FOWARA

Forested Water Retention Areas

Guideline for decision makers, forest managers and land owners

Edited by

Jost Armbruster, Alexandra Muley-Fritze, Ulrike Pfarr, Regina Rhodius, Daniel Siepmann-Schinker, Benoit Sittler, Volker Späth, Michèle Trémolières, Heinz Rennenberg, Jürgen Kreuzwieser

FOWARA Guideline (2006)

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The results of the social science analysis (Part B-9 and Part E) are mainly based within the 4 case studies along the river Rhine, where 25 expert interviews were made with representatives of municipalities, citizens´ initiatives and associations, planning authorities and authorities responsible for the planning approval procedure and affected land users. The results of the case studies were disputed in a discussion with representatives of planning authorities in March 2006 and were examined if they were transferable to other cases. Thank you to all participants of the interviews and the discussion, and to all people who arranged the corresponding contacts – with their statements they contributed to a better understanding of the planning process and to the recommendations which were brought together into this guideline.

Summary

The implementation of water retention areas is an important measure for flood protection

The extreme floods in Europe in recent years have caused dramatic financial losses in the regions affected. Climate models predict a significantly increased risk for weather extremes including flood events for the Northern half of Europe due to global climate change. As one important measure for flood protection, water retention areas are constructed along the river systems and are often realised in forest ecosystems. This provokes conflicts with different groups of interest such as forest owners and the public society, because the loss of financial resources and of recreational functions of the forests is feared.

Developing management strategies for forested water retention facilities

The overall objective of FOWARA was the development of sustainable management strategies in order to help maintaining the economical and ecological value of forest ecosystems in water retention areas. This can contribute to reduce the conflicts experienced during the implementation of water retention areas. The FOWARA project involved ten partners from The Netherlands, France and Germany which cover different fields of interest relevant for fulfilling this task. The results of these working groups have been used to develop the present practical guideline.

Studies on the vegetation composition, soil characteristics, the growth pattern of trees, and an assessment of damage on vegetation were carried out. Furthermore it was tested, which tree species were best adapted to the environmental conditions given in water retention areas. Besides the field-studies, such studies were also performed under controlled conditions. In the following section some of the results obtained are summarized. They indicate which consequences have to be expected when forests are used as water retention facilities. It is important to mention that there are differences if water retention areas are considered which are usually established in former floodplain areas or retention basins which are often covered by forests which never experienced a flooding event.

(Re)flooding of former riparian forest has positive effects on water and nutrient cycles: improved groundwater quality and improved plant growth

An intensive study performed at the Polder Erstein in France indicated some positive effects of flooding. The Polder Erstein is located in a former riparian forest which has not been flooded for ca. 40 years when the canalisation works were finished. First flood events occurred at this site in January 2003. The studies clearly showed that the long-lasting prevention of floods resulted in changes in the nitrogen cycle causing increased nitrate concentrations in the groundwater thereby strongly impairing groundwater quality. Moreover, flood prevention suppressed input of sediments and minerals from the river and modified hydrological functioning. From our studies it is concluded that re-flooding of former retention areas will contribute to an at least partially reestablishment of the natural hydrological functions. Part of this is the reconstitution of a high retention capacity meaning that nutrients such as nitrogen are retained by the ecosystem thereby improving groundwater quality, and partially made available for improved growth of vegetation.

Flooding can change vegetation composition but may have positive effects on tree seedling growth

Along topographic gradients in flooded areas the vegetation composition was studied. In this frame a great influence of the altitude was visible. The species composition in several forests showed similar patterns with typical species occurring at the sites

with similar heights of flood water and corresponding flooding durations. Considering the growth and survival of tree seedlings it also became obvious that in water retention facilities as well as naturally flooded regions, flood tolerant seedlings grew better compared to forests where flooding does not occur. In contrast, seedlings of flood sensitive trees died due to flood events. The faster growth of adapted seedlings was a surprising result which can be explained by a better water supply and an improved availability of nutrients in such areas. However, in contrast to seedlings, adult trees of tolerant species did not show significant changes in growth in water retention areas compared to trees at non-flooded sites.

Classification of tree species according to their flooding tolerance

In floodplains and numerous water retention areas, the damage developing on adult trees was assessed. It became clear, that damage depended on the tree species considered. A ranking of tree species' flooding tolerance was established. Species such as Common Beech showing a high degree of damage and partially dying due to flooding, where classified as highly sensitive. In contrast, species like Penduncculate Oak, Common Ash and others were relatively well adapted to flooding, although also here significant damage could be observed. The correlation of damage with the flooding regimes indicated that the presence of stagnant water in retention areas was problematic. At sites exposed to such conditions major damage were observed. Typically, parts of the cambium died leading to scars in the bark. The development of such visible damage may be a consequence of severe plant internal disturbances such as impacts on photosynthetic activity, carbon and energy metabolism but also the impact of pathogenic fungi may be of significance.

The FOWARA results can be used to perform a risk analysis

The knowledge obtained from our studies has been used to generalize a method to perform a proper risk assessment for forests in water retention facilities which was originally generated for one special retention facility. Starting from generally known input parameters such as maximal flood heights that have to be expected during water retention and the tree composition of the considered forest stand, risk classes for individual trees but also whole forest stands can be calculated. As a result the damage that has to be expected due to future water retention events will be computed. Moreover management strategies to keep damage at a limited level are given.

How to deal with public participation

An important part of FOWARA dealt with realisation of planned water retention areas on a political level. In several case studies, it was investigated which constraining factors exist aggravating the implementation of such flood prevention measures. The focus of this study was on the role that public participation plays in this context. The results have been used to provide recommendations in order to facilitate the realisation of water retention areas from the beginning of the whole planning process.

Chapter A
Introduction

A - Introduction

<u>Jürgen Kreuzwieser</u>

The extreme floods in Germany at the rivers Oder (1997), Rhine (1983, 1999) and Elbe (2002) caused water logging of wide areas that have led to enormous economical losses in the range of some billion EUR and to more than 100 deaths (IKSR 1998, IKSE 2004). The flood at the Elbe river alone caused financial damage ranging around 8.9 billion EUR in Germany (IKSE 2004).

In order to reduce such risks, it is required that rivers obtain more space to extent during flooding events (IKSR 1998). For this purpose former riparian areas have to be reactivated as retention areas. Beside the huge polders along the Upper Rhine which are of regional significance, several water retention areas are planned on a local basis. Because of the high population density particularly in the Rhine valley, such water retention areas are often located in forest ecosystems (LfU 1999). Most of these forests were exposed to flooding never before or in the case of former alluvial floodplains have been adapted to the new and dry hydrological conditions by changes in structure and floristic composition of forests (Trémolières et al. 1998) and in the soil chemistry (Trémolières et al. 1993).

For the construction of retention areas environmental impact assessments are obligatory in which possible damage on vegetation have to be estimated. Presently such assessments are performed on the basis of literature studies and on data of the flooding events along the river Rhine in 1999. In areas where the history of human use is old and intense, the creation of water retention areas must not only consider ecological objectives but also social aspects. The construction of water retention areas are often quite controversially discussed; forest owners (communes, private owners) fear financial losses due to damaged trees, public society the loss of recreational functions of forests, due to loss of biodiversity and a changed appearance of the forest as a whole and the impact of water retention on the valuable floodplain ecosystems. Such concerns often lead to vehement controversies between these different groups of interest which cause difficulties and may even prevent the construction of water retention zones. E.g., at the river Rhine the creation of regional water retention areas and re-naturalization concepts are/were often inhibited by forest owning communities (Winkel 2000). The risk of flood disasters therefore still remains high along the river Rhine.

One major cause for such conflicts is the lack of knowledge and information. In particular, it is not exactly known

(1) if and to what extent flooding will affect different plant species in these economical and ecological important forest ecosystems. So far damage is not even uniformly described, and also not properly assessed. It is also still under discussion to what extent the age/developmental stage of species plays a role and whether the appearance of damage is connected to the flooding regime (water height, duration and frequency of flooding, seasonal dependencies, flow velocity of water, etc.).

(2) what processes are responsible for the occurrence of damage and/or benefits, and how flooding influences the growth of plants, their vitality, mortality and the regeneration and performance of seedlings.

These uncertainties prevent (i) the development and application of appropriate measures in order to manage water retention areas and (ii) an estimation of the further development of forest ecosystems in water retention areas as well as an estimation of financial losses due to damage to trees and/or changed growth of trees.

Objectives of the FOWARA project

The main objective of the project was to develop and test strategies for a sustainable management of forested water retention areas of regional and local significance. With a multidisciplinary approach recommendations (tree species, origins, ecological flooding, characteristical flooding time, frequency and water heights, influential factors of the implementation and possibilities for the realisation, etc.) for decision makers for a future sustainable landuse and water management of water retention areas were developed. This will help to maintain on the one hand the function, stability, biodiversity and the growth potential of temporary flooded forests and on the other hand the multi-functional value of the forest stands for forest owners and the society.

Management strategies for retention areas can only be successful for the longer term, if people in the affected areas support them. Because of this, the natural science research of FOWARA was accompanied by social science analyses of the Institute of Forest and Environmental Policy of the University of Freiburg, Germany. Within four case studies along the Upper Rhine Valley, the following questions were addressed with the help of the methods of qualitative empirical social research (document analysis, expert interviews, technical discussion and the observation of planning processes):

- Which factors influence the intensity of the conflict between affected communities and planning authorities?
- Which instruments could be used to solve or avoid these conflicts?
- Which are the success factors concerning participation and basic conditions in the case of the planning of retention areas?

To make sure that attention is paid to the different perspectives of the planning process, in each case study expert interviews with a representative of each affected group were made (planning authority, the municipality, citizens´ initiatives, affected lobbies (agriculture, forestry, nature conservation) as well as the authority responsible for the planning approval procedure).

Who should use this guideline?

This guideline summarizes the results which the working groups have gathered during the duration of the FOWARA project. This experience has been obtained by intensive work in the river Rhine catchment, mainly in the State Baden-Wurttemberg and in The Netherlands. Information was also available on the situation in retention areas at a smaller scale which are distributed in Baden-Wurttemberg and Rhineland Palatinate.

This guideline is aimed at decision makers involved in planning and construction of forested water retention areas, river and flood hazard management, including:

- Planners and Water Resource Managers
- Forest Managers
- Engineers

The guideline will also be of interest to a wider audience including people directly affected by the risks and consequences of flooding and their wider communities and central government and public agencies as support to understanding of management practice of forested water retention areas.

Purpose

The purpose of this guideline is to:

- provide guidance on current thinking and practice on the planning of forested water retention areas in the North-West Europe region
- aid in the understanding of the planning process
- provide detailed support on tree species which should be used in forested water retention areas
- provide a risk assessment and information which damage has to be expected during the implementation of flooding in such areas
- present research results on the development of forests due to the use as water retention areas.

This guideline is not intended to be prescriptive but it includes a range of measures which individuals or organisations responsible for the construction and management of forested water retention areas can use. As river systems differ, practitioners will need to apply the guideline in the context of their individual situations. The case studies and examples have been included to make the guideline as applicable and relevant to a number of different situations as possible. Further information and advice can be obtained from individual contributors.

Process Used to Develop these Guideline

This guideline has been prepared by a group of experienced researchers and practitioners from around Germany, France and The Netherlands who are currently involved in research in floodplain forests and the management of water retention areas. The guideline includes current knowledge and understanding about these topics and provides practical examples from individual project partners.

The guideline was developed as the result of a project funded by the European Community in the frame of the Interreg IIIb-programme North-West Europe. This project involved a team made up of 10 regional partners including one water management authority. A series of workshops were held with the project team to discuss the nature and extent of the guideline, to review issues that should be addressed by the guideline and discuss and decide best practice recommendations.

How to use the guideline

The guideline is divided into five chapters.

Chapter A: Introduction - This chapter sets out the purpose and scope and who should use the guideline.

Chapter B: Why do we need water retention areas? - This chapter introduces the need of concepts of floodplain management planning and provides a historical and international perspective.

