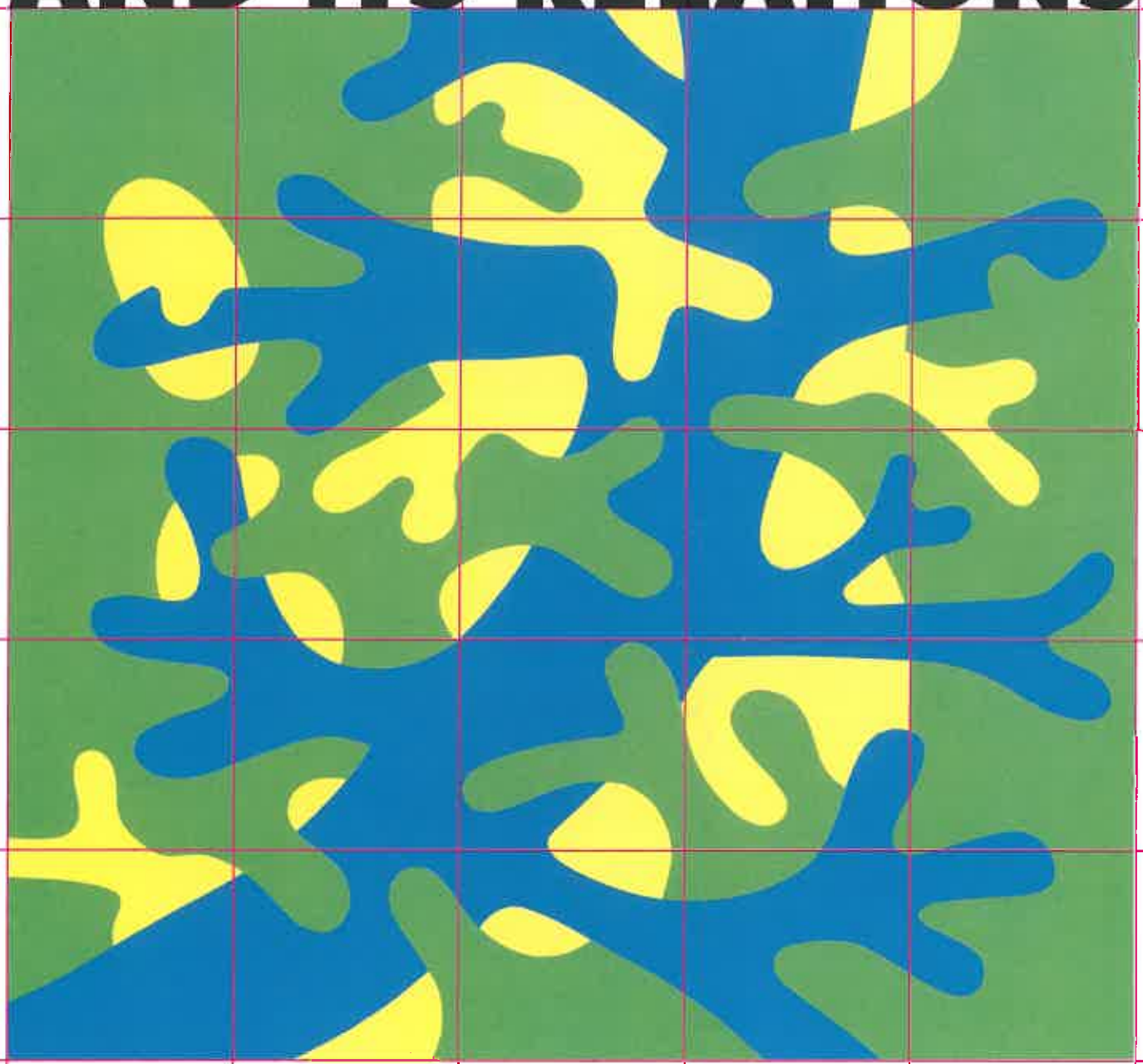
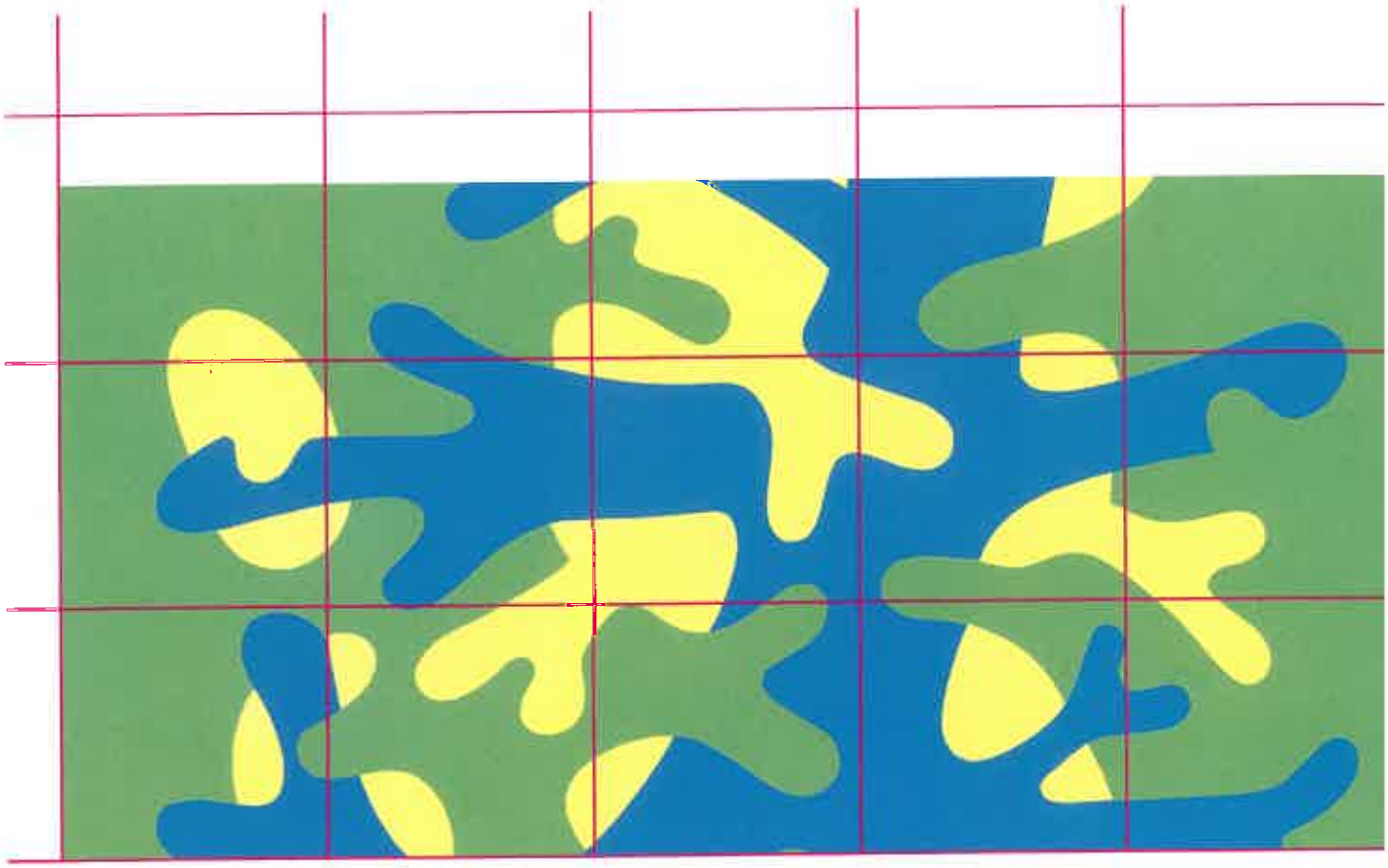
The Rhine A RIVER AND ITS RELATIONS



INTERNATIONALE KOMMISSION ZUM SCHUTZE DES RHEINS
INTERNATIONAL COMMISSION FOR THE PROTECTION OF THE RHINE



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Heinrich Heine (1844)
Welcome, oh Father Rhine
How have you been doing?
Often have I thought of you,
impatiently and full of nostalgia

How is Father Rhine doing? His waters have become much cleaner, more and more salmons migrate from the sea as far upstream as the Upper Rhine.

The Iffezheim barrage weir interrupts migration, but a fish passage is under construction. The final sprint for the "Salmon 2000" programme - but what then? May we lean back and rest on the laurels of a model river remediation?

The Rhine has already replied. After the first success of the Rhine Action Programme "Salmon 2000" the canalized river uttered its discontent with great floodings. The riparian states have understood the warning signals. Extreme floodings would endanger millions of people and assets worth billions in the Rhine floodplains. Therefore, the International Commission for the Protection of the Rhine (ICPR) has drafted an **Action Plan on Flood Defence** and developed an integrated programme for the Rhine and its alluvial areas.

The economic performances of people along the Rhine during the last two thousand years have been considerable. However, ignoring their chains of manifestation, man interfered with complex natural cycles. Age-old relations were torn apart and the Rhine ecosystem lost its balance. There must be a way permitting the use of the Rhine in line with nature and socio-economic requirements. At the outcome of the 1992 Rio de Janeiro meeting, the states of the world agreed on **sustainable development**. Transboundary **river management** as the ICPR practises for the Rhine and as the European Union pursues for the whole of Europe may implement sustainable water policy.

1. **Resources** – How we use the Rhine

There are different reasons for the Rhine developing into an economic axis in Europe. The decisive factors were above all the water way and the Rhine as a source of the raw material water. The diversity of the city cultures on its banks since the Middle Ages also had its part.

From Basle to Rotterdam industrial centres developed as pearls on a lace. Today the Rhine is the most heavily used river with the greatest diversity of use throughout Europe. It flows through four countries, nine countries have part in its watershed.

Victor Hugo (1839)
„... I love rivers, carrying ideas as well as goods ... of all rivers I most love the Rhine"

From the second half of the 19th century, the development of the Rhine into a waterway and the construction of harbours, railroads and roads turned the Rhine valley into the traffic axis it is today. Two main industries have developed from the formerly great commercial diversity with textile industry in a leading position: heavy industry and chemical industry. The latter often developed from dye-works supplying the textile industry. For the chemical industry, the Rhine developed to an important site factor as it allowed the transportation of raw materials and products and it was also a source of cooling and process water and of disposing of the waste water.

In the 20th century, the Rhine additionally developed into a centre of energy: electrical networks as well as numerous coal and nuclear power stations were built, along with refineries and petroleum and natural gas pipelines.

