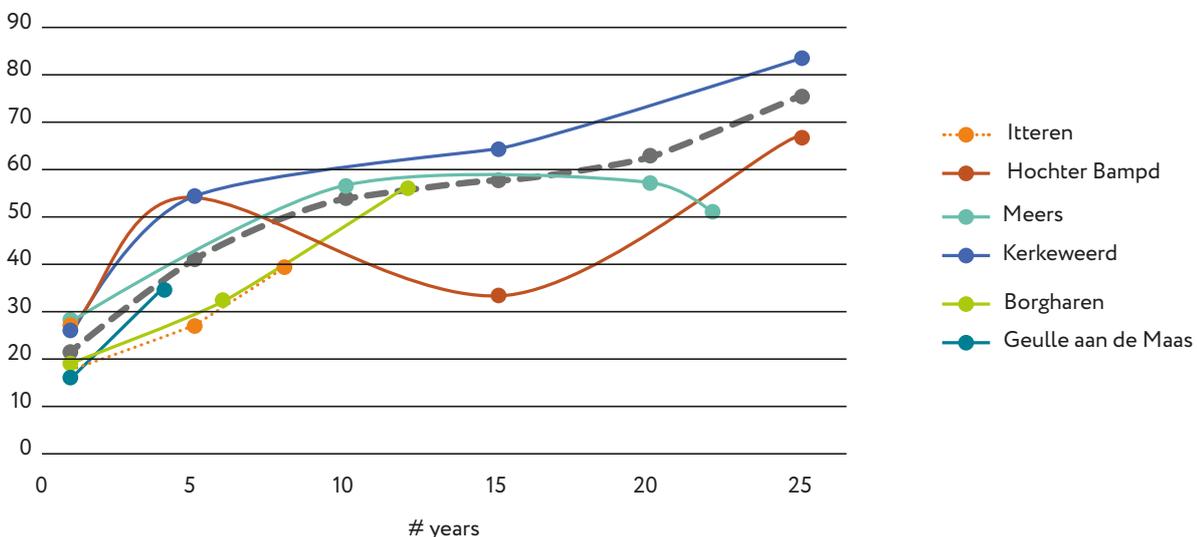
Go with the flow, black poplar shows the way