Chapter C: How does flooding affect forested areas? - Here some natural-scientific studies of project partners are presented indicating the changes and the development of forests as affected by flooding.

Chapter D: Recommendations to manage forested water retention areas – This chapter provides practical advice along with detailed information of best practice.

Chapter E: Recommendations for public participation in the planning of retention areas – Here advice for the planning process is given.

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Chapter B
Why do we need water retention areas?

B - Why do we need water retention areas?

Jürgen Kreuzwieser, Bianca Nijhof, Ulrike Pfarr, Heinz Rennenberg, Regina Rhodius, Daniel Siepmann-Schinker, Benoît Sittler, Michèle Trémolières

B1 - Floodplain ecosystems important to FOWARA

The ecosystem of interest in the management of forested water retention areas is characterized by a stream and its floodplain. Biological processes in these forests are implicitly conditioned by watershed and floodplain characteristics and processes, such as seasonal flooding, water, sediment, and nutrients delivery from the watershed, upstream landuse, and tree composition. Also human activities, such as construction of dams and water power facilities, and conversion of landuse influence floodplain ecosystems.

In middle Europe floodplain ecosystems still remain on 7 % of the surface covering two third of wildlife and natural habitats (University of Karlsruhe 2005). The most important remaining floodplain forests exist along the streams of Oder (PL/D ~160 km^2), Elbe (CZ/D ~120 km^2), Danube (A ~ 60 km^2), Loire (F ~150-200 km^2), and river Rhine (F/D ~130 km^2). Concerning the FOWARA project issues research activities focused on the river Rhine and its tributaries.

B2 - The River Rhine - one of Europe's largest river systems

The river Rhine is one of Europe's largest river systems. Its headwater zone is located in the Swiss alpine region. On the 1,320 km lasting way to the North Sea the river Rhine crosses 9 European countries (ICPR 2006).

The average discharge in the region of the Upper Rhine Valley – along the French-German-border where most of the broad forested water retention areas are situated – is ~1,000 m^3/s; in The Netherlands it is ~2,000 m^3/s. The discharge during flood hazards reached >5,000 m^3/s in the Upper Rhine region and >13,000 m^3/s in The Netherlands (Figure B-1). Flood occurrence in the Upper Rhine Valley depends mostly on the snow melt in the Alps, so the main flood period is in spring. Floods in The Netherlands are influenced by tributaries of the river Rhine, so hazards occur mainly in winter.

Figure B-1: *Catchment area of the river Rhine*

B3 - The Upper Rhine Valley along the French-German-Border

Flood protection, industrialization and changes in ecosystem

The Upper Rhine Valley was naturally characterized by a wide branched stream system with hundreds of islands. From flood to flood the river arms shifted and the islands moved. Succession in the ecosystem started from the beginning again. Further to the north the river used to be characterized by huge meanders, swinging softly through the wide valley.

Since the end of the 18th century man has changed the Rhine valley ecosystem again and again. In order to protect people, villages and agricultural land against flood damage, long dyke systems were built at some hundred meters distance from the river all along the Upper Rhine. These flood protection measures were necessary because of the increasing number of inhabitants and the enormous demand for land. During flood periods, water could still flow into the woodlands between the river and the dykes but no longer into the areas beyond the dykes.

In that time the most far-reaching consequences for the ecosystem were caused by the canalizing of the river. Engineers identified the shortest river course, and then along that course more or less 20 m wide ditches were dug out. Short parallel dykes were built to direct the water forces into those ditches. At high water the ditches' entrance and exit were opened. Water followed the new course and shaped new channels. If erosion reached channel width of 200 – 250 m the embankments were fixed (Figure B-2).

In the northern part of the valley many meanders were cut and the river was shortened especially for the development of cargo shipping. The stream channel became about 100 km shorter. Large old river arms without any connection to the river Rhine became typical of the ecosystem.

Increasing demand for energy in the 20th century

In accordance with the Treaty of Versailles, hydropower stations were constructed in the period between 1928 and 1977: the Grand Canal d'Alsace (40 km) with four power stations, four bypasses (up to 10 km each) with power stations and another two power stations directly across the river. A new dyke system was built directly along the stream in order to dam the water for an efficient use of the turbines. In combination with the construction of these hydropower stations each barrage was combined with locks to enable shipping.

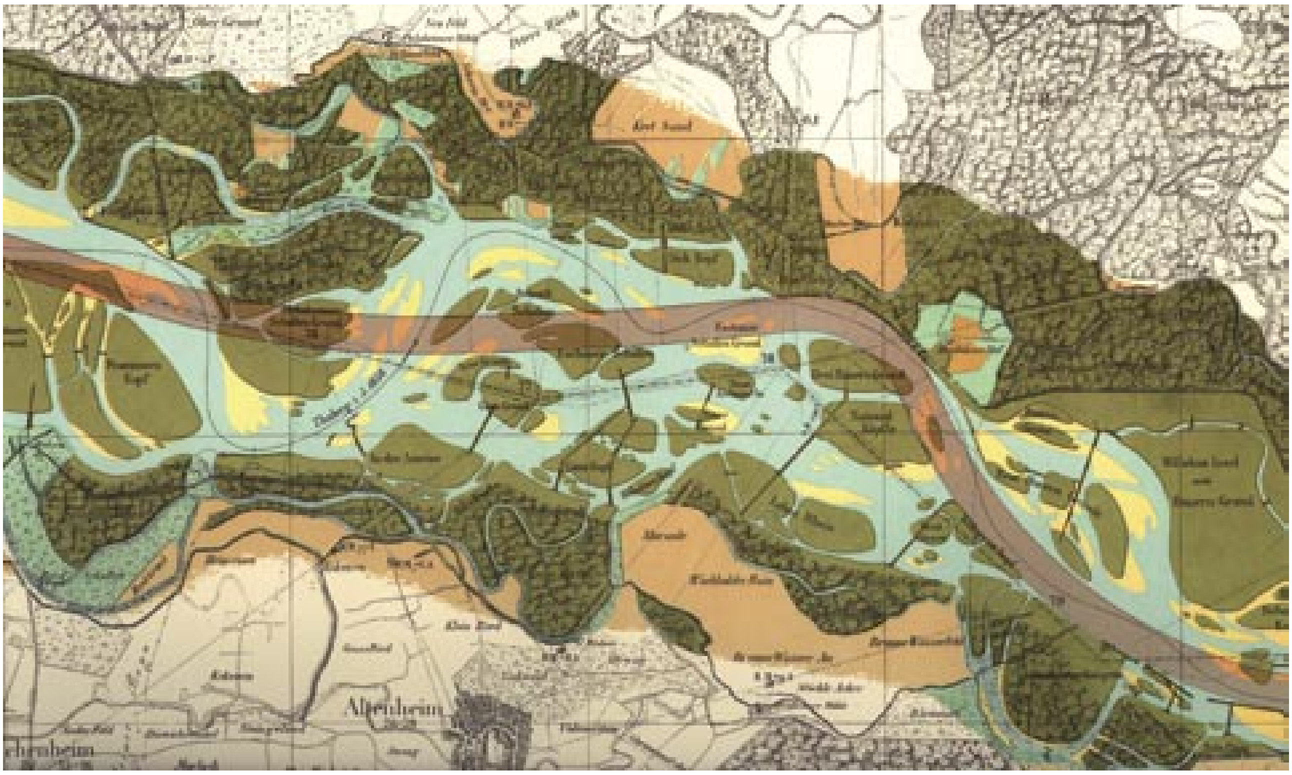

Figure B-2: Historic map showing the stream channel system of the river Rhine around 1820 and the conversion planning (Rheinstromkarte 1838)

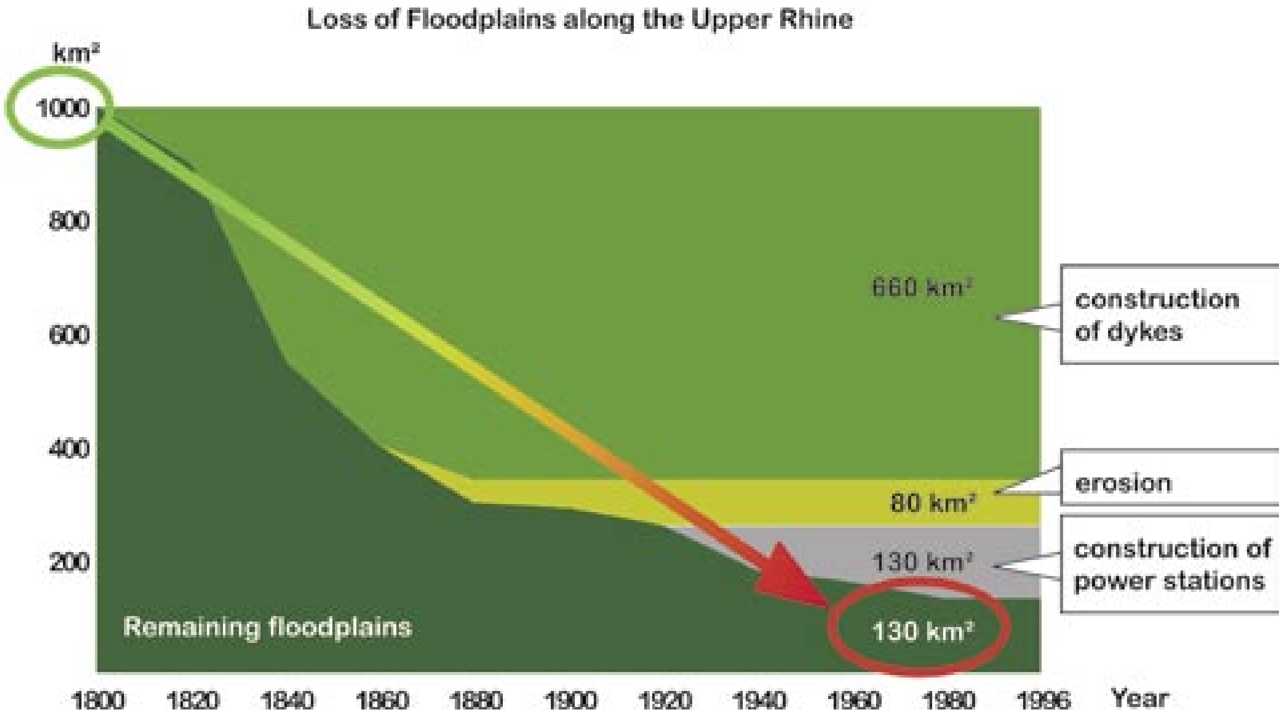

Figure B-3: *Loss of alluvial floodplains along the Upper Rhine between Basle and Karlsruhe: only 130 km² are still connected to the river*

Consequences for flood danger and the ecosystem

As a result of these man-made changes the danger of floods has increased dramatically downstream the canalized part. The original alluvial floodplains along the Upper Rhine, with an area of 1,000 km^2 in the 19th century, were successively cut off from the river. Today there are only 130 km^2 alluvial floodplains left (Figure B-3). This loss of nearly 900 km^2 together with the stronger erosion processes due to the shortening of the river Rhine cause enormous danger during flood periods. The floodplains no longer serve as water reservoir and the shortening of channel system lead to faster flood waves, which now meet with tributary flood waves.

Variety of landuse in Baden-Wurttemberg

Agricultural (mainly corn and asparagus) and infrastructural uses are dominating former floodplain areas. Less than 30% of the former floodplain area is covered by more or less natural biotopes. Forests (7.5%), tributary river channels (6%), and meadows (5%) are the widest spread of these biotopes. Due to the operation of future water retention facilities (see below) about 50 km^2 of former floodplain forests can get reconnected to the water regime of the river Rhine. Most of these forest sites are in the property of communities, only a small amount is in the property of Baden-Wurttemberg.

Nearly all forests designated as future water retention facilities are protected NATURA 2000 habitats.

Variety of landuse in Alsace

Along the river Rhine, in the upper part of the former alluvial floodplains were covered by forests (60.4%), to a less degree by meadows (3.8%), and aquatic biotopes (2.7% of streams, channels, ponds, gravel pits, marsh…). Village and agricultural land covered the terraces outside the dykes built during the 19th century. In the lower part agricultural use played a major role.