Old relations with the Rhine

But man's relation with the Rhine goes further back in time. 2000 years ago, people along the Rhine cherished the river as god „Rhenus". During the first wars man fought tough battles along the Rhine frontier and Cesar reported of women's prophecies from „whirls, meanders and roars" of the river.

People believed in the divine forces of the river at least up to the Middle Ages.

Roman rivergod *Rhenus*

Ancient names
Celtic: *Renos* (=flowing water, river, sea)
Latin: *Rhenus*

Francesco Petrarca (1333)
on the Rhine near Cologne:
"The banks were entirely covered by a huge, gleaming crowd of women. ... In the gay medley they washed their white hands and arms in the torrential stream ... it was said to be an age-old custom ... and possibly threatening disaster is being rinsed away by the washing in the river this very day."

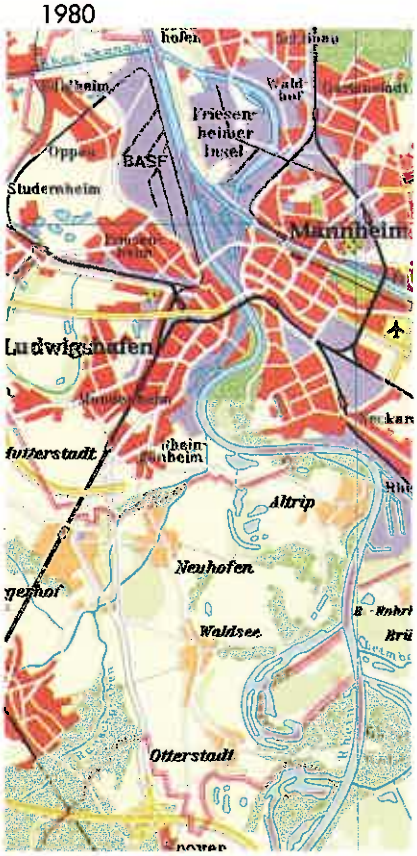
As the Rhine landscape changed more and more with the beginning of the Industrial Age, poets and painters of the Romantic Age recalled the natural beauty of its valley, they were the first tourists to travel through it and they often regretted the loss of nature.
Maps of the Upper Rhine near Mannheim show the rapid increase in population and urban settlements.

Right until 200 years ago, as long as the Rhine was a torrential stream, its natural riches fed primeval trades: salmon fishermen, bird catchers and gold washers.

Robert Lauterborn (1938):
on the Upper Rhine until the beginning of the 19th century:
"Boatmen and raftsmen, silently gliding downstream, some salmon fishermen on the banks in their reed huts wrapped up in nets, gold-washers and fowlers on the gravel banks, the gold-washers tirelessly pouring one shovel of gravel or sand after the other onto the wash bank, the fowler silently and patiently trying to bait the by-passing flocks of Nordic ducks into their nets. All these figures and professions which have remained the same since ancestral days."

1850

1980



Heinrich Böll (1977):
"I spent the major part of my childhood and youth along the Rhine. Just sitting on its banks, watching the ships.
The cosmopolitan aspect of this act probably deeply impressed and marked me."

The Middle Rhine at the Loreley rock

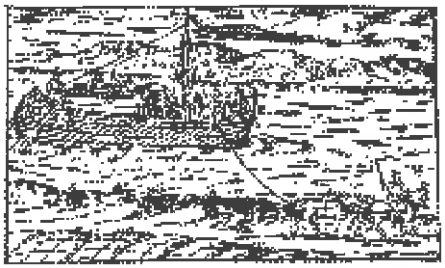
Free passage for ships

The first boatmen on the Rhine were Ice Age hunters travelling on the Rhine in dug-outs some 12,000 years ago. Later on, Celts and Romans turned the Rhine into a trade way with their rowing boats and the first cargo vessels. Rafting of timber equally began in Roman times. From the Middle Ages on, traders used vessels to sail or to tow which after 1820 were replaced by steam vessels. After 1900 motor boats capable of transporting several thousands of tons replaced the steam vessels.

Erich Kästner (1932) on the Loreley:
We are changing. So are the vessels. The Rhine is straightened and dammed. Time goes by. You no longer die while shipping, just because a fair woman continually combs her hair.

The free passage of the vessels was more and more often impeded by the *"multitude of dynasties"* as the French historian Lucien Febvre called it. *"In 1789 there were 97 'sovereign' states on the banks of the Rhine between the R. Lauter and the IJssel"*. The 1814 Paris Peace Treaty and the 1886 Mannheim Act of the Rhine bordering countries granted free traffic for vessels on the Rhine.

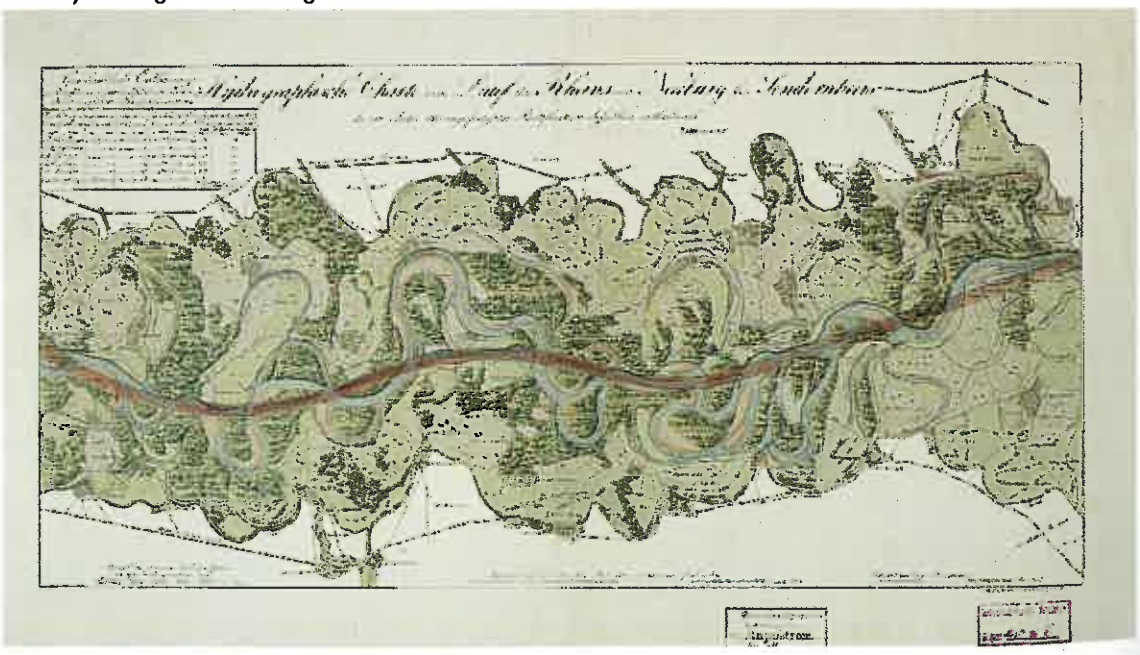
When the hydraulics engineers forced the torrential stream into a stable bed and fixed its course to gain land, they more or less improved navigation as a by-product. It was not until the Rhine was developed into a major waterway - e.g. by improving the dangerous narrow stretch along the Loreley - that the Rhine became one of the world-wide most trafficked waterways with Duisburg as the largest inland port and Rotterdam as the largest sea port. The vessels transport raw materials and goods, many dangerous chemical substances and - last but not least - tourists. Annually, some 200.000 vessels cross the German-Dutch border transporting about 140 million tons of cargo, above all construction material, petrochemical products, ore and charcoal.



Towing on the Rhine around 1600

Victor Hugo (1839), Andernach
"On the other bank of the Rhine, at the foot of a high and dull hillside, thirteen horses slowly towed another ship upstream. Its huge triangular sails were filled by the evening winds, helping the horses with their task. The measured steps of the teams, the sound of their bells and the cracking of whips came across to me."

The straightening of the Upper Rhine by the engineer Tulla began in 1817



Silver salmon were the gold of the Rhine

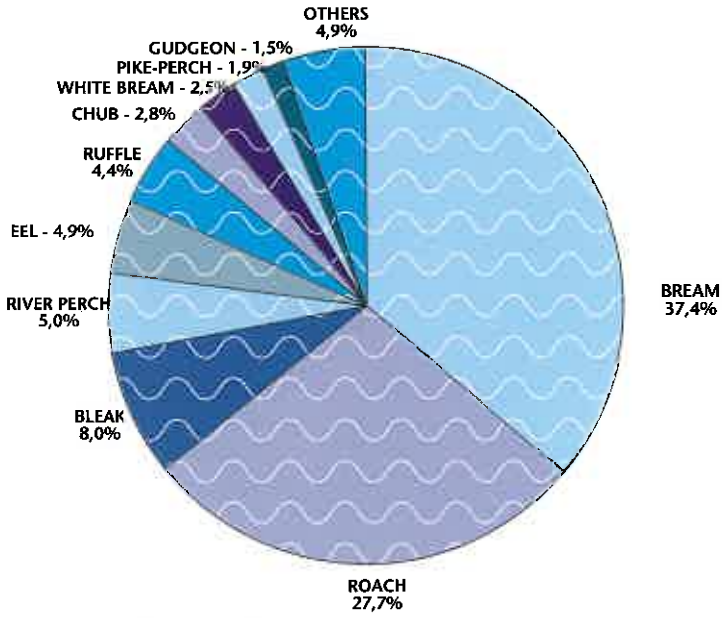
Right up to the end of the 18th century the Rhine, abounding in fish, was an important source of food. It was said to be Europe's best salmon river and until the end of the 19th century fishery was considered to be a gold mine.

Fisherman with salmon on the Lower Rhine near Xanten 1934

Victor Hugo (1839)
near St. Goar:
"From time to time, halfways hidden below brambles and willow bushes and almost lying in ambush, a sort of gigantic spider appears. ... This spider is a jumping net. Some time later the mysterious lifting stick limps up in this silent loneliness, the loathsome animal rises, holding a net between its four legs, in the middle of which a beautiful silver salmon twists and jumps."

Formerly, there were hundreds of professional fishermen from the Upper to the Lower Rhine, today there are only a few of them. Angling as leisure occupation has clearly increased. Some 200.000 anglers are recorded along the Rhine.

In the 1920s, salmon fishermen on the Lower Rhine complained about the bad taste of the fish due to the discharge of phenol containing wastewater from the Ruhr area.
Today Rhine fish no longer taste of phenol and contain considerably less residue contamination with heavy metals and chlorine organic substances than only some years ago.



Today about 45 fish species are living in the Rhine. Due to the monotonous structure of the Rhine, most of them are modest white fish species.