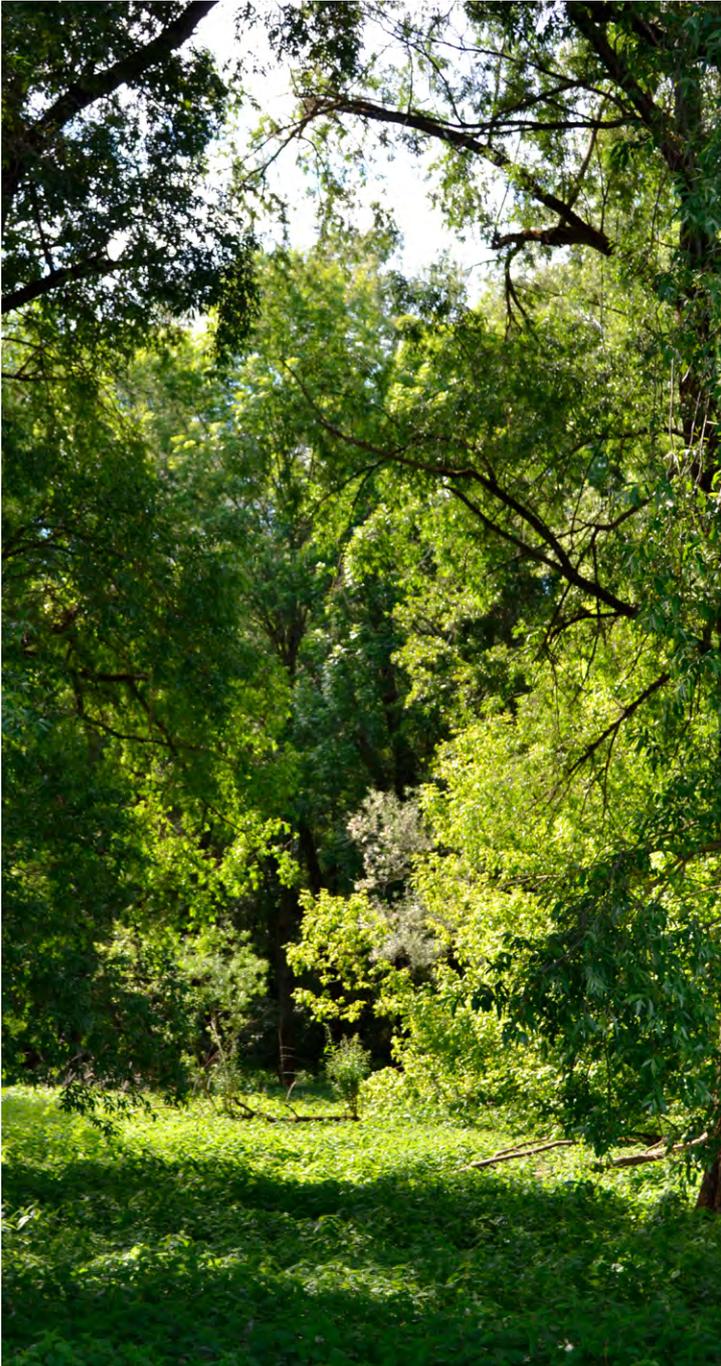
6. TIME OF DEVELOPMENT



The graph – and in particular the moving average curve in the dotted line – shows that the richness in characteristic species after the start of nature restoration doubled in the first 5 years, and tripled in 20 years. For the investigated sites, there are obviously some exceptions to the rule. The Hochtter Bampd site showed a drop back after 15 years of growth due to the high river embankment that was still present and caused strong

silty deposits. Lowering of the river bank 10 years ago showed a strong positive response and now the site is 'back on track'. For Meers, the restoration work is still in execution and this resulted in a small retreat, since some higher levees were excavated, and the restoration of especially these higher zones needs to restart in the site.





The epiphytic mosses that characterise the flood forests also showed a remarkable recovery in the area. Where the cultural landscape of the Meuse valley showed no more flooded forests, in the restoration sites the forests developed quickly, and the presence of the wooded upstream catchment enabled the prompt restoration of this species group. Even in the former monitoring round in 2008, some 80 species were documented for the forest of Hochter Bampd, and in a recent inventory some more very rare species (*Scleropodium cespitans*, *Dialytrichia mucronate*) were added to the already impressive list. The richness and species composition now strongly corresponds to that of the old growth flood forests of the Rhine. Also, the mosaics of grassland and shrubs need time to develop species-rich structures that attract many species of plants, insects and birds.

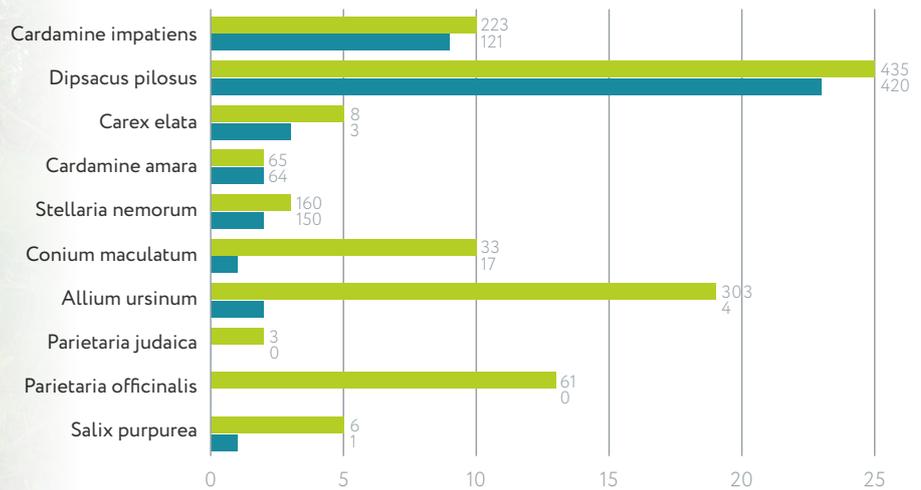
The habitats that need the most time to develop are definitely the woodland habitats, both for the vegetation structure to develop, and for soil formation. In the sites, we observe that, in the last decade, development made a strong surge in these habitats. The fringes and softwood forest types were already showing high quality a decade ago – with more new characteristic species arriving – but especially the hardwood forests clearly needed these 30 years and are seeing a remarkably strong expansion of characteristic species nowadays.