The canalization of the Upper Rhine in the 20th century led to a complete removal of floods on the French border.

B4 - The River Rhine in The Netherlands

Changes in the past

In the Lower Rhine region within The Netherlands in the tenth century people started building dykes alongside the riverbanks to create safe summer pastures on the floodplain. Further back they built sturdier dykes to contain the river in winter and early spring, when it was swollen by ice flows and snow melt from the European hinterland. In 1707 the Pannerden Canal was created. It started as a tool used for distributing the water between the river Rhine's branches to create a more defensible eastern border, but by then was further excavated to improve the water distribution between the river branches. Over the centuries the dykes were constantly raised and strengthened, overflows, drainage pools, pumping stations and storm flood barriers were created. Also a large number of meanders were cut off. Floodplains silted up and there was less room left for the river in flood. A combination of upstream deforestation and urban development and the growing Dutch population led to an increasing pressure on every available piece of land. In 1993 and 1995 severe winter floods brought a rude awakening.

Nature development along rivers

In The Netherlands nature development along the rivers is not allowed to compromise flood defence. Floodplain forests and other rough vegetation on the floodplains impede a river's flow when water levels are high. This would increase the danger of flooding. The Directorate-General for Public Works and Water Management (Rijkswaterstaat) limited the amount of forest to develop within the floodplains of the Dutch rivers to 10% of the total area.

In the Cyclic Floodplain Rejuvenation (CFR) strategy the enhancement and preservation of the ecological quality of the river and its floodplain are combined with the maintenance of safety levels against flooding. At different locations within the river system several measures from the Room for Rivers concept, like floodplain lowering, (re)constructing lateral channels and floodplain lakes and removing artificial levees are taken. These measures create room for morphological and ecological processes development in the floodplains. As a consequence, the diversity of vegetation types and habitats will increase and thereby enhance the biodiversity. After a period of time the hydraulic roughness of the vegetation in the area will have increased to such an extent that, in combination with floodplain elevation due to sedimentation, the water levels during high floods will reach the safety level. Measures will have to be taken. The scale and frequency of these measures depend on the succession rate and the required decrease of the water levels for both flood protection and ecological development. This procedure gives the opportunity to have all possible ecotopes, including forests, of a floodplain present in the Dutch river system.

Variety of land use in floodplains of The Netherlands

78% of the embanked floodplains of the river Rhine can be indicated as non-nature, mainly being production grassland. The remaining (nature) area consists of mostly water and an equal amount of (natural) floodplain forest, brushwood/marsh and (natural) grasslands. Slight differences concerning the distribution of floodplain forests can be noted between the different branches of the river Rhine, where the Bovenrijn - Waal has a larger area covered with (natural) floodplain forest compared to the Pannerden Canal - Nederrijn-Lek and the IJssel (Middelkoop & van Haselen 1999).

Table B-1: *Landuse in the embanked floodplains of the river Rhine (percentages, Middelkoop & van Haselen 1999)*

	Rhine branches in The Netherlands [%]		
Landuse	Bovenrijn-Waal	Pannerden Canal – Nederrijn-Lek	IJssel
Floodplain forest (nature)	4	1	1
Brushwood / marsh	5	2	1
Grassland (nature)	1	5	3
Water	19	11	11
Production forest	0	1	1
Arable land	4	4	8
Production grass	61	69	72
Built-up area	5	5	3
Other land use	1	1	1
Total nature	29	20	16
Total non-nature	71	80	84

Functions of the rivers

River water is used in industry, drinking water production, agriculture and water management in polders, but also functions as a (inter)national transport infrastructure. At the same time flood defence, nature, agriculture, recreation, and mining have to be accommodated on the small strips of floodplain. The integration of several functions of the rivers asks for a creative approach in river management to serve the several objectives. Local excavation of floodplains in The Netherlands can be valuable not only in terms of flood defence, but also for nature development and the extraction of clay and sand.

B5 - Increasing knowledge in flood protection management

Technical Flood Protection in the early 20th century

If there would occur a hazardous flood today, something which happens statistically once every 200 years, the Upper Rhine's dyke system downstream from the last barrage would be flooded. An economic loss of a minimum of 6 Bill EURO would be the result. Once this danger was recognized, an international committee on flood protection was set up. Solutions were worked out to protect the Rhine valley against such a flood. Following extensive scientific calculations, the first plan devised was to build huge reservoirs with dams up to 10 meters high. The volume required for the protection of the northern Upper Rhine region was about 260 Mio m^3 (Alsace 64 Mio m^3; Baden-Wurttemberg 126 Mio m^3; Rhineland-Palatinate 66 Mio m^3: Hochwasser-Studienkommission 1978).

Due to this concept Baden-Wurttemberg started in 1987 with the operation of the Polder Altenheim. But from the very first trial flood, negative effects and risks became apparent. The enormous height of the water inside the polder during the trial caused extensive damage to the forests inside and led to several groundwater problems on the outside. Parts of fauna and flora were also harmed.

Increasing knowledge

In order to avoid further damage on the ecosystem as well as to avoid groundwater problems on the outside, the plans for flood protection management were adapted. Combining the experience made with knowledge of natural alluvial floodplains Baden-Wurttemberg decided in 1996 to implement the Integrated Rhine Programme (Gewässerdirektion Südlicher Oberrhein/Hochrhein 1997). Under this programme the height of the water during retention inside a polder was limited to an average of 2.50 m aside of crossing dams (upstream side). It is also important that water flows fast enough through a polder to avoid damage to trees caused by stagnant water and a lack of oxygen.

Due to these prerequisites it was necessary to include more former floodplain areas into the concept. Extensive surveys of the landscape between Basle and Mannheim came to the conclusion that 13 sites with different kinds of flood protection facilities are needed in Baden-Wurttemberg (Figure B-4).

Under the new concept the required amount of volume today is about 270 Mio m^3 (Alsace 58.4 Mio m^3; Baden-Wurttemberg 167.3 Mio m^3; Rhineland-Palatinate 41 Mio m^3).

Duty to implement an environment-friendly operation

The polders need to be used for flood protection statistically only every ten years. This has far-reaching consequences for the fauna and flora.

In central Europe no sound ecosystem exists that can tolerate flooding every ten years without any damage occurring. Therefore there are only very few indigenous species that can survive in such areas. The flooding of polders for flood protection has therefore an enormous impact on nature, which in turn has legal consequences. Under German nature conservation law, negative impacts on nature and the landscape have to be avoided; if still damage occurs compensation must be made (Siepe 2002).

Flood protection is vital, so the negative effects cannot be avoided. Unlike the building of a factory or a highway, the operation of a polder does not disturb nature completely but just causes damage to parts of the current biotopes and plants and animals. Depending on the discharge of the river Rhine, small amounts of water are used to flood the polders during periods when no flood protection is necessary. These floodings (called "ecological floodings") will minimize damage to nature and due to a medium-term change in the ecosystem will avoid future damage. The ecological floodings help animals to adapt their behaviour to flood and further prevent the natural growth of plants, especially tree species which are not flood tolerant.

Flood Protection Act in The Netherlands

In The Netherlands the Flood Protection Act applies strict safety regulations to primary flood defences, such as dykes, dams, weirs, dunes, storm tide barriers, locks and inlets. In 1996 the Flood Protection Act linked the level of protection required to the nature of the flood threat and the seriousness of the potential consequences in a given area. The safety standard for the riverside areas was set at an average of one flood event per 1,250 years. The highest water level which a defence should be able to withstand is referred to as the design hydraulic load (DHL).

The DHL is associated to a level of river flow, the design discharge. Using mathematical river models,

Figure B-4: Flood protection facilities along the Upper Rhine Valley, located in Alsace (F), Baden-Wurttemberg and Rhineland-Palatinate (D) it is possible to calculate design water levels along the river branches in The Netherlands.

B6 - How does the current operation of forested retention areas look like?

Polder Erstein (F)

On the French side of the river Rhine there are two polders in operation: Polder Moder (inaugurated 1992) and Polder Erstein (inaugurated 2004, Figure B-4). The Polder Erstein covers an area of about 600 ha and is mainly forested. These forests are owned by public (state forest or parish forest) and private enterprises (Electricité de France – EDF, Voies Navigables de France – VNF). About 375 ha of the forests are protected as Forêt de protection, which means that deforestation is forbidden. Another 180 ha of the forests are protected as Natural reserve.

Since 1963 (date of building of hydropower of Gerstheim), when the canalisation works were finished, the forests have not been flooded anymore. The river Rhine heritage still consists on deposits of silt, sand and gravel. Groundwater level at 1 m depth now is characterized by low amplitudes (about 0.5 m) and by a hydrological network of former lateral arms without any connection with the river itself.

The main plant communities consist on different sub-associations of the community with oak, ash and elm (162 ha: hardwood forest composed of ash, oak, elm, white poplar in the canopy). The forest steps of the succession are also present (3 ha: pioneer softwoods and mixed soft/hardwood). The natural reserve includes also some reed communities, moist, sub-natural meadows (0.25 ha) and dry open lands (0.2 ha).

Table B-2: *Details of the operation management of Polder Erstein (Voies navigables de France 2004)*

Discharge of the river Rhine	average duration	period of time	what will happen inside the polder?
> 1,500 m^3/s	60 days/year	whole year	water will run through former channel system
> 2,000 m^3/s		June and July	ecological floodings will cover parts of the forest
> 3,600 m^3/s	max. 20 days	every 10 years	beginning of retention flooding: the whole area will be flooded

In case the discharge of the river Rhine will exceed 2,000 m^3/s the ecological floodings might start. A local law from the Prefect proposes a monitoring for evaluate the impacts of the flooding restoration.

Polder Altenheim (D)

The Polder Altenheim is situated in the neighbourhood of the barrage of Kehl/Strasbourg. Before the construction of this barrage in 1968, the forests, meadows and agricultural sites now situated inside the polder were flooded regularly. Between 1968 and 1987 this area was no longer connected to the river Rhine. For about 20 years there had been no floods. Due to the new dryer conditions, management had changed the forest cultivation into non- or less flood-tolerant tree species, as for example sycamore. As a result, during the first operation of the new polder, water flowed into an ecosystem no longer adapted to floods. The bark of trees, especially sycamore, gashed or trees even died.

After recognizing these damage operation management has been adapted. In accordance to the discharge of the river Rhine defined amounts of water are used now for ecological floodings.

Inside the polder forestry covers 262 ha (managed forests with sycamore, ash, poplar and oak).

The experience with ecological floodings now last for more than 16 years. Since its test use in March 1987 the polder was in operation for flood protection in March 1988, February 1990, February 1999, and in May 1999.

Table B-3: *Details of the operation management of Polder Altenheim (Regierungspräsidium Freiburg)*

Discharge of the river Rhine	discharge through polder	period of time	what will happen inside the polder?
> 1,550 m^3/s – 1,900 m^3/s	20 – 40 m^3/s	according to discharge	water will run through existing and former channel system
1,900 m^3/s – 2,200 m^3/s	40 – 60 m^3/s	according to discharge	ecological floodings will cover about 10% to 30% of the forest
2,200 m^3/s – 2,800 m^3/s	60 - 80 m^3/s	according to discharge	ecological floodings will cover about 30% to 80% of the forest
2,800 m^3/s – 3,800 m^3/s	0 m^3/s	in case of forecasted retention	water will run through the outlet in order to provide total volume for retention use
> 3,800 m^3/s	max. 150 m^3/s	every 10 years	beginning of retention flooding: the whole area will be flooded

Basin Dietenbach (D)

Out of hundreds of retention basins along tributaries of the river Rhine in Baden-Wurttemberg and in Alsace only a small number of basins suitable for the FOWARA objectives could be defined (Figure B-5). Especially for the forested retention basin Dietenbach situated close to Freiburg data on long term research investigations are available. Table B-4 gives an overview on all flooding events since the inauguration of the basin in 1992.