Pure Rhine water is worth gold

People living on the banks of the Rhine did probably not use to drink water directly from the Rhine. Even the clean Rhine carried along too much suspended matter.
20 million of the 50 million people today living in the Rhine catchment area **drink** purified Rhine water which is mostly gained from riverbank filtrate. As a matter of precaution the water works pass the water through activated carbon filters. Still, drinking water from water works is examined closer than most other beverages.

Since the Middle Ages, hygienic conditions must have stunk to high heaven in the towns on the banks of the Rhine. But right up to the 19th century there was no sewerage so that no effluents were discharged into the Rhine. Floodings, however, had to swallow a lot.

It was not until the second half of the 19th century that the Rhine served as washing machine and sewage channel. In 1901 the development of the Rhine into a *"sewer"* was a topic of discussion in the German Reichstag. Upon this discussion, the Reichsgesundheitsrat gave order to canvas the Rhine and found a red sewage plume between Ludwigshafen and Worms. The city of Frankental discharged *"dirty waters carrying a medley of floating rests of dirt", the Mannheim paper pulp industry added "yellowish waters".*

Victor Hugo (1839)
about Wellmich on the Middle Rhine:
"On the banks of the Rhine young laundresses are chatting, gaily beating their linen in the sun."

water works

Samuel Taylor Coleridge (1798):
The River Rhine, it is well known,
Doth wash your City of Cologne;
But tell me, Nymphs? What power divine
Shall hence forth wash the River Rhine?

Wolfgang Koeppen (1953):
"On the roads along the Rhine black Mercedes roar downstream beside the waters. Downstream the sludge, downstream the driftwood, downstream the bacteria, downstream the excrements and the lyes of industry."

Landfill "de Slufter" in Rotterdam

In 1976, at the peak of the Rhine pollution, even the German Home Office stated under the title *"Just dump it into the Rhine": "The salmon age belongs to the past. Instead, the sewage fungus Sphaerotilus thrives abundantly."*

In the meantime, Rhine water quality has considerably improved. Formerly, the city of Rotterdam annually had to dredge 10 million m3 of contaminated sludge out of the Rotterdam harbour basin which were then tipped into the hazardous 200 million-guilder waste landfill "de Slufter". Today "only" 5 million m3 of sludge are being disposed in this depot.

Today, more than 90 % of the waste-water generated by industry, trade and households in the Rhine area is cleaned by wastewater purification plants. However, the diffuse inputs of pollutants trouble the water quality. Precautionary action and close surveillance by administration must be carried on. The contamination of the Rhine with heavy metals and many pollutants has decreased, the oxygen content and the species number of micro-organisms living in the river bed have increased. There are many adaptable new species among them, e.g. mussels, snails and small crustaceans from the Caspian Sea, North America and Asia which have come through the canals and with ships.

From 1990 to 1995 the basket clam *Corbicula fluminea*, originally at home in East Asia, came upstream the Rhine from the estuary to Basle and is, in certain stretches, the most frequent mussel species.

The tamed river - a source of power

Alfons Paquet (1923):
"... thus a collective and Faustian fantasy is planning the engineerlike development of the river, being unchained and tamed at the same time." (...)
"The hydraulic power of the Upper Rhine corresponds to the intensity of combustion resting in the inexhaustible stocks of a gigantic coal mine."

The Laufen-Falls at Laufenburg around 1850 with "salmon scales" on the banks

Laufenburg hydroelectric power plant today

As early as the Middle Ages many water mills in the Rhine area exploited hydraulic power. They converted it into mechanical energy in order to grind corn and quartz, to saw wood or to crush ore.

With a view to gaining electric power with the recently invented turbines the Swiss started to turn the Upper Rhine into a succession of lakes towards the end of the 19th century. The barrage weirs of 11 hydro-electric power stations drowned waterfalls and cataracts. Thus, in 1914, the well-known Laufen (rapids) of Laufenburg vanished. Today, only 4 stretches with free flow are left on the High Rhine, upstream the Falls of Schaffhausen and at the confluences of the Rhine with the Rivers Thur and Aare. The hydroelectric power plants on the High Rhine barred the salmon migration route towards the old spawning grounds in the River Aare and other affluents.

The development with a view to exploiting hydroelectric power on the Upper Rhine started in 1928. Four hydroelectric power stations were built in a canal parallel to the Rhine, thus almost drying up the old bed of the Rhine we today call "Restrhein". In the following section up to Strasbourg, four hydroelectric power stations with "canal loops" were built. Downstream of this section two further power stations were built in the canalized Rhine itself, 1974 in Gambsheim and 1977 in Iffezheim. These too represent insurmountable barriers for migratory fish such as the salmon.

Rich land on the riverside

40 % of the surface of the Rhine catchment area are exploited by agriculture. Passing by ground and surface water, all those fields, meadows and vineyards dewater into the Rhine. Prior to the regulation of the Rhine, floodings carrying along polytrophic fine sediments naturally fertilized the Rhine floodplains.

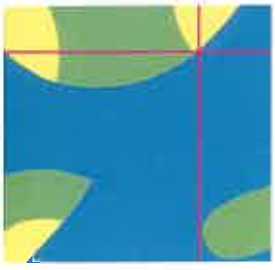
Prior to its regulation, the Russian author Karamsin travelled through the Upper Rhine valley between Mainz and Mannheim and also experienced the threatening effect of the floods in the fertile "rich plains". This "voice of the water", as the expressionist poet Hendrik Marsman called it, still particularly characterizes the Rhine delta area in the Netherlands.

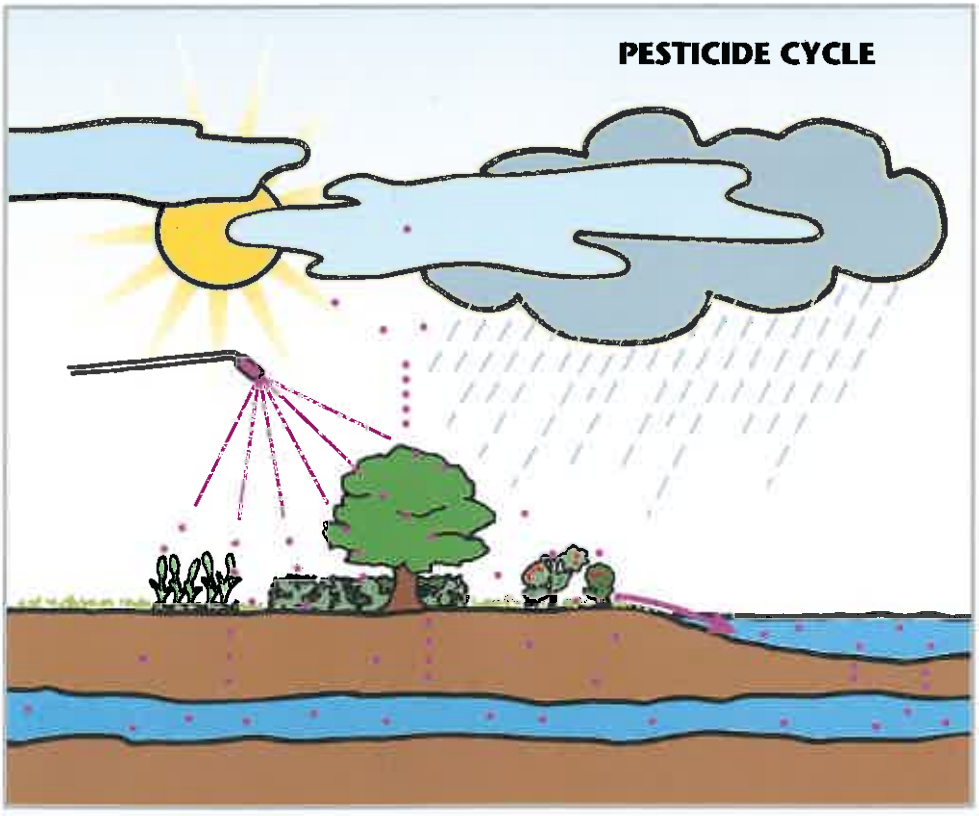
Agriculture and viticulture are today most profitable and most intensive in the floodplains along the Upper and Lower Rhine, in the drained marshes of the Delta Rhine and on the steep slopes of the Moselle and the Middle Rhine.

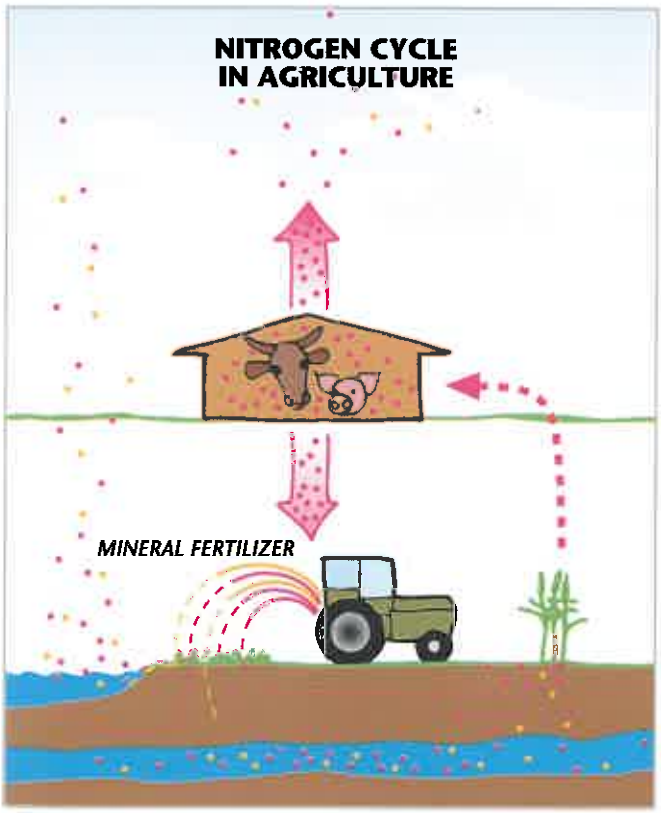
Hendrik Marsman (1899 - 1940):
Thinking of Holland
I see broad streams
lazily flowing
through wide lowlands (...)
And farms,
sunk deep
in the enormous space (...)
The skies hang low
and the sun
gradually wraps up
in many coloured grey
everywhere
the voice of the water,
eternally portentous,
eternally feared.

Nikolaj Michailowitsch Karamsin (1766):
"Heavy rain had caused the Rivers Rhine and Neckar to swell enormously, their devastating waves flooded gardens, fields and villages. Part of a demolished house floated here, ... There a poor bleating sheep was carried away by the waves. - At certain places we had to drive through the waters which sometimes even penetrated into the car . ... when the car turned into a long avenue beginning about three werst off Mannheim. Along the entire way, water was standing up to this avenue which resembled a bridge, since the water was quite calm."