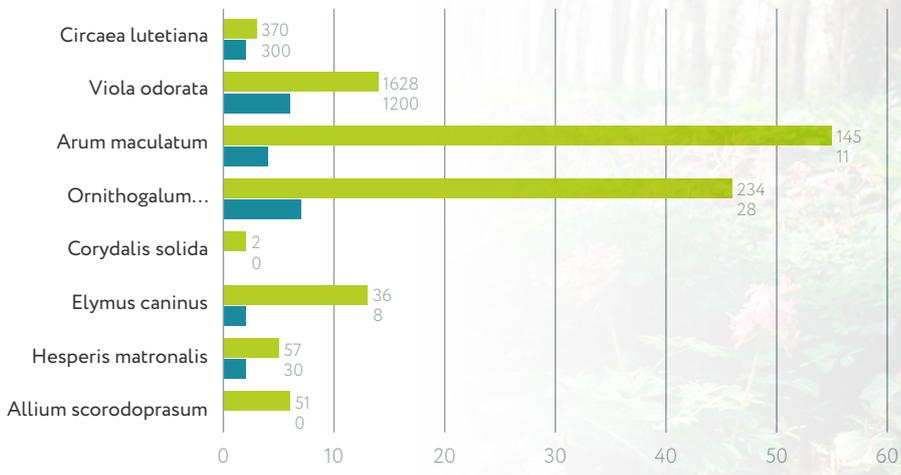
6430 Riparian tall herb fringes



91E0* Softwood forests



91F0 Riparian hardwood forests



locations 2019 2007



PEOPLE ARE CENTRAL TO RESTORATION SUCCESS

LOCAL ADOPTION AND APPRAISAL OF THE NATURAL RIVER PARK

The restoration of the river has also restored the local community's relationship with the river. Where people had turned away from the river ever since navigation had been abandoned, the river was restricted in a confined harness with huge dikes, and the once thriving fisherman's villages and little harbours died out, the image now has changed drastically. The overlooked small cores of the old villages are newly revived and the river is back in the people's hearts. A survey of a thousand valley residents conducted by 'Visit Flanders' showed a 90% appraisal of the nature restoration, and an equally high share of the local people responded by taking advantage of the new natural areas to go walking and biking.

When asked which aspects make the Meuse Valley River Park most attractive, the river views and the hiking and biking infrastructure scored at the same high level as peace and quiet, the natural areas and remarkably also the presence of wildlife. The inhabitants are therefore very fond of the nature restoration: no less than 92% of the respondents agree that the natural areas should

be enhanced, 91% want to continue enjoying it by walking or cycling, and 69% think that areas should have extra protection during the breeding season. Just over half of the inhabitants want to do their bit, for example by collecting litter on the banks (57%) and showing visitors the way (43%).

The shift toward rewilding even proves to lead to local societal benefits from new opportunities, e.g., ecotourism, alongside helping to maintain the often important cultural heritage associated with wildlife and natural habitats. In this setting, it was important to properly engage local communities and stakeholders, and consider how people and restoration efforts interact, and identify ways to avoid or overcome unwanted outcomes. The installation of the River Park Meuse Valley just did that, in combination with the investment in restoring cultural heritage and old villages, providing hiking and biking facilities and promoting the recreational tourism potential of the region.



The implementation of rewilding demands continued monitoring of ecological outcomes and socio-ecological dynamics to allow for adjustments via adaptive management if necessary. Importantly, with more and more people living in densely settled areas, rewilding offers possibilities for re-engaging with nature, positively affecting quality of life and mental health, especially if also implemented at smaller scales with heavily populated landscapes such as the Meuse valley.