Table B-4: *Flooding events of the retention basin Dietenbach (University of Freiburg)*

date of flooding event	height	duration
May 1994	2,20 m	5 days
June 1995	2,10 m	6 days
July 1996	2,20 m	4 days
July 2001	1,90 m	3 days
May 2002	2,10 m	5 days (experiments)
November 2002	2,00m	4 days
March 2006	1,50 m	2 days

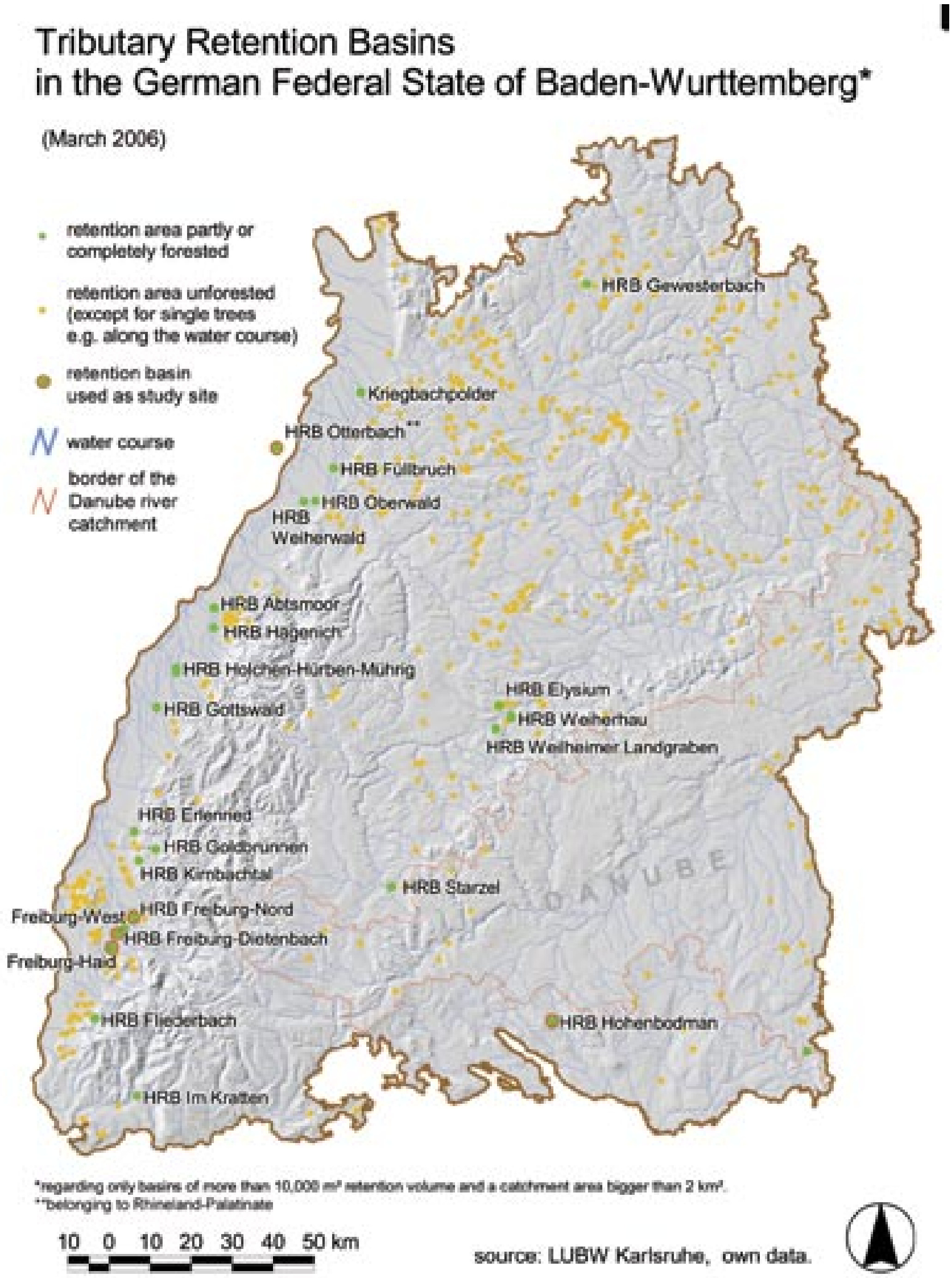

Figure B-5: Retention Facilities along tributaries of the rivers Rhine and Danube in Baden-Wurttemberg

Table B-5: *Main Characteristics of Forested Water Retention Facilities*

	Tributary Retention Facilities (data by University of Freiburg)	Retention Facilities along the river Rhine (data by Regierungspräsidium Freiburg)
CURRENT FACILITIES		
number of facilities	625 retention facilities in Baden-Wurttemberg: 456 dry retention basins, 146 retention basins with permanent lake; 27 of these are partly or completely forested (Figure B-5)	21 retention facilities along the Upper Rhine between Basle and Mannheim: 13 located in Baden-Wurttemberg 6 located in Rhineland Palatinate 2 located in France 8 of these 21 facilities are in operation (Figure B-4)
CHARACTERISTICS		
location/situation	along or beside the tributaries of the rivers Rhine and Danube	along the river Rhine; former alluvial floodplains
total surface	retention surface from 1 to 250 ha	surface between 210 ha and 700 ha
total volume	ranging from less than 1,000 m³ to more than 2.5 Mio. m³	retention capacity between 5.3 Mio m³ and 37 Mio m³
current land use	mainly agriculture (pasture, only some crop-land), sometimes woodland	About 70 % of the areas inside the retention facilities in Baden-Wurttemberg are under forest management; another 15 % are covered by water and infrastructural facilities. Retention facilities in Alsace are mainly forested; those in Rhineland-Palatinate are mainly under agricultural use.
relief	very different: from flat zones with little slope to narrow valleys with steep slopes	flat zones with little slope carved by usually dry former side channels of the river Rhine
HYDROLOGY		
catchment area	ranging from 0.3 km² (ret. bas. Landkutschers Kapf) until more than 1,000 km² (ret. bas. Gottswald), mean area of 110 km² (forested basins) water gauge Oberkirch/Rench (ret. bas. Holchen-Hürben-Mührig): 215 km²	water depth gauge Basle: 35,929 km² water depth gauge Maxau (Karlsruhe): 50,196 km²
channel length	ranging from 0.5 km (ret.bas. Landkutschers Kapf) until more than 90 km (Kinzig -> ret. bas. Gottswald), medium of 15 km (forested basins) Rench (Holchen-Hürben-Mürich (HHM): 60 km Kinzig (ret. bas. Gottswald): 90 km	River Rhine 1,320 km French-German Border 184 km The Netherlands 136 km
discharge	regular discharges of less than 1 m³/s up to 25 m³/s e.g. — HHM* — Gottswald** MW — 71 m³/s — 25,4 m³/s HQ 10 — 140 m³/s — 661 m³/s HQ 50 — 201 m³/s — 932 m³/s HQ 100 — 229 m³/s — 1049 m³/s *gauge Oberkirch/Rench **gauge Schwaibach/Kinzig	water discharge gauge — Basle — Maxau MW — 1,060 m³/s — 1,255 m³/s HQ 10 — 3,645 m³/s — 4,100 m³/s HQ 100 — 4,549 m³/s — 5,300 m³/s HQ 200 — 4,790 m³/s — 5,700 m³/s
reason for extreme floods	snow melt in combination with long lasting rainfall during winter or heavy rainfall during summer	snow melt in upper catchment area or long lasting rain events in combination with frozen surface
FLOOD CHARACTERISTICS INSIDE FACILITIES		
flood occurrence	varying from a couple of times per year up to once in five to ten years	floods which will require the operation of retention facilities along the river Rhine will statistically occur every 10 years.
flood duration	some hours up to some weeks (maximum duration known: 44 days in HRB Hohenbodman); usually 1-3 days; duration depends on many factors like flooding event, discharge of outlet, catchment area	retention floodings will last about 9 days including filling and draining; ecological floodings in the average will occur several times a year and last 57 days/year in the average (between a few hours and up to several weeks) with changing discharge
flood height	some decimeters up to more than 14m (HRB Hohenbodman), depending on height of dam and amount of retained water	usually 2.50 m at maximum near dikes across water flowing direction; south of those dikes the inundation height will be lower
flood velocity	generally stagnant	depending on relief, forest stand situation and existing water channels; during floodings inlet and outlet buildings usually will allow running water

B7 - Comparison of polders and basins

In order to provide an overview of the different types of retention facilities which were studied during the FOWARA project Table B-5 gives some information on the number of the facilities and their main characteristics.

While most of the retention facilities in Alsace and Baden-Wurttemberg which are situated along the river Rhine are forested only few (4%) of the tributary facilities are partly forested. According to the differing catchment areas the total surface and total retention volume are widely spread.

B8 - Climate change and increasing risk of flooding events

The public discussion on global climate change almost exclusively focuses on future changes in temperatures whereas changes in precipitation patterns remain relatively unregarded, although this factor is of highest importance for agricultural used ecosystems and forests. Changes in precipitation patterns have contributed to an increasing number of natural disasters (EM-DAT 2002) which e.g. have caused a world wide economical loss of about 55 billion USD in 2000 (Münchner Rück 2003). It has been shown that the global amount of precipitation has increased because of the higher temperatures and the subsequent intensification of the atmosphere's hydrological cycle. This has caused an increased frequency of zonal circulations of clouds in Central Europe between 1889 and 1990 leading to a statistical significant increase of precipitation during winter and spring (Bardossy & Caspary 1990, Schönwiese et al. 1993) and a significantly higher total annual amount of rainfall in the Northern half of Europe (Hegerl et al. 1994). As a consequence, the average water flow in the largest German rivers has increased by about 26% over the last 60 years (Schumann 1993). In Southern Germany for example, the average annual amount of rainfall has increased by ca. 10% in the last 30 years. However, whereas in summer it has decreased by 20%, it increased by 30% in spring (Werner et al. 2000). For the future, different climate models predict further changes of precipitation patterns with even higher precipitation during winter and spring in these regions which will cause a considerably higher risk of flooding in Central and Northern Europe (IPCC 1997, ICPR 1998). In addition it is predicted that the number of days with precipitation will decrease in Southern Germany, but the number of days with heavy rain events (above 20 mm per day) will generally increase (Rennenberg et al. 2004). We have therefore to expect the paradox situation that drought periods will increase in summer but due to the intensification of precipitation, regionally / locally there will be more flooding events at the same time (Rennenberg et al. 2004, Kunstmann et al. 2004, Knoche & Forkel 2004).

B9 - Which concerns are affected, which conflicts do occur?

"Room for rivers"- after the flood events of the last decades, this slogan gradually seemed to find broad acceptance in our society. The establishment of retention areas is one of a set of measures to avoid or minimise damage in the case of a flood. Although there is a kind of social agreement in the necessity of such measures, however, the selection of concrete areas often leads to conflicts.

What are the reasons? The people living in the flood protected areas are not used any more to flood events. In the floodplains different kinds of land use have been established (Figure B-6).

Intervening in existing property rights and already competing utilisation claims, the designation of retention areas causes a typical distributional conflict (Claus & Gans 1994). Different interests are affected: municipalities and local residents are afraid to lose their recreation areas, forest owners to have a loss of income due to damage in their forest stands, while nature conservation groups hope to achieve the restoration of former floodplains. These different opinions can be seen in the public discussion in newspaper articles and posters (Figure B-7).

The publics and landowners reactions on the planning depend on several factors. In the case of a retention area which is situated close to the settlement and which is regularly used as a recreation area, there are much more concerns than in areas far away from residential estates or which are of no significance for the further settlement development. In such a case many details have to be discussed: how to protect housing estates from water damage, how often has the retention area to be closed for visitors, how will the area be cleaned from mud, which possibilities for future developments will be left for municipalities?