Upper Rhine south of Iffezheim

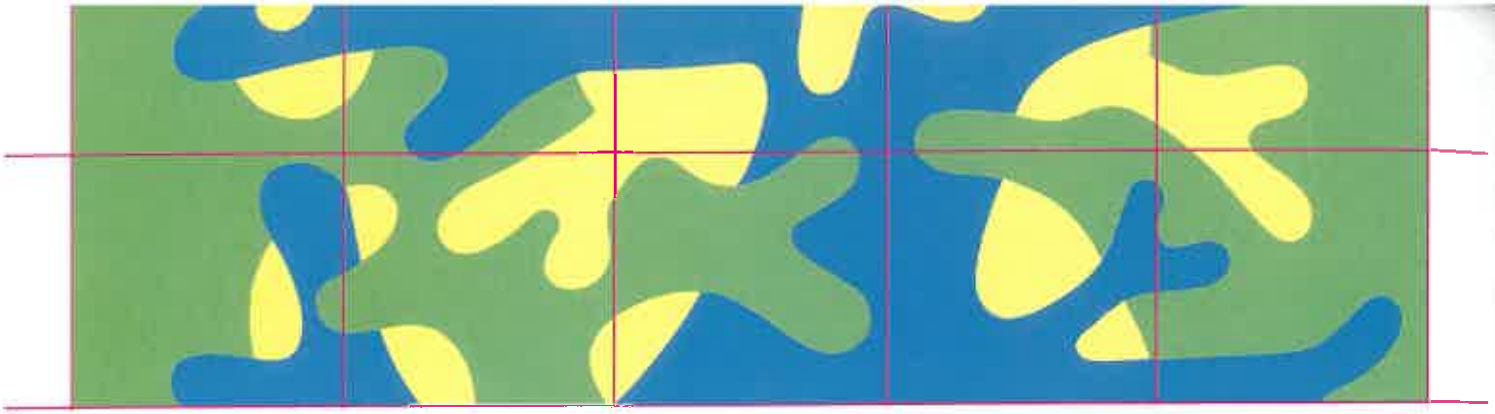






Too intensive agriculture often interferes with water bodies and its biocenoses due to fertilizers and biocides, erosion and uniform landscapes..

In the same way, other uses may harm the Rhine and its floodplains. River development cuts off backwaters, which are then filled in by sedimentation or silt more rapidly. Barrage weirs turn the rivers into a chain of lakes, hinder fish migration and lead to a deepening of the riverbed downstream of the weirs, so that the water table of the valley sinks in line with the river. Dyking and construction in the floodplains lead to higher flood waves and tear apart the ecological inter-relationships between the Rhine and the surrounding land.



2. The Rhine and its nature – the ecological network

Biologically, we may consider the Rhine as an ecosystem, as a network of inter-relations between its habitats and living organisms, its energy and material cycles which open towards the exterior and change in the course of time.

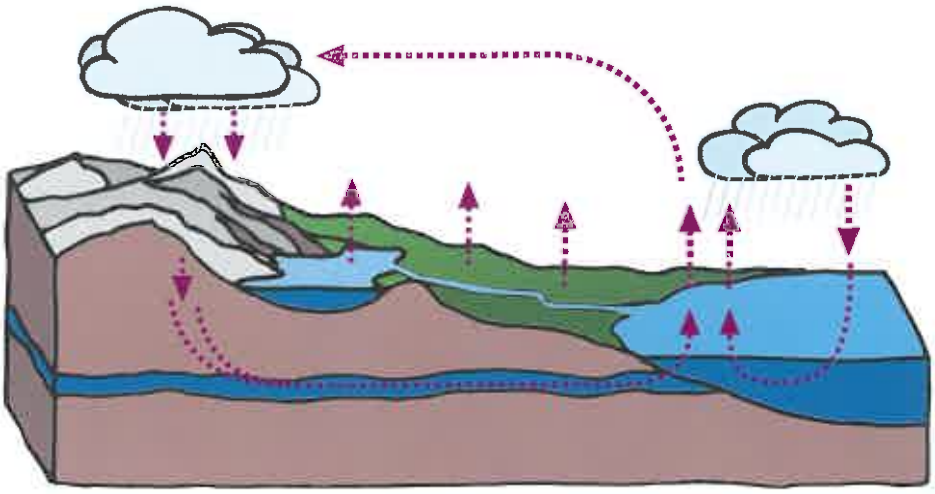
People are part of the Rhine ecosystem and have taken great influence on it. On the other hand, the river influences us, as historians such as Lucien Febvre say: even though, at times, the Rhine separated people, its great special feature is to unite and to reconcile, to promote intellectual and material exchanges.

Berndt Heydemann (1997):
"Ecology is nothing but biological economy."
"... species join to ecosystems comparable to geographical core areas and an economic network."

A stream such as the Rhine shows the typical characteristics of an ecosystem, that is openness, dynamics and network development much more clearly than e. g. a lake. Nevertheless, it is only in the recent past that we have again begun to consider its landscape as a whole.

2 500 years ago, the Greek philosopher Heraklit is said to have said *"Pantha rei - everything flows"*. The biochemist Erwin Chargaff recently wrote *"Flowing while remaining is a sign of life"*. But it is still a mystery in what way the dynamic balance of energy, matter and information works in the ecosystems of our earth. The Dutch poet van den Vondel was probably among the first to describe the well-known **water cycle**.

ecosystem
originally Greek:
oikos = house, belonging to the household
systema = aggregated whole



Joost van den Vondel (1667)
"A network of veins streams through our body like thousands of water veins stream through the earth. The beaming sun draws its steam from the oceans, concentrated in clouds it falls down as rain."

Jan van Goyen (1652)

"The ground water: a hidden pillow"

Ground water connects a river with its valley, since there is a constant exchange between the two. At times of mean water level, the ground water flows underground with the river. During times of low water level, the ground water supplies the river and during floods water flows from the river into the ground water.
Apart from that, new ground water arises from precipitations penetrating into the soil, gathering over impermeable layers, such as clay. In places where the ground water table is close under the surface of the earth, as is the case in the shoulder hollows of the Rhine floodplains, a particular vegetation may grow in valley bogs and fen carrs.

Where ground water seeps, a **spring** rises and a brook begins. There are marshy pool springs, cataract springs, seeping springs or bog springs. The temperature of the spring hardly varies, which is why it appears to be cold in summer and warm in winter. The filling of the springs naturally depends on the precipitations, the water seepage in the soil, the movement of the ground water and the ground water table.

Alfons Paquet (1923):
... the mild firmness of the current and its hidden pillow, the ground water, providing fields, villages and towns with wells."

" A splendidly created water life"

The Rhine is not only made up of the main stream and the glacier sources in the Alps, but of thousands of sources in its **catchment area** with hundreds of brooks, affluents and lakes. In this net of water bodies water flows in every direction, but always downstream towards the sea.

Alfons Paquet (1923):
"On the map, the Rhine looks like a tree. Its sources are the roots, its affluents are the branches of the stem, its many delta branches are the crown. It is an organism, indeed ... It is a system, a splendidly created water life in the middle of the country ..."

Delta Rhine

Lower Rhine

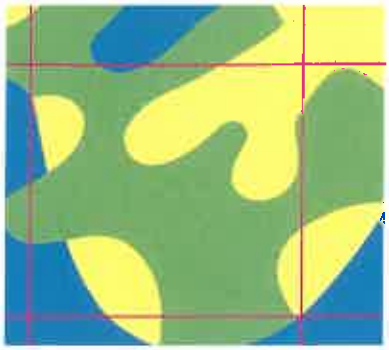
Middle Rhine

Upper Rhine

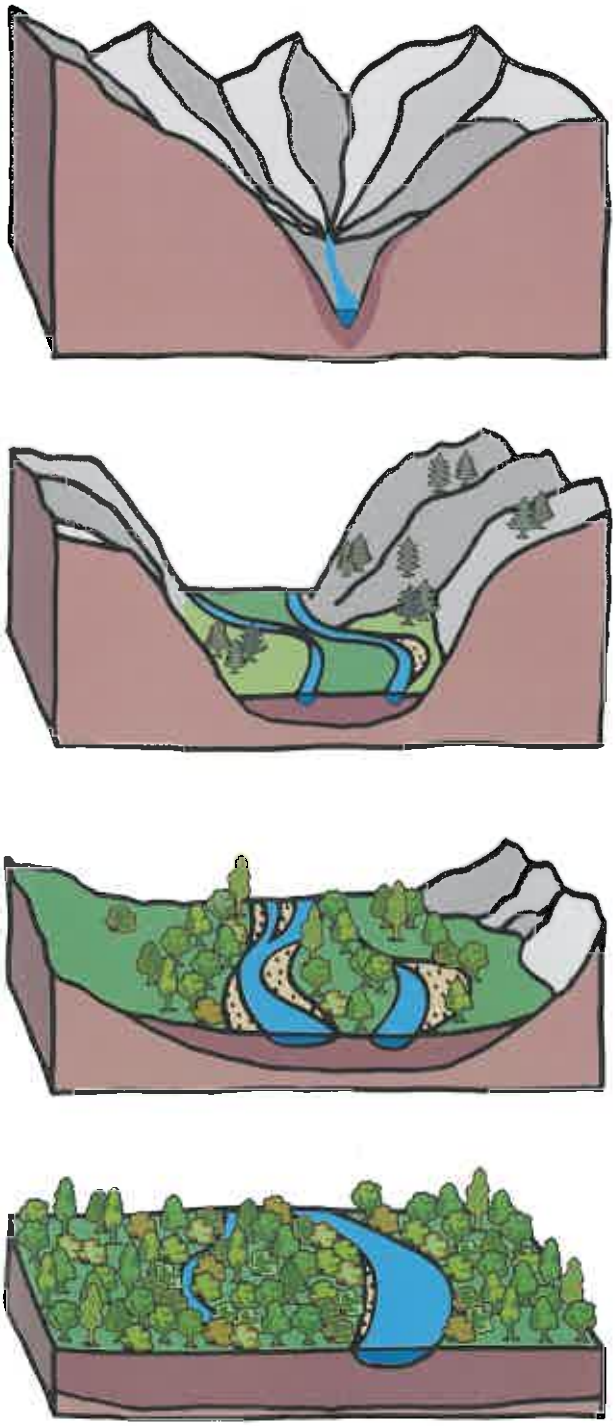
High Rhine

The Rhine catchment area:
total surface 185.000 km²
Germany: about 100.000 km²
Switzerland, France,
Netherlands: about 20 - 30.000 km² each
Italy, Austria, Liechtenstein,
Luxembourg, Belgium: about 10.000 km²

In the course of the history of the earth the Rhine has changed its appearance, it has grown like a tree. 5 million years ago, the primeval Rhine (Ur-Rhein) had its source at the Kaiserstuhl and flowed into the sea even before the present German-Dutch border. Later on, its watershed grew to comprise the River Aare and the Alp Rhine which had earlier joined the Rhône and the Danube.