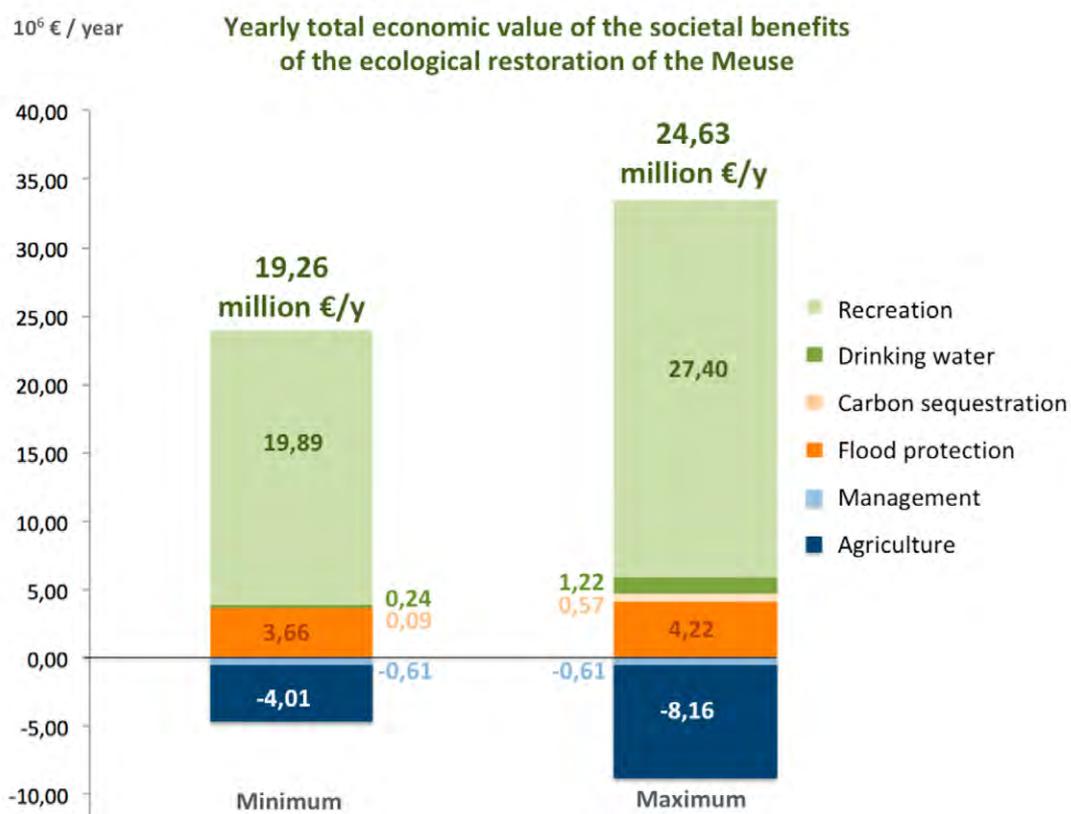
RECREATIONAL TOURISM AND ECONOMIC VALUE

With the restoration project, recreational tourism rediscovered the region. Nowadays, the valley of the Meuse annually receives more than a million visitors with the intention of experiencing nature, hiking or cycling. Based on the number of daily and overnight visitors and their average daily spending, the revenue for recreation with the principal aim of experiencing nature, hiking or cy-

cling results in some 25 million euros on a yearly basis (according to a study by Hasselt University).

Where these figures result from the strict survey of the nature-based revenues, the entire leisure economy of the Meuse region has benefited and currently amounts to more than 1 billion euros in revenues each year.





The yearly total economic value of the social benefits that were calculated for the effects of the restoration measures in the Meuse valley on recreation, drinking water provisioning, flood protection and carbon sequestration are expected to vary between € 19.26 million and € 24.63 million. Maintenance costs, management costs and the decrease in surface area of agricultural lands have been accounted for. Other societal benefits that were identified but not valued economically are expected to significantly increase the magnitude of the results.





CONCLUSION AND RECOMMENDATIONS

The river ecosystem has an exceptional capacity to restore itself, and especially with a little help in the success factors of providing space, connection, freedom for shifting and flooding, rewilding and time. A remarkable recovery was observed in plants and animals, in an abundance and richness that impresses both experts and occasional visitors or tourists.

We can raise some critical points for river ecosystem restoration in conclusion as well:

- Allowing erosion and bank retreat as basis for the hydromorphology and ecology at the basis of the ecosystem, feeding the river with the necessary sediment and woody debris that is at the basis of the shifting habitat mosaic and the ever-rejuvenating habitat patches both in the water and on land.
- Restoring the natural flow regime, solving the fluctuations and unnatural low flows and peak velocities due to upstream dams and weirs, and at the same time working on the hydrology at catchment level, to leverage the extended low flows.
- The events of July 2021 shows that not only low flows, but also extreme high flows will occur due to climate change. A further creation of flood-adapted nature can be an extra lever for the region's future.

COLOPHON

The following partners contributed to this brochure

- 4 nature conservation organisations who manage the nature areas and increasingly work towards an integrated management: Natuurmonumenten, Staatsbosbeheer (NL), Limburgs Landschap and Natuurpunt (BE).
- 2 river management authorities that initiated the close cross-border collaboration: De Vlaamse Waterweg and Rijkswaterstaat.
- ARK/WWF showing the way with their ideas and experiments, and continuing with a focus on education and awareness raising for ecosystem restoration
- the gravel extraction consortia involved in the realisation work: Consortium Grensmaas and Steen-goed
- Regional Landscape Kempen en Maasland, who have developed the river park, together with the 11 municipalities, 2 provinces and partners in tourism, heritage and nature
- Dutch and Belgian ecologists started with MaasinBeeld and other initiatives to investigate long-term ecological developments and communicate the results
- the project is also supported by the Research Institute for Nature and Forest INBO, by Rewilding Europe and, through LIFE IP Deltanatuur, is also supported by the EU
- Illustrations: Jeroen Helmer, Ark Nature Development
- Text: Kris Van Looy & Gijs Kurstjens
- Thanks also to 'reading commission' David Gilvear and Jochem Kail

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