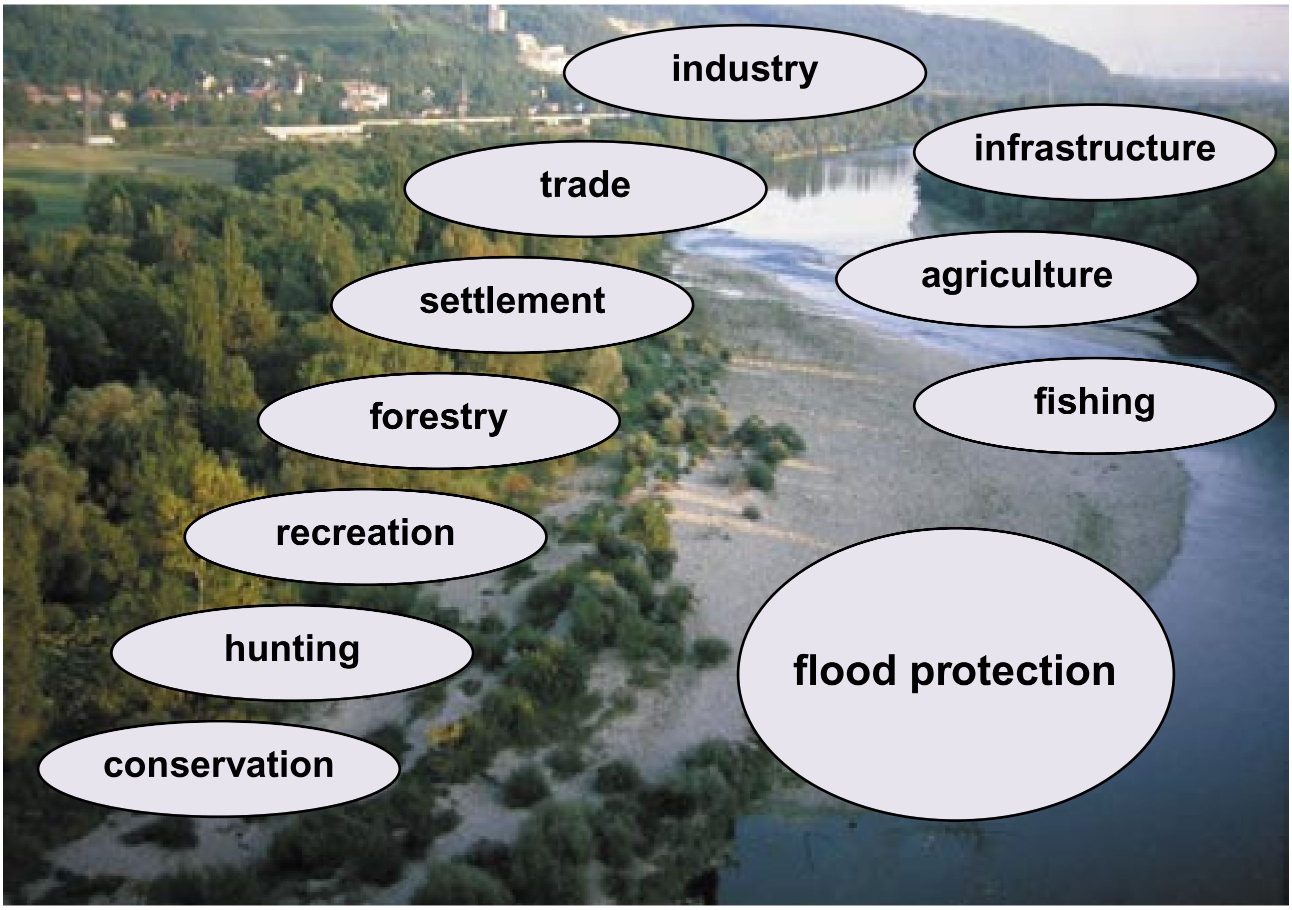

Figure B-6: *Flood protection is intervening in existing and already competing utilisation claims*


„Da wird noch lange nicht gebaggert“

Aus der Regio

Alte Sünden rückgängig machen

„Die Wildstromaue - eine Chance für die

Wenn Mäuse und Igel absaufen

Figure B-7: *Headlines in regional newspapers concerning retention areas at the Upper Rhine: „There won‘t be digged so soon“, „To reverse old sins“, “The wild floodplain - a chance for nature”, „When mice and hedgehogs drown“*

Figure B-8: *„Ecological flooding - not in this way! “ - a poster of the Breisach citizen’s initiative referring to the retention area Kulturwehr Breisach and Breisach/Burkheim*

Most opposition is caused by the ecological flooding (Figure B-8). Residents and land users regard this measure as an unnecessary additional burden constraining other use of the area such as tourism and recreation. Local residents often feel closely connected to their surrounding landscape and are afraid of measures which from their point of view could destroy it. Therefore they are not convinced to achieve an ecological improvement by using periodical flooding.

The attitude of affected municipalities and their residents has a great influence on the planning process. They mostly adopt one of the following positions towards retention areas:

- „We agree and hope to benefit from the planning": The municipality integrates the planning in the own settlement development.
- "We agree only under specific conditions": The municipality supports flood protection in general but expects minimisation and compensation of negative effects of the measures.
- "We do not agree since we are not responsible for the floods": The affected municipality does not feel responsible to provide retention areas for floods caused by interferences in river systems in other regions. They tell affected regions to take actions themselves like to give up creating buildings near the river.

The most important aspect to land owners and users is to get an appropriate compensation for disadvantages. There already exist a lot of experiences in using standardised compensation catalogues for agricultural or forested areas and the instrument of property exchange.

So the implementation of flood retention areas includes always a difficult and often longsome process of balancing different interests. The described concerns are incorporated into the formal planning procedures (regional planning procedure, planning approval procedure). To be successful in planning, beside a scientific knowledge and having the suitable political and financial basic conditions, it is necessary to have an insight into informal participatory planning and communication processes. Therefore in chapter E advices will be given how to deal with difficult situations concerning the communication in a planning process and how to choose suitable participatory methods.

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Chapter C
How does flooding affect forested areas?

C - How does flooding affect forested areas?

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C1 - What are the characteristics of alluvial forests?

Floodplains develop as a result of fluvial dynamics driven by varying water discharges from the watershed. Their present morphology reflects the hydrological history with high floods as major events shaping the landscape. Communities of natural indigenous species that establish themselves within these zones are used to coping with the inherent physical conditions as outlined below.

Hydrological conditions of alluvial ecosystems

The changing discharges of the water regime as well as large floods govern much of the hydrological processes and patterns prevailing in alluvial ecosystems. During floods the channel width increases and includes some or all of the floodplain in order to accommodate the increased discharge. Such overbank flooding is generally characterised by high spatial as well as temporal variability. In large rivers in low relief like the river Rhine, the overbank flooding, under natural conditions, has the potential to inundate a large area extending up to several kilometres from the main channel.

During such events, and as a rule, hydrological exchanges occur between groundwater and surface water with surface water penetrating the alluvium and recharging the alluvial aquifer. This horizontal and vertical seepage from surface water bodies that affect the dynamics of the aquifer is closely linked to the water regime of the river. Furthermore, because of the influence of the soil vegetation system, these interactions contribute to purifying the flood water, since the vegetation absorbs nutrients while the soil colloids (clay, silt) adsorb cations (Sanchez-Perez et al. 1991).

An example of such dynamics is given in Figure C-1.

The typical groundwater fluctuations of an alluvial forest are shown on the very left part of Figure C-1. Wet periods are just as characteristic as dry periods with deep groundwater level. With the construction of a hydropower station an upstream part of the river changed into near-stagnant water and the stream channel bed began to seal. The amplitude of groundwater fluctuations became smaller; dry periods with deep groundwater levels were no longer possible. With the beginning of ecological floodings in the nearby forested water retention facility the amplitude of groundwater fluctuations enlarged again.

Thus in this guideline the first focus will be on the effect of flooding on the transfer of water, sediments and nutrients into alluvial forests and into groundwater.

Geomorphological processes create a spatially heterogenic mosaic of landforms, soils and habitats.

The strong interactions between short lasting, high stream power floods and channel and sediment movement create a dynamic situation within the alluvial zone. While the channel does undergo adjustment to changing discharges, with cutbank migration, bed degradation, bank erosion, and overbank deposition the bottomland morphology is continuously

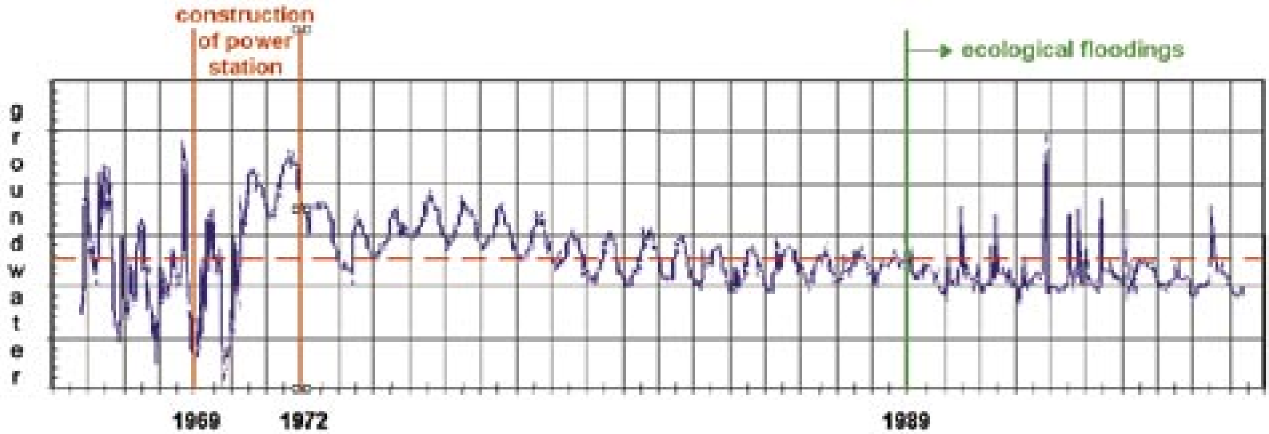


Figure C-1: Development of groundwater fluctuations due to the changes of the stream corridor (1969 to 1972) and the operation of a water retention facility (since 1989); Polder Altenheim, Germany reshaped. The materials in the floodplains become commonly segregated by size into lenses and beds consisting primarily of gravel, silt loams, clay loams, sand loams and sand. As a result, surface soil textures (and thus soil ecology) in floodplain forests may change quickly and to a large extent.

Adaptions of vegetation communities

Vegetation establishes in accordance with the degree of species adaptation to flood regime. The distribution patterns of vegetation types may be considered to be a reflection of the flood gradient with the most flood-tolerant species and communities occurring in the most flood-prone reaches of the floodplain, while the least flood-tolerant species are found in areas least subject to periodic inundation. Vegetation succession along this flood gradient is therefore strongly influenced by the long term flow regime or average annual flood pattern, as well as by unusual hydrological events and soil characteristics (Figure C-2).

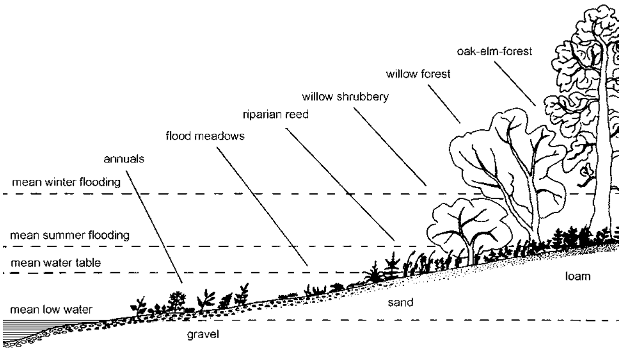


Figure C-2: *Scheme of the vegetation zones of a Central European stream (modified according to Wisskirchen 1995)*

For temperate European regions, the following typical zonation of woody vegetation (Table C-1) can be found. Data collected in flooded forests along the river Rhine after two extreme floods in February and May 1999 serve as a wide basis to specify the conditions of alluvial zones and the riparian forests between Iffezheim and Karlsruhe.