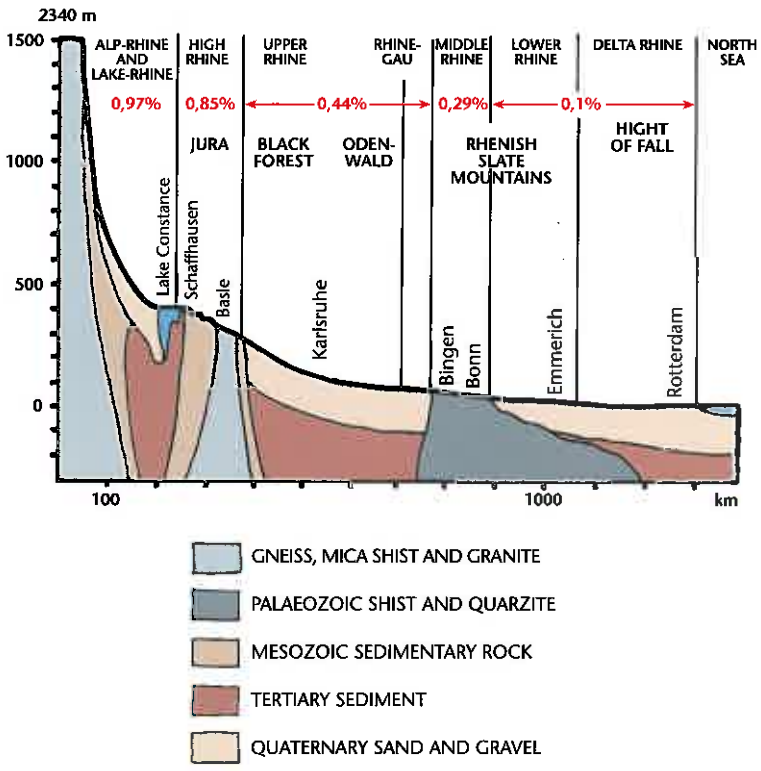


Until quite recently, the geological history of the Rhine was reflected by the **dispersal pattern of its fauna**. The correction of the Rhine and the stocking with fish has however almost wiped out the memory of the river, as these actions uniformed the main stream. Formerly, there was an invisible frontier in the middle of the Upper Rhine, which splitted the spreading of certain species of snails, mussels, even fish. The northern species belonged to the fauna of the primeval Rhine with the Rivers Kinzig and Lower Neckar as its roots, the southern species belonged to the formerly separate Rhine system of the Rivers Ill, Aare and the Alp Rhine.



Cross-sections of a natural river landscape

Longitudinal profile of the Rhine



Habitat patch connectivity in streams

The natural ecosystem of flowing waters may be considered as a *continuous whole*, which gradually changes with the gradient. Three sections may be distinguished: the upper, the middle and the lower reaches with the index fish species trout, umber, barbel and bream. The "mincing species" living of the leaves falling from the trees are typical groups of micro-organisms living in the river bottom of the upper reaches. In the broader and sunny middle reaches the "grazing species" are the typical micro-organisms living on the algae growing on stones. Suspended algae, the so-called phytoplancton serving as food for minuscule crustaceans of the zooplankton thrive in slowly flowing waters and in backwaters. In the lower reaches the bottom-dwelling fauna almost exclusively consists of "gatherers or filter-feeders" which only make up half of the fauna further upstream.

The larva of the Rhine-ephemera Oligoneuriella rhenana was formerly abundantly present in the Rhine, today it is only found in the affluents

Ragnar Kinzelbach (1992):
"The losses and increases of species in the Rhine have changed its fauna more lastingly during the past 150 years than did the 10.000 years since the stabilization of the river system, following the last Ice Age."

The ecological longitudinal segmentation may hardly be traced in today's Rhine system. River development has suppressed specialized species, which e.g. depend on a complex benthic structure. Thus, many species belonging to the group of stone flies may no longer be found. Within the framework of the ICPR Rhine Action Programme more than 200 species of bottom-dwelling micro-organisms were inventoried in the Rhine between Lake Constance and the North Sea in 1990 and in 1995.

The river biocenoses have perfectly developed the strategy of a rapid **recolonization** after natural disasters, such as floodings or low water. Micro-organisms then return from the layer between the river bottom an the ground water *(hyporheal layer)* where even fish larvae, e.g. of salmon may hide in sandfilled interstices up to 30 centimetres below the river bottom. Apart from that, life in rivers may be restored due to passive drifting downstream and to active movement upstream (fish, crustaceans) and above the water surface (insects). Seeds and insects reach new banks when travelling on floodwaves or on flotsam. However, river regulation, the construction of dikes and impoundments heavily hinder migration.

Technical river regulation and impoundments interfere with or reduce:

- river dynamics
- river bank vegetation
- relationships between the river and its floodplains
- migration of aquatic organisms
- natural species diversity

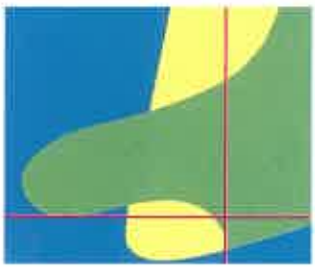
"Intact alluvial areas are like the Wadden Sea"

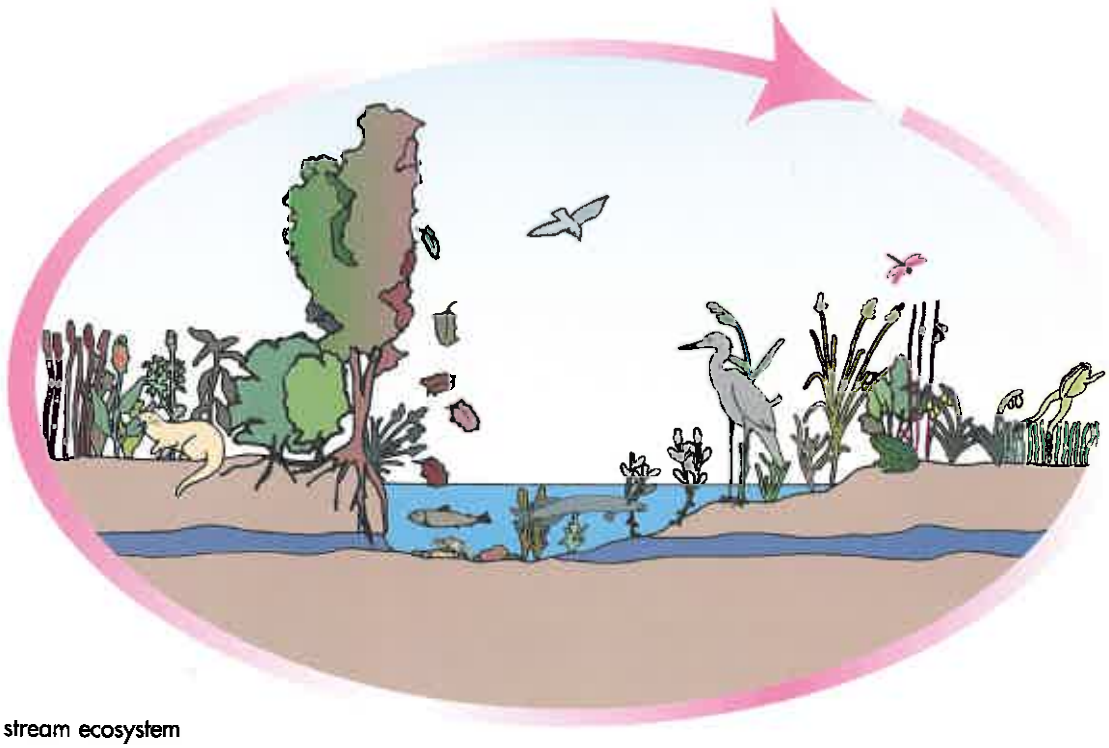
The floodplain or the zone of water exchange in the river valley is influenced by floodings. It is a zone of contact between river and land from where species may spread. In the headwaters of brooks this zone is by nature narrow, along the river it may cover kilometres.

Trees growing along the brooks give shade, keep their temperature low and protect the banks against erosion. Leaves and insects falling into it feed the aquatic microfauna. Together with the Wadden Sea, the rivers and their floodplains originally formed the most productive ecosystems in Europe with the greatest species diversity. Due to their elevated biological activity, riverside soils figure among the most fertile ones. Biocenoses of floodplains and rivers are interconnected by a diversified network.

Floodplains and riparian zones are exposed to a continuous fluctuation of humidity and aridity, of sedimentation and erosion, of nutrient inputs and leaching. Plant and animal communities have adapted themselves to such dynamics; they do not only tolerate them, but they even depend on them for their survival.

Henri Décamps (1996):
"Most of the processes involved in the structure and function of river ecosystems are controlled by floodplain forests."





stream ecosystem

Herwig Klemp (1997):
"Intact floodplains are like the Wadden Sea: Both are inconceivable without the continuous rise and fall of the water, but the variation of water level is much more irregular in the floodplains than that of ebb and tide."

little bittern

British inula

euphorbia

bluethroat

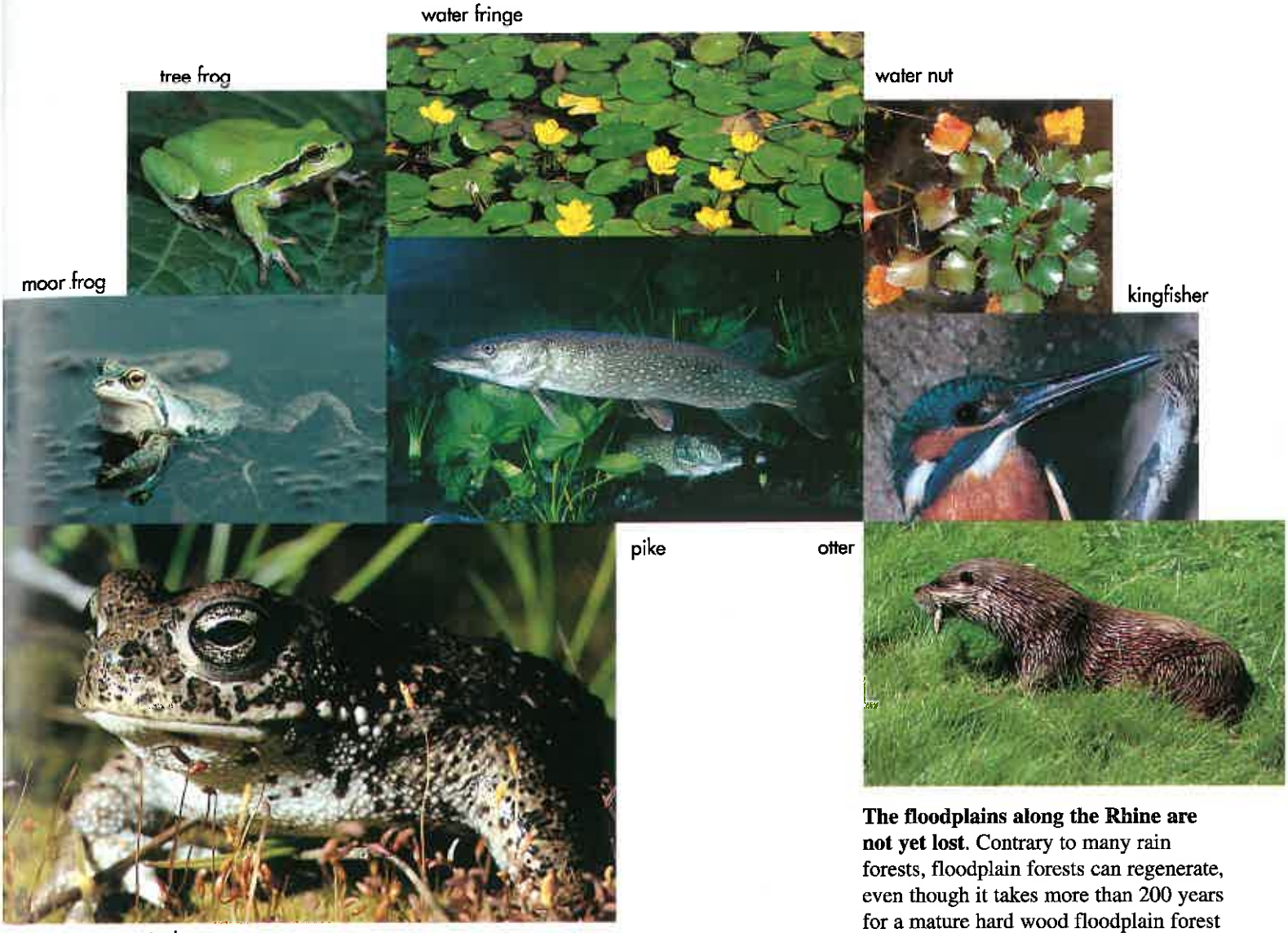
Due to their luxuriant growth, their complicated vertical stratification and their abundance in liana, **the last floodplain forests** of the Upper Rhine are comparable to tropical rain forests. The hard wood floodplain forests containing more than 40 woodlike plant species belong to the most diversified and most highly developed plant communities in Europe.

nightingale

After floodwaves have destroyed the vegetation, the life cycle of the floodplains begins anew with the first tender pioneer plants emerging from the bare soil. The **light wood floodplain forests** where silver-leaf poplars and black poplars grow, are the next stage of development on the raw soil along the river. Willow roots sprout from branches in the driftwood and form floodplain shrubberies. Due to their deep roots and their supple branches they resist to future floodings. Black poplars spread due to their subterranean root-suckers. After 60 to 120 years the light wood floodplain forests may slowly develop into a wood of alders and ash trees before becoming a more stable **hard wood floodplain forest** dominated by ash tree, elms and common oak, where wild apple and pear trees blossom and the lianas of clematis, hop, ivy and wild grapes rank around the trees and hang from their crowns like a veil. It takes another 150 years before this forest has attained its definite maturity. Only at an age of 250 years has this forest reached the stage of a well-balanced mosaic comprising all stages of development, including the ecologically important dead wood. The open crowns of the ash trees allow the growth of a dense underbrush of bushes and herbs.

Due to this species and vegetation diversity, a multitude of insects and **birds** may develop. Among them six species of woodpeckers, golden oriole, and nightingale joining in a marvellous spring concert in order to mark out their territories. The rich structure of the hard wood floodplain forests explains why we find the most species rich avifauna in Europe with a maximum density of up to 200 couples on a surface of about 10 ha. Today, many of the floodplain bird species no longer breed along the Rhine. This is e.g. true of osprey and little crake, other species, like bluethroat and little bittern have become rare.

middle-spotted woodpecker



The **amphibians** are particularly well adapted to the habitats with varying humidity. When floodings withdraw and only leave behind marshy pools on the naked soil, tree frogs, natterjacks and green toads gather around the puddles and invite their far-away partners by loud snarls or warbles to join them for mating. The puddles quickly heat in the sun and permit a rapid development of the tadpoles. But their life is a race against death. New floodings may carry away the spawn, hot-spells may dry out the puddles. In this case a black, tar-like film of dead tadpoles covers the hollows. But some of them manage to survive and leave the puddles as minuscule toads or frogs.

Formerly, the floodplain forest covered a surface of 2.000 km² along the Upper Rhine, it was up to 12 km wide and split up by many backwaters, pools and beaver meadows. Today, about 150 km² of riverside forest are left, 70 % of which consist of forest plantations. Less than 1,5 km² of subnatural floodplain forests older than 150 years may still be found. Originally, floodplain forests along the Lower Rhine reached a width of up to 15 km, vast reedy areas, swamps and lakes covered the Rhine estuary. Centuries ago, the floodplain forests along the Lower Rhine were developed into meadows. Only 2.3 % of the 160 km² of remnant floodplains along the Northrhine-Westphalian Lower Rhine are still sub-spontaneous.

The big **mammal species**, such as elk, aurochs, bear and wolf which formerly prowled through the floodplain forests along the Rhine disappeared in the Middle Ages. Beaver and otter were almost extirpated in the 19th century. However, some beavers still build their lodges in the headwaters of the Alsacian Moselle.

The floodplains along the Rhine are not yet lost. Contrary to many rain forests, floodplain forests can regenerate, even though it takes more than 200 years for a mature hard wood floodplain forest to develop. Afforestation would not lead to a natural floodplain forest.

Too high water retention levels harm the floodplain forest, as its roots and bottom dwelling animals die of a lack of oxygen. New alluvial forests along the Rhine need time and space regularly inundated by floods, space in which floods may widely spread, rise and sink according to a natural rhythm, like the "breath of floodplains".

beaver

3. Actions for the Rhine: how we save inter-relationships

The first aid actions for the Rhine have proved successful. Thanks to improved waste-water treatment the river my breathe again. But it is still not feeling well. The ICPR recommends several operations. Obstacles must be removed from the river's circulation, green lungs must be transplanted, backwaters reconnected. And what then? The patient needs a holistic therapy, room to develop, contacts and a job which no longer wears him out. A management compatible with nature uses and recycling the resources of the Rhine. This is the royal course the ICPR proposes in its *Ecological Master Plan*.

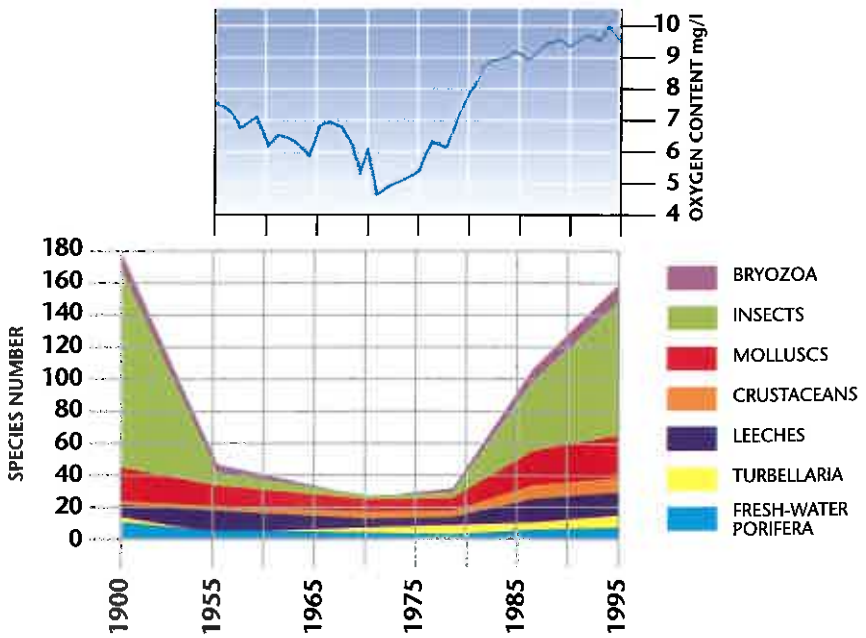
This is how the vision of a united Europe develops through the protection of the Rhine.

Alfons Paquet (1923): *A landscape like that of the Rhine ... bears the dream of its ideal form uniting nations as a seed in itself.*

Modern wastewater treatment technologies, such as *permeation under pressure* may hold back pollutants

Successful first aid

As far as water quality is concerned, the ICPR *Rhine Action Programme* has almost reached its targets. The oxygen content of the Rhine is close to the optimum. The reduction of important pollutants by far more than 50 % and the reduction of industrial accidents prove successful. Unfortunately, the "diffuse" inputs of nutrients and biocides are still problematic. The inputs of dangerous substances, such as heavy metals and organic halogenated compounds of industrial origin must be further reduced, preferably by replacing and avoiding them in the production process or by installing closed industrial water circuits. Completely clean Rhine water will probably remain utopia. But the preservation and improvement of the good water quality is a prerequisite for a living river.



The species number of micro-organisms has increased in line with the rise of the oxygen content of the Rhine water

Ernst Ulrich von Weizsäcker (1992):
"As far as the water quality of the Rhine is concerned, a success story seems to develop. Nevertheless the ecosystem is still ill, physically as well as biologically."

Operation living river

The Rhine chemistry is thus satisfactory, but not its physics and biology. Rhine water quality seems to be convenient, but the river may not flow freely and its bed is too narrow. Only when the river may spread wider will "the beautiful and abundant life" return, as the water scientist Rolf-Dieter Wilken expressed his vision.

The target of the **ICPR Action Programme Salmon 2000** is to improve the Rhine ecosystem to such an extent that by the year 2000 salmon and other migratory fish may again become native Rhine species.