Due to man made changes of river channels and to the construction of huge dike systems the present-day inundation characteristics differ from natural alluvial ecosystems. Nevertheless, Table C-1 provides a framework for the construction and operation of forested water retention areas. The results of the FOWARA project described in the following chapters enable at least to specify recommendations to forest managers and people involved in planning and operation of retention facilities.

Table C-1: *Alluvial zones corresponding flood height/duration and characteristic tree species. Inundation characteristics depending on data ascertained between Iffezheim and Karlsruhe (water depth gauge Maxau) (Michiels & Aldinger 2002, Pfarr 2002)*

alluvial zone	average flood height above ground [m]	average flood duration 1.4. – 30.9. [days]	maximum flood duration 1.4. - 30.9. [days]	characteristic tree species*
softwood	> 2.70	> 60	> 140	White Willow
between soft- and hardwood	2.70 – 2.20	60 - 33	140 - 110	White Willow, poplar, Small-leaved Elm, Pendunculate Oak
lower hardwood	2.20 – 1.70	33 - 15	110 - 65	Pendunculate Oak
middle hardwood	1.70 – 0.90	15 - 4	65 - 35	Comon Ash, European Hornbeam, Small-leaved Lime, Field Maple
high hardwood	0.90 – 0.30	4 - 1	35 - 10	sycamore
upper hardwood	≤ 0.30	< 1	< 10	Common Beech, Wild Cherry

*scientific names of tree species can be found in Annex 2.

C2 - How does (re)flooding influence the groundwater?

Any flood event affects the groundwater to some extent as well as the physical and chemical composition, both rising groundwater (seepage) and overbank flood water soaking through the ground to temporarily replenish the aquifer, with a corresponding rise of the water table.

Floodplains are recognised by their purifying capacity with respect to the lateral and vertical transfer of nutrients through the soil root system (e.g. nitrate and phosphate Sanchez-Perez et al. 1991, 1999). The reduction of transfer into the groundwater and/or to the river takes place at the terrestrial-aquatic interfaces (lateral transfer) and in riparian vegetated zones (lateral and vertical transfer, Figure C-3, Takatert et al.1999, Brüsch & Nilsson 1993, Clement et al. 2003). These zones act as a buffer zone and reduce the transfer of nitrates from upland ecosystems to the river. However the nitrate removal rate is very heterogeneous, estimated at 1400 kgN/ha/year within a flooded forested area (Sanchez Perez et al. 1999). This largely depends on the ease of flooding, the duration and the frequency of the floods. This rate is high compared with a poorly drained zone which retains only 120 kgN/ha/year (Nelsson et al. 1995) or 390-490 kgN/ha/year in wet meadows (Leonardson et al. 1994).

Re-flooded ecosystems

The prevention of floods has resulted in a modification of the nitrogen cycle and, in particular, in increased nitrate levels in the groundwater at an average depth of 5-6 m.

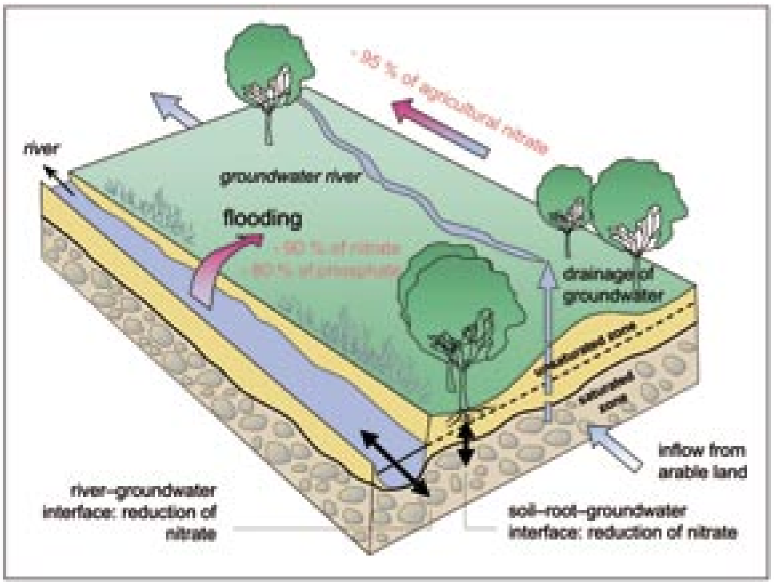


Figure C-3: *Scheme of fluxes and reduction of nutriment transfer in an alluvial forest (according to* TAKATERT *1999, modified)*

To analyse the changes in the groundwater chemistry because of re-flooding in an alluvial zone, a nitrogen model was used which specifically examined the mineral forms nitrate, nitrite and ammonium in the floodplain at the Upper Rhine (Polder Erstein). There a sector of a floodplain has not been flooded for two centuries (referred to as the 'external zone') and another sector has not been flooded since 1970 ('internal zone'). They were compared to each other, which resulted in some quite interesting insights into the processes (Figure C-4).

The amplitude of the groundwater levels was definitely higher near the river Rhine (not flooded since 1975) and showed a slight decrease with increasing distance away from the river Rhine (Figure C-5). The space-time variations of the nutrients, nitrates and phosphates were weak in the external zone. Nitrate concentrations in the groundwater were at least four times higher in the external zone than in the internal zone, whereas the phosphates exhibited similar concentrations. This result is connected to the low amplitudes of the groundwater levels in the external zone. Indeed, the strong variations in the groundwater levels support alternate periods of nitrification and denitrification, which causes a reduction in nitrates. The nitrate content in the external zone reached levels up to 15 mg/l N-NO_3, but remained low in the internal zone (less than 1.5 mg/l). The two

Figure C-4: *Map of Polder Erstein and research stations (*PARTY *2003)*

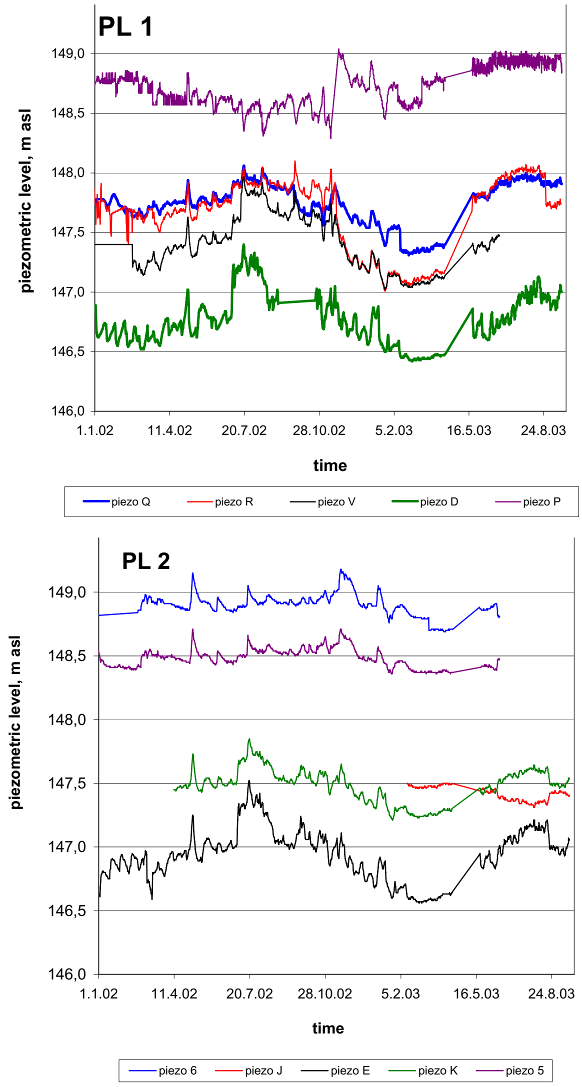


Figure C-5: *Development of groundwater fluctuations in a sector not flooded since 200 years PL2 and a sector not flooded for 35 years PL1 (Polder Erstein, France)* other forms of nitrogen, resulting from the reduction of nitrate, did not change with the duration of the flood-free period.

Groundwater at 2 m and 5 m depths were different in nitrate content: the deep groundwater (beneath the root) was a little more contaminated than the shallow groundwater in the internal zone. It might be that the roots of trees take up the nutrients (especially nitrates) at the surface. In case of excess supply not being absorbed by the roots, and no denitrification occurring at the surface, nitrates infiltrate into the groundwater (Sanchez & Trémolières 2003).

Changing nitrogen transfer after re-flooding

The prevention of the floods also suppressed the inputs of sediments and minerals from the river and nutrient transformation by the previously mentioned processes, and modifies the hydrological functioning of the non-flooded areas. Restoration efforts are made to improve the functioning of surrounding forested wetlands. For example the State of Louisiana proposed diversions of Mississippi water into nearby coastal wetlands in order to mimic flood events (Lane et al. 2003) resulting in a controversial discussion. The fear was that the offshore waters of the Gulf of Mexico could be enriched with excess nitrate which then would contribute to low oxygen content due to excessive algal growth. However the authors observed that the newly restored wetland was poor in nitrogen content, and the diversion had no major effect on the water quality of Lake Cataouatche situated in the upper Mississippi estuary that received diverted waters from the stream now flowing through the restored wetland. In fact, most of the nitrate in the Mississippi river was removed from the river in the upper reaches of the estuary in a reconstructed basin (Delaune et al. 2001). In southern Sweden, Jansson et al. (1994) listed the possibilities for the use of wetlands in order to reduce the nitrogen transport for different habitats like different types of wetlands, lakes etc. Ponds with macrophytes are the most efficient in nitrogen trapping, compared to flooded forests and meadows.

In Polder Erstein it was shown that the restoration of floods greatly influenced the transfer of nitrate into the groundwater. In fact, the nitrate concentrations increased just after a flood, especially in the internal downstream part of the re-flooded sector, where the concentrations in the groundwater were very low. The phosphate concentrations did not vary. However, after the floodwater receded, the concentrations quickly returned to their former levels (Figure C-6). At present it can be concluded that re-flooding modifies the transfer of nitrate on a short period (in this case probably due to the low duration of floods).

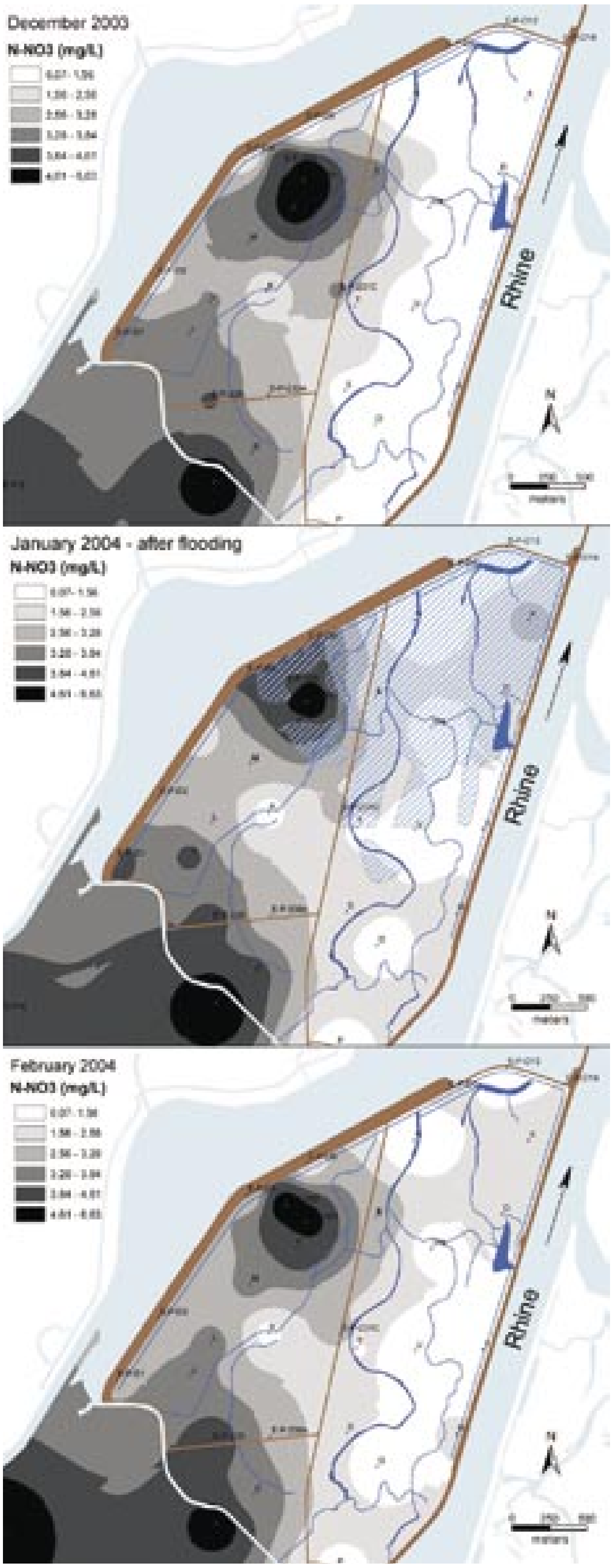


Figure C-6: *Change in nitrate in groundwater with reflooding in the Polder Erstein (Ginger Environment 2003)*

What is happening during the transfer through the soil? In the solution, the variations of nitrogen concentrations in the soil solution were higher than in those measured in the groundwater over the study period (2004, 2005). As with the groundwater, the soil solution at different depths revealed significant differences between both sectors, one sector not flooded for 200 years named "external" to dykes) and another not flooded for 30 years (named "internal"). The internal east sector had very low concentrations, less than 1mg/l N-NO_3, whereas the mean concentrations in the external zone varied between 3 to 5mg/l. Here an increase in the concentration was observed along with increasing depth. This was not the case in the internal sector.

Nitrogen concentrations in the soil solution were higher than those measured in the groundwater in the former channel. The opposite result was obtained for the terrace.

The re-flooding (flood of January 2004) influenced transfer through the soil, in spite of its short duration. Although only a part of the study site was affected, a significant increase in the nitrate level was observed in the flooded sectors, even in the sector close to the river Rhine where the contents were always very low.

After flooding the nitrate concentrations decreased in all soil horizons in the internal zone, in both forest stands of the channel and in the terrace, whereas ammonium concentrations tended to increase (Figure C-7).

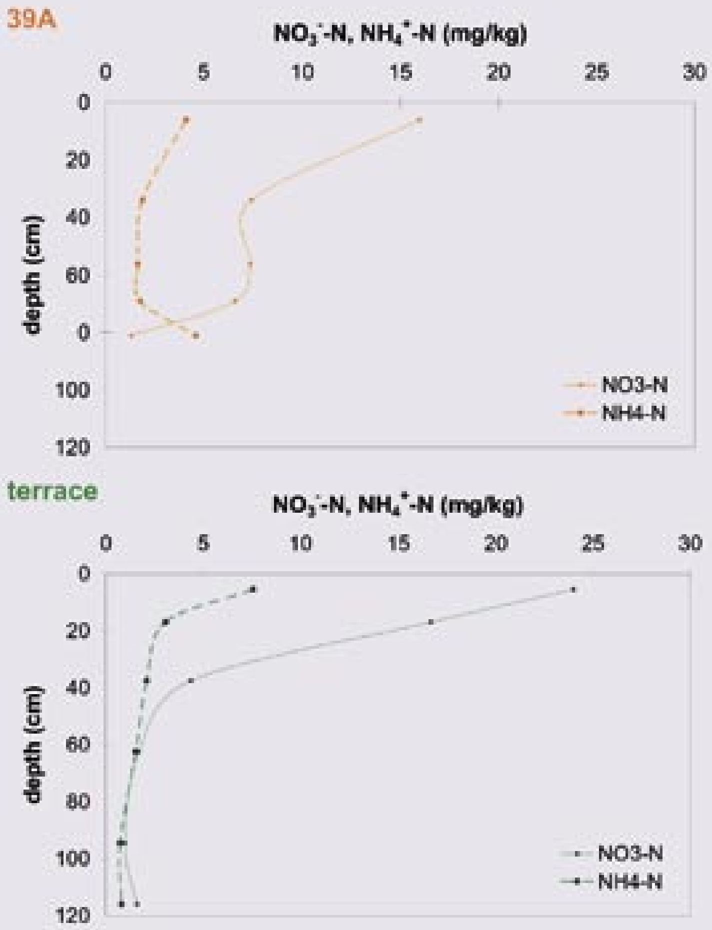


Figure C-7: Mineral nitrogen contents in the soil of a sector not flooded for 200 years (39A) and sector not flooded for 35 years (terrace); see Figure C-4 for location

All of these results confirmed the reducing effect of the flood in the reflooded soil, whereas soils without floods are mostly nitrifying which is demonstrated by the high level of nitrate in soils of the external sector. Besides denitrification, vegetation uptake has an effect on the reduction of nitrate transfer through the soil.

Does the extent of nitrogen transfer depend on the intensity, frequency or duration of floods?

Hydrogeological conditions, together with the hydrology, were important factors controlling the removal of nutrients. Thus, a year of intermediate disturbance (e.g. with flood episodes over a short period and groundwater rising over a variable duration) seem to be more efficient in nutrient removal (TAKATERT ET AL. 1999).

An estimation of the time required for efficient nitrate reduction was determined in an experiment based on soil cores.

Denitrification experiment: soil cores were taken from three different alluvial soils of the Polder Erstein. They were put into glass columns and were then exposed to nitrate-enriched Rhine water (50 mg NO_3^- /l). After three to four days of flooding at a rate of 5 ml/min, nitrate levels in the soil solution decreased in both the external and internal zone (Figure C-8). The process responsible for this reduction of initial nitrate load is called denitrification.

Denitrification potential rate of field and artificially flooded soil cores from the internal area was quite similar. The highest value was measured in surface silt loam: up to 20 µg N-N_2O / g dry soil at the 24th hour of incubation (terrace soil sample which was rich in organic matter) and only 5 µg N-N_2O / g dry soil at the 48th hour (channel). In the external area a clear difference was found between field and artificially flooded soil samples (Figure C-8). The denitrifying capacity of the zone unflooded for 222 years still exists but is delayed due to flood prevention.

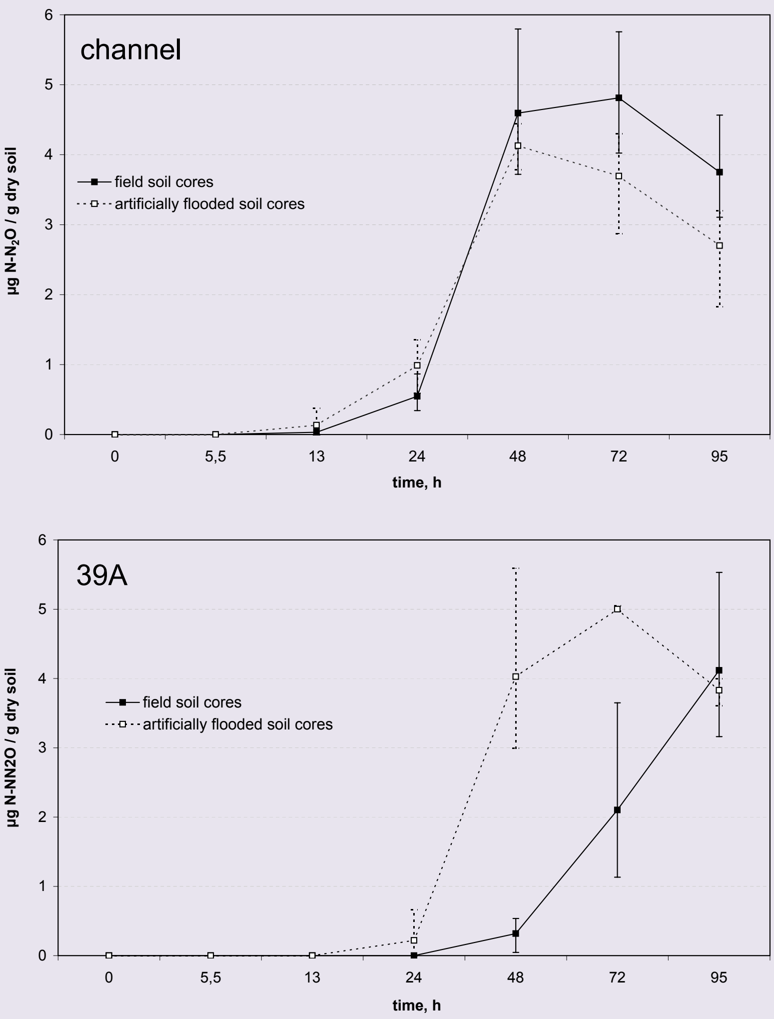


Figure C-8: *Denitrification potential in the soils of the former channel of the internal zone (channel) and in the external zone (39A); see Figure C-4 for location*

C3 - How does flooding affect the soil?

Waterlogging of soils reduces soil aeration at short notice to a very low degree. The detained water occupies the previously gas-filled pores thus limiting the gas exchange between soil and air to a very slow molecular diffusion. The remaining oxygen is quickly consumed by microorganisms. Only anaerobic bacteria and fungi can survive under these conditions. Generally speaking, all metabolic processes such as the decomposition of litter are slowed down and thus the nutrient cycle and the soil pH value is modified (Kozlowski et al. 1991).

These processes are dependent on the flow velocity, the temperature and the oxygen content of the water and therefore act much more strongly in tributary retention basins than in polders or even natural floodplains due to the slowing of water flow (stagnant water conditions).

Other than in permanently wet sites, retained water in water retention basins draws back mostly before severe anoxic conditions can establish. The macropores enable the retained water to seep away quickly.

Another important impact of flooding on the soil is the deposition of mineral and organic sediments on the soil surface and in the macropores. In tributary retention basins, each flooding event can leave behind a thick layer of mud (in some places more than 6 cm (Rusdea & Sittler 1997)). The sedimentation rate is closely related to the frequency of waterlogging and the distance from the water's edge. Where the greatest extent is reached, it may exceed two metres in extreme cases, after being in operation for almost 40 years (Figure C-9).

***Figure C-9:** Profile of sediment body in the retention basin at Hohenbodman, southern Germany. Note the cut fir roots indicating former soil surface*

The deposited sediments have a higher base status than the original topsoil, indicated by an increase of the pH-value towards the bottom outlet. In the same way, the calcium content is considerably higher there than in the non-waterlogged areas. The flooding can bring in considerable amounts of organic debris, which might then be deposited and relocated. If the flow velocity is high (e.g. at the water's edge) the organic layer will be removed (Figure C-10). Especially fine debris will be deposited on the fringe of the retention area. If bigger driftwood gets stuck in front of standing stems, a barrier can be formed subsequently which then holds back more and more (also fine) debris.

***Figure C-10:** Organic litter after the impact of flood water collected in a small basin south of Freiburg, Germany: at the water´s edge the leaves have been washed away, whilst in the middle the litter has been moistened and the uppermost part it has been relocated*

Through occasional inundation as is the case in natural floodplains, the soil repeatedly becomes moistened, which is indicated by the massed presence of hygrophilic plant species. As a result of the improved moisture availability litter is decomposed more rapidly, as is revealed by decomposition of the oak litter, a usually recalcitrant litter (Badre 1996). In retention basins this is revealed by the absence of a fermentation and humification horizon and high levels of earthworm activity in the lower inundation areas. There the soil texture becomes crumbly and rich in macropores due to the high bioactivity (Figure C-11). The chemical composition of the soil changes depending on fluctuations of water level.

***Figure C-11:** Soil surface in lowest reaches in the retention basin Freiburg-Nord, Germany*

C4 - How does flooding affect the ground vegetation?

Once the hydrological regime becomes altered, ecological adjustments will induce changes in the plant communities, and select species according to their ability to withstand site conditions imposed by these modified hydrological conditions.

Whereas in tributary retention basins the existing forest stand must adapt to the altered ecological conditions, ground vegetation with inundation and sediment resistant species similar to riparian vegetation can establish.