Target: return of migratory fish:
salmon, sea trout, allice shad, thwaite shad, houting, nase, sturgeon, sea lamprey, river lamprey

The implementation of the *"Ecological Master Plan for the Rhine"* began in 1991. The ICPR aims at protecting the natural reaches along the Rhine and its affluents, to restore as many perturbated reaches as possible, to inter-connect habitats in the river corridor, to reconnect backwaters with the river, to remove obstacles for fish migration and to restore and develop sub-natural habitats for typical Rhine-organisms.

Thanks to intensive efforts made in all riparian states and to the efforts of many anglers' associations a great number of targets have already been achieved within *"Salmon 2000"*. Since 1990, salmon migrate from the North Sea through the Rhine delta and the Lower Rhine into the Rhine affluent Sieg, where natural reproduction is being observed since 1994. Since 1995 salmon migrate 700 km upstream as far as the Iffezheim impoundment. In 1996, 32 salmon mature to spawn and 63 sea trout were caught at the foot of the Iffezheim barrage weir during electrofishing campaigns. They were released further upstream in the spawning rivers. In the spring of 1997 an international convention on the construction of fish passages on the Iffezheim and Gambsheim barrage weirs was signed. The Iffezheim fish passage is supposed to be operational before the year 2000. Further upstream several more barrage weirs obstruct migration as far as the High Rhine. Much work remains to be done here.

Atlantic salmon

Paul Baron (1996)
"After having been the reason of discord, will the river in future unite the nations? The return of the salmon is a sign of progress in the right direction."

Flood protection by giving the river more space

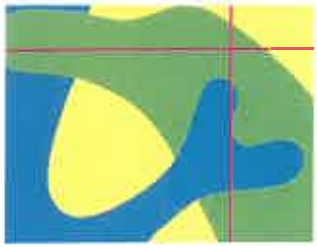
Times of high and low water are part of the natural hydrologic cycle. Rhine discharges vary with glacier and snow melting as well as with precipitations and the water uptake of the watershed.

However, today floodings must recede quicker and with a greater depth of runoff than what was the case earlier. Therefore, floodwaves of the Rhine often overlap with those of the affluents. And we have drawn too close up to the river.

Local flood protection measures, such as dikes, for example, often increase the negative impact of floodings further downstream. The river development of the Upper Rhine confined the river cross section from a width of 12 km to 200 to 250 metres, shortened its course by 82 km, reduced the floodplain by 130 km² only due to the construction of barrages and reduced the travelling time of a high water surge from Basle to Karlsruhe from 64 to 23 hours. River development shortened the course of the Lower Rhine by 23 km. Today the Rhine only disposes of 15 % of its original floodplains.

Heinrich Böll (1960)
"And I am still afraid of the Rhine ... murmuring so gently and weirdly through children's dreams, a gloomy god claiming to have proved that he still demands victims: heathen, nature, no signs of charm, he spreads as wide as the sea, penetrates into apartments, greenishly rises in the cellars, surges from the canals, roars below the arches of the bridges: it is Undine's formidable father."

Cologne 1993/95



Hans Dieter Hüsch (1984)
on the Lower Rhine
Homberg
"My grandparents' world
on my father's side
The small and warm house
which drowned several times
when the Rhine overflowed its banks
rolled across the fields
penetrated the houses
and people sat on the roofs
resigned and poor
and started all over again:
what else is there to do?"

A landscape with extensive residential areas, industry, intensive agriculture and damaged forests retains little water. That is why floodings of the Rhine with recurrence intervals of 100 years have increased. An extreme flooding of the Rhine like that of 1882/83 due to several days' rain on frozen grounds would be even more disastrous today and top the dikes.

Thus flood crests must be topped. Along the Rhine this is only possible by **"letting the river expand"**, that is by relocating the dikes or by creating retention areas behind them. A German-French convention of 1982 which has so far only been implemented in part demands a flood protection similar to that existing before the river development. Along the Upper as well as the Lower Rhine a total of 125 km² of "new" alluvial areas are planned today. But this is by far not enough.

Floodplains along the Rhine
formerly: 8.000 km² (100,0 %)
today: 1.200 km² (15,0 %)
green reclamation: 125 km² (1,6 %)

Deventer on the IJssel, Netherlands, 1995

Extreme floods
menace the Upper Rhine
between Iffezheim and Bingen:
700.000 people
12 - 25 billion DM worth
of property

The ICPR has drafted an

Action Plan on Food Defence

"integrating the target of an ecological improvement of the Rhine and its alluvial area".

The action plan proposes to give the river more possibilities of expansion, to inform the population about flood risks, to reduce the risk of damage and to improve flood forecasts.

Soil protecting agriculture and forestry, unsealing of surfaces, promotion of rainwater seepage and renaturalization of rivers belong to the further **flood protection measures**. Forests must be preserved and managed in accordance with nature's requirements since they store water which slowly flows back into the rivers and they protect against erosion.

Holistic water policy has started

For a long time those living upstream the Rhine believed they could not trouble the waters. But much happened during the cleanup of the Rhine. All riverains discharge less pollutants and, in addition, they now plan not to translocate flood problems further downstream. The confident transboundary co-operation along the Rhine has most certainly contributed to the fact that *"after me the deluge"* will never range among the guidelines of tomorrow's water policy. Future **ICPR** water policy will be continued on the basis of a holistic ecological approach and base on a new Convention with a programme orientated towards the future.

In 1997, the Commission of the European Community proposed a draft for a *Council Directive establishing a framework for Community action in the field of water policy* with environment protection as its main target. This draft proposes a harmonized management of the different river basins like the ICPR has practised so far. Large rivers and their floodplains are to be managed by taking into account the existing interactions between surface and ground water. In future, the chemical and the ecological quality of water bodies will be extensively evaluated and improved.

The new *agricultural policy* of the European Union plans to link subsidies and taxes to ecological achievements in order to support the targets of nature and water protection. The new Swiss law on agriculture provides for direct payments for ecological achievements. At the time being, the ICPR is examining economic instruments which may promote the application of fertilizers and pesticides under the aspect of water protection.

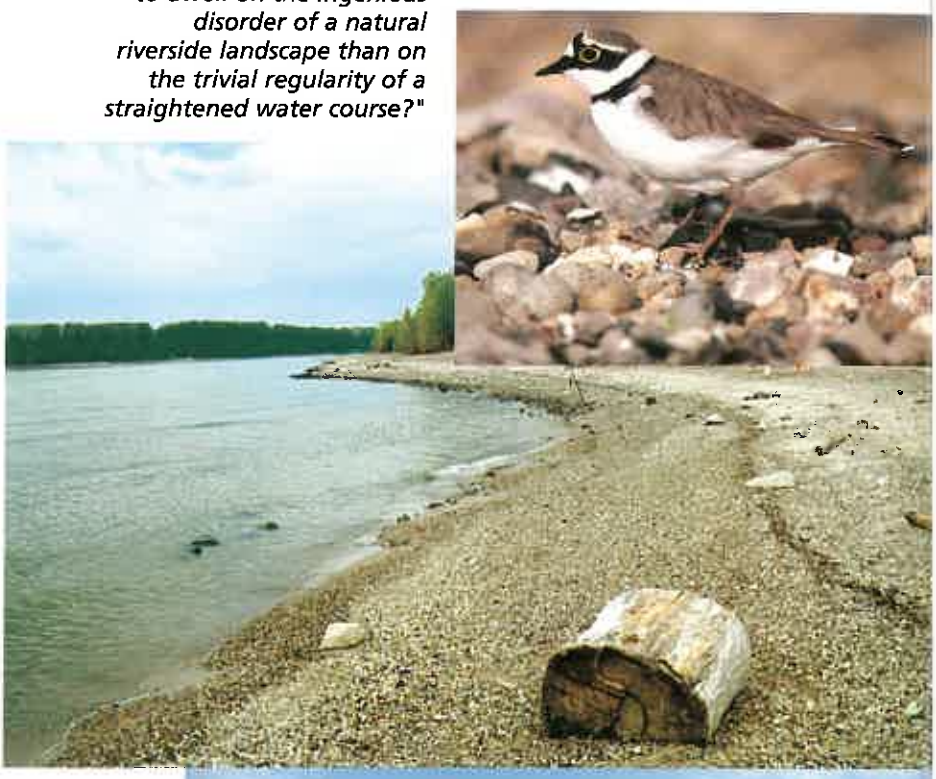
Ecological agriculture supports the aim of water and nature protection as long as it is orientated towards a closed material cycle, a density of life-stock adapted to the size of the land and fertilization according to the individual need of plants. *Riparian belts* and hedges protect against erosion and leaching from intensive agriculture and reduce the carrying off of fertilizers and plant protective agents due to windbreak. In floodplains, *grassland management* must be preferred to agriculture as many tons of mould per ha. are being drifted off the fields in floodplains, whereas only a fraction is drifted off the meadows. Many brooks used to be technically developed in order to avoid floodings. Today we realize that such interferences must be avoided. As many fields located in river and brook floodplains as possible must be developed into riverside meadows or, in the direct vicinity of water bodies, into woods.

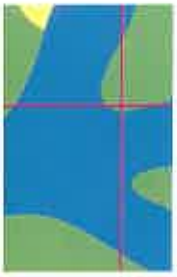
Birds are indicators of the ecological quality of water bodies: the common sandpiper breeds where riverbank structures are near to their natural state.

Rhine protection after the year 2000

The modern concept of Rhine protection unites targets which used to be considered contradictory: use and cleanup, flood protection and nature protection. If we succeed in sustainably using the Rhine in an environmentally appropriate manner, we clean up the river at the same time. If we give back enough land for the river to spread in case of floods, we protect our settlements in the valley. At the same time, floodplains may develop to become alluvial areas near to their natural state and establish new links in the *"river landscape network development system"*.

Friedrich Schiller (1793):
"Who of us would not prefer to dwell on the ingenious disorder of a natural riverside landscape than on the trivial regularity of a straightened water course?"





Emil Dister (1994)
"If today's scientific nature protection has recognized that the fragmentation and isolation of our landscape is one of the main reasons for the dramatic species impoverishment, priority must be given to our efforts to create a natural river landscape network development system."

The recreation of the **ecological network** source - brook - river - riverbed - floodplain - groundwater, the removal of longitudinal and transversal hydraulic obstructions is what is meant by the *renaturation or restoration* of streams. In the most ideal case, nature itself may take over. A brook is left to find its way, plants and animals return. If we render some of the space to brooks and rivers, this will be possible. We might even loosen the tight corselette of the Rhine and give a chance to more floodplain forests.

Floodplain forests and riverside shrubbery

- filter and clean floodwater,
- recharge ground water
- protect against waves and erosion
- absorb water like sponges
- cut off flood crests,
- tolerate water expanding on a surface for a long time (silver poplar up to 190, common oak up to 97 days annually),
- belong to the most precious and most endangered biotopes in Europe.

The areas of ecological importance along the Rhine have been entered into maps of biotopes and figure in the *ICPR atlas of the Rhine*. Such biotopes, which have lost their links, must now be interconnected to form a network. This habitat patch connectivity along the Rhine will be part of a European habitat network.

The Rhine has extensive connections with its surroundings. Via the **North Sea** it is connected with the oceans and vice versa. Many connections are related to the life cycle of migrating fish and the transportation of substances in water. Young salmon leave the Rhine for the Atlantic Ocean where they feed and grow until they are mature enough to return to the Rhine. With a view to facilitating the restoration of the stocks of salmon and sea trout in the Rhine, the countries bordering the North Sea decided on their **fisheries conference** in Bergen in 1997 to support an interdiction of salmon and sea trout catches in coastal and marine areas. In the end, Rhine pollution pours into the North Sea, excessive nutrient inputs pollute the water, noxious substances concentrate in marine organisms and drift eastwards towards the Wadden Sea.

The Wadden Sea stretching from the Netherlands via Germany to Denmark figures among the most important wetlands of the world, it is "nursery ground" for fish, resting place for almost all waders and waterfowl from Greenland to Siberia and habitat for piscivores at the end of the food chain, e.g. the seal. After a most threatening decline in stock due to illness, this mammal species has now recovered. Who knows whether the cleaner Rhine has not contributed to its recovery.

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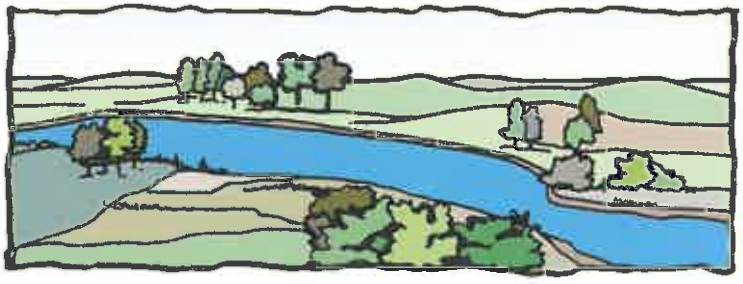
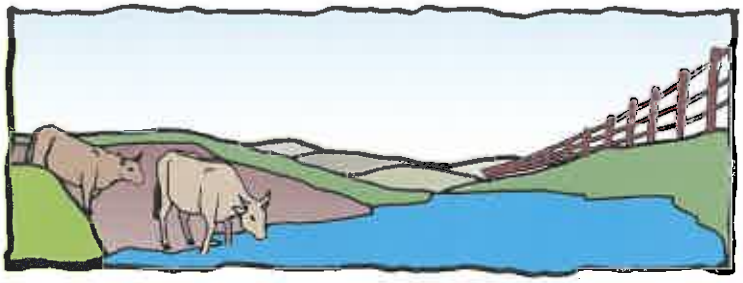
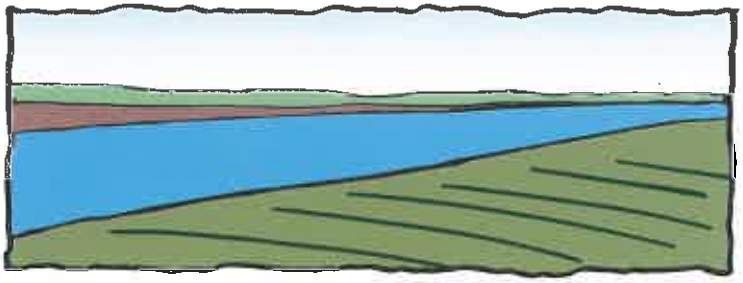
The ideal river



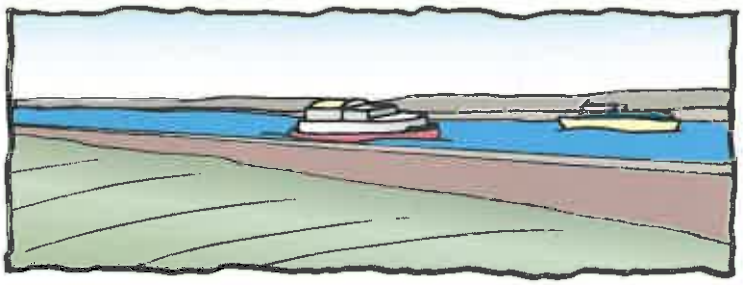
... for nature protection?



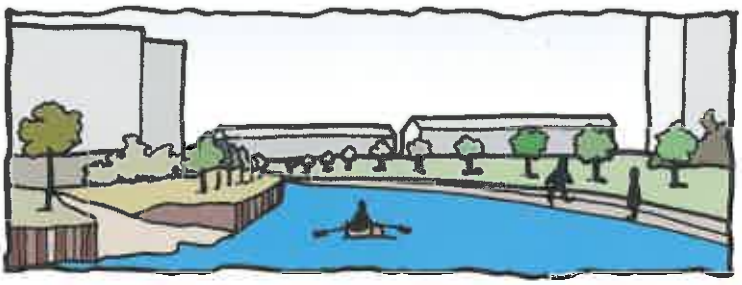
... for agriculture?



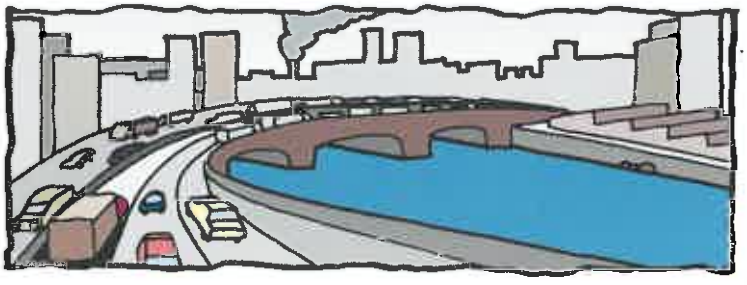
... for drainage?



... for shipping?



... for recreation?



... for economy?

Dialogue with the Rhine

Joost van den Vondel (1629):
"De Rijnstroom"
Illustrious Rhine! My sweet dream!
Where shall your poets stand
and praise you? Home river!
Coming from the Swiss Alps,
Artery of Europe.

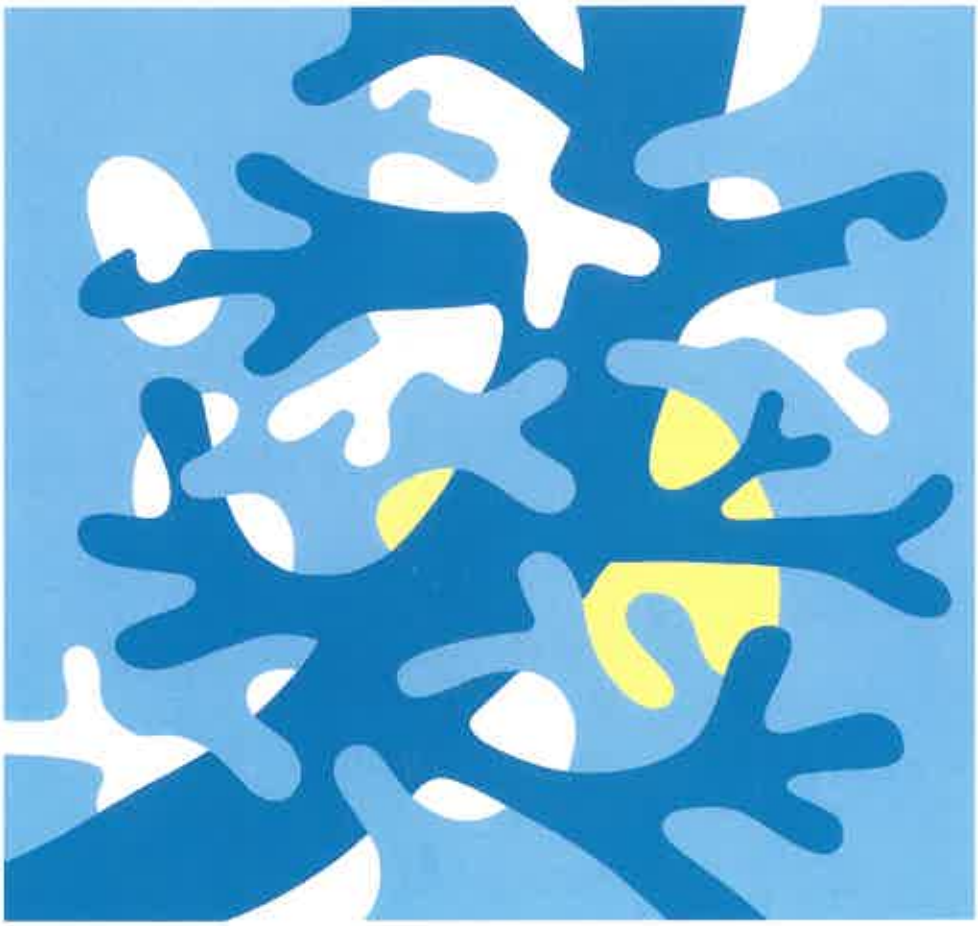
Poets call the Rhine *illustrious* (Vondel 1629), *born free* (Hölderlin 1801), *proud and noble* (Hugo 1836), *sovereign* (Böll, 1960). This of course is not the language used by the technicians solving partial problems along the river.

Artists see the river as a whole. Ecologists try the same thing in their way. And what do water politicians do along the Rhine and throughout Europe? They accomplish a quantum transition towards global water protection.

Wolfgang Erz (1995)
"Nature protection is only possible on the basis of humanity, a humanity without frontiers - between the states and in everybody's head."

Who is to accomplish holistic water protection of and along the Rhine? We can only do it together - with scientists, state administrations and private organizations. The ICPR has begun to associate different organizations of industry, municipalities and nature protection to its work in order to achieve a maximum consensus before planning action. People living of and along the Rhine must decide in favour of the river, formulate common targets, act in common and take common responsibility.

There is no need for worshipping the Rhine, but we might treat the river and its landscape with more respect and care. We would then turn towards a culture which is fitter for the future, for us and for our children along the Rhine.



Heinrich Heine (1844)
Be satisfied, Father Rhine,
do not think of bad songs
soon you will hear a better song
farewell - we'll see again