Species favouring dry and/or non-inundated conditions such as *Carex brizoides, Stellaria holostea, Hedera helix, Convallaria maialis, Oxalis acetosella* and *Stachys sylvatica* (as observed in the Otterbach, Hohenbodman, Freiburg-Nord, and Freiburg-Haid basins, south-western Germany) occurred in the higher non-flooded reaches of the retention basin. In the frequently inundated areas species indicative of both nutrient and nitrogen rich, as well as moist conditions arose in large coverage e.g. *Urtica dioica, Aegopodium podagraria, Alliaria petiolata, Allium ursinum* and *Ranunculus ficaria* (Figure C-12).

***Figure C-12:** Dense carpet of Ranunculus ficaria in lowest reaches of Freiburg-Nord basin*

Looking at the vegetation zone scheme in the introduction of chapter C, for retention basins it can be stated that with increasing flooding and sedimentation intensity the ground vegetation changes from a typical oak-elm forest herb layer to a willow forest herb layer or in the case of high sedimentation rates (basin Hohenbodman) a willow-shrubbery herb layer. In case of higher disturbance riparian reeds, flood meadows or even pioneer sites with annuals will establish. This however has been observed only at dams with high water table fluctuations and prolonged inundation periods (Pardey 1997, Wisskirchen 1995).

The opposite could be observed at Polder Erstein: after 35 years of flood prevention, the ground vegetation exhibited a marked decrease in hygrophilic species and an increase in mesophilic species. Like many other sites along the canalised river Rhine the forest at Erstein lost its typical species (plants and animals) and has been invaded by more common species better adapted to dry habitats.

These shifts are best illustrated in Table C-2 pointing to a noticeable decline of the typical alluvial species concomitant with a progressive replacement by mesophilic species.

***Table C-2:** Vegetation shifts documented as a result of the suppression of flooding in Polder Erstein*

	noticeable increase in abundance	noticeable decrease
Cornus sanguinea		x
Circaea lutetiana		x
Impatiens glandulifera		x
Equisetum hyemale		x
Cornus mas	x	
Corylus avellana	x	
Anemone nemorosa	x	
Carex acutiformis	x	
Festuca gigantea	x	

However, the major changes have already occurred and indeed probably took place very soon after canalisation. Indeed, observations from most forests of the river Rhine area indicate a rapid decrease in the luxuriant, species-rich carpet of hygrophilic grass species like *Impatiens noli tangere, Impatiens glandulifera, Carex acutiformis,* as well as the guild of species linked to fluvial dynamics like *Equisetum hyemale, Thalictrum aquilegifolium*. Mesic species such as *Bra-*

chypodium sylvaticum, *Paris quadrifolia* and *Carex sylvatica* developed rapidly after the prevention of flooding.

In the regeneration layer, typical alluvial forest species such as Penduncculate Oak, poplar species and elm species were missing, whereas sycamore and Common Ash were becoming increasingly abundant. The seedlings of pioneer woody species had become very scarce due to the increasing rarity of mature seed trees, the abundance of young ash and sycamore in gaps, and the absence of germination opportunities for these species highly vulnerable to grass competition. In addition, the increasing numbers of mesophilic species such as *Corylus avellana* and Field Maple represented new competitors. These latter species will probably play a significant role in future regeneration. *Hedera helix* and *Clematis vitalba* have also expanded since the prevention of flooding as they are sensitive to anoxia which might occur during flooding.

A specific study of *Hedera helix* has shown that the conditions optimal for its growth can be found in alluvial forests. Indeed, a comparison of *Hedera helix* plants revealed that those observed in an upland forest exhibited smaller diameters and lower annual growth rates than plants of about the same age in a flooded forest. However, temporary waterlogging in flooded forests severely limits the expansion of *Hedera helix*. This is particularly evident where flood durations are longer. *Hedera helix* benefits forest communities by protecting the floor from frost and erosion, increasing soil nutrient levels through the rapid decomposition of its litter in early summer, and by providing winter shelter and food to many species of birds, insects and mammals.

As such, Hedera helix plays a significant role in the forest ecosystem and should not be manually removed in polders, especially as it is naturally regulated by floods.

C5 - How does flooding affect tree seedlings and rejuvenation?

Tree seedlings are essential for natural regeneration of forests. In regularly flooded areas, seedlings of forest species can germinate only during non-flooded times, but most of them die back during the following flooding periods (Hall & Smith 1955). This could be confirmed during vegetation relevés in retention basin Freiburg-Nord during spring and summer. Almost all seedlings of the existing forest stand which had been recorded during the spring relevé were missing in the summer relevé.

Many freshly germinated tree seedlings are very sensitive to floodwater inundation. The non-woody parts of the plant (leaves, fresh part of stem) decay under water and dry out when the water recedes (Figure C-13). The seedling can sprout shoots from the woody part of the plant, but in the event of a repeated flooding the chances of seedling survival fall dramatically as the limited reserves are expended. In the long run, the seedlings react to flooding with reduced shoot growth (Kühne 2004, Siebel et al. 1998, see also below).

The influence of regular floods on the growth of hardwood seedlings (individuals <2 m) was studied in 2004 and 2005 in Polder Erstein (where no flooding has taken place since 1970) and in the forest of Rhinau (regularly flooded), both located in France.

Figure C-13: *Damaged seedling of Field Maple after 23 days of inundation in April and 7 days in May; floodplain of the Upper Rhine*

The comparison of growth rates revealed that all species grew more rapidly in the regularly flooded forest. Of the ten species common to both forests, seven exhibited a significantly higher growth rate: Sycamore, ash, Wild Cherry, Blackthorn, Grey Alder, Common Dogwood and European Spindle, whereas elm, Hawthorn, and Wild Privet showed no difference in growth rate.

The flora of the forest of Rhinau profits from moist fertile soils. Rising groundwater levels and floods bring several mineral elements contained in the water and in allochthonous sediments and facilitate better plant mineral nutrition by increasing the bioavailability of certain nutrients. Seedling growth is probably also stimulated by the risk of the plant of being submerged when floods do occur. The faster the plant grows the lower the risk of it being damaged or killed by a flood.

Wild ungulates are another element of the forest ecosystem that can be deeply involved in driving regeneration dynamics. A study of browsing by roe deer carried out in the two forests showed that deer foraging influences competitive relationships amongst species by reducing differentially the growth rate of seedlings. Overall, browsing indirectly favoured Common Ash, sycamore and Bird Cherry, whereas Hawthorn, Blackthorn, elm, Grey Alder and European Spindle were disadvantaged. In the flooded forest, however, the reduction of the growth capacity resulting from browsing was less for all species. This may be a consequence of a lower browsing intensity as deer is less abundant in Rhinau, but it may also be due to the higher soil fertility and water availability, which facilitated high growth rates and thus rapid biomass replacement. A regularly flooded forest may therefore be less susceptible to deer damage. These interactions and their effects on regeneration dynamics deserve special attention when managing such forests.

Observations concerning the flood tolerance of tree seedlings were made in the floodplain forest near Rastatt and in the former floodplain forest of Leimersheim. An overview over the determined threshold is given in Table C-3.

Seedlings of oak survived a flood of more than 30 inundation days without damage (maximum 46 days near Rastatt). In this period complete water coverage was prevailing. On the same sites seedlings and rejuvenation of Field Maple has endured the same flooding period without damage whereas ash seedlings died. The threshold for ash seedlings may be defined as 35 days. Seedlings of sycamore and Norway Maple died completely on sites with flood durations ranging from 21 – 46 days whereas in Au am Rhein 16 days were tolerated without damage. Therefore the threshold must be in the range of 16 to 20 days.

Table C-3: *Flood tolerance and threshold values of rejuvenation and seedlings*

tree species:	size of rejuvenation	threshold values „no damage < " in days	threshold values „losses > " in days	study area
oak	seedlings	46	-	Au am Rhein 1999
oak	seedlings	36	-	Au am Rhein 1999
oak	seedlings	>30	-	Leimersheim 1999
Field Maple	seedlings	46	-	Au am Rhein 1999
Common Ash	seedlings	35	-	Rastatt-Wintersdorf 1999
Common Ash	seedlings	-	46	Au am Rhein 1999
Common Ash	seedlings	21		Leimersheim 1999*
Common Ash	seedlings	14		Leimersheim 1999*
sycamore	seedlings	-	46	Au am Rhein 1999
sycamore	seedlings	16	-	Au am Rhein 1995
sycamore	seedlings	-	28	Au am Rhein 2001
sycamore	seedlings		21	Leimersheim 1999*
Norway Maple	seedlings	-	46	Au am Rhein 1999

*Source: IUS (2004) Vegetationskundliche Untersuchungen im Überflutungsgebiet Kahnbusch/ Langrohr bei Leimersheim - unpublished expertise

As a result of the removal of bottomland vegetation a lot of oak seedlings were found. This can be traced back to an increased light availability and a decrease in the mice population.

Insights on the effects of flooding on seedlings are also available from experiments on sycamore, Norway Maple, Common Ash, and hornbeam done in a field station near Freiburg as well as from in field observations in Fortmond and Zalkerbos (The Netherlands). Based on statistical tests applied to these observations, there was evidence that seedlings from Norway Maple are unable to cope with prolonged inundation, while in many other species, flooding reduced the root, shoot and stem weight of seedlings as observed among Norway Maple and hornbeam.

For Common Ash, the response to flooding of the root, the shoot, and the diameter–height relationships was reduced. Hence, Common Ash has a stronger reduction in stem growth than root growth under flooded conditions and a stronger reduction in diameter growth than height growth under flooded conditions.

Prolonged inundation of oak seedlings were also reported as detrimental and prevented seedling recruitment of this species in such areas, but this failure may also result from concurrence by the adjacent ground vegetation (Wagner 2006).

C6 - How does flooding influence tree growth?

Based on retrospective and actual tree growth analyses, described in the literature as well as observed in surveys conducted by FOWARA in various situations (natural floodplain, retention basin), many patterns were observed in trees exposed to inundation. Even if results outlined here cannot be generalised to all species composing the forest stands due to the limited number of samples and situations documented. Such general restrictions were also expressed by Brockway & Bradley (1995) who noted that because of a high variability concerning site and flooding conditions in riparian forests it is not possible to generalise the effects documented at single trees (Figure C-14).

Inundations lasting less than 10 days do not have any significant direct or short-term effects on radial changes in Penduculate Oak, Common Ash and Common Beech. The major determining factor seems to be the weather conditions.

Dendro-ecological reconstructions of flooding history point to various long-term effects, however with contrasting results, including, in some situations, an increase of radial growth as a reaction to shorter inundation while longer inundation may be associated with an impairment of radial growth. For Common Ash, inundation may promote a significant increase during the year in which the inundation took place, even in trees displaying some bark lesions induced by the flooding in naturally inundated floodplains. However, in the case of stagnant water in retention basins, the situation may be different with negative effects on growth (Figure C-15). In this respect, quite contrasting observations have been made in the floodplain of the Mississippi where Burban & Andresen (1994) found that the diameter growth of Green Ash, which is often categorised as relatively tolerant of flooding, was 80 percent greater than normal when water remained on the ground from spring through August. Prolonged inundation during spring flooding was further reported as causing Bur Oak to develop shrunken vessels (St. George et al. 2002) while Yanosky (1983) stated that the Green Ash he examined built abnormal earlywood vessels after defoliation. This was induced by flooding at the beginning of the vegetation period. In the case of defoliation only later in the summer, large-diameter ring-porous vessels were built in the latewood.

Even sensitive species such as Common Beech may exhibit a radial growth increase in the year where it was exposed to inundation, provided these latter were linked with flow velocities typical for floodplains (i.e. no stagnant conditions). In contrast, radial growth impairment in these species may be expected after having been subjected to stagnant water conditions in small retention basins.

Some case studies showed that the impact of flood events on timber quality is limited to the flood year, but in the years following the flood event the density is not affected. Likewise, available data suggest that timber quality changes may affect only the basal parts of the trunk, with no additional effect on the timber quality of the upper trunk sections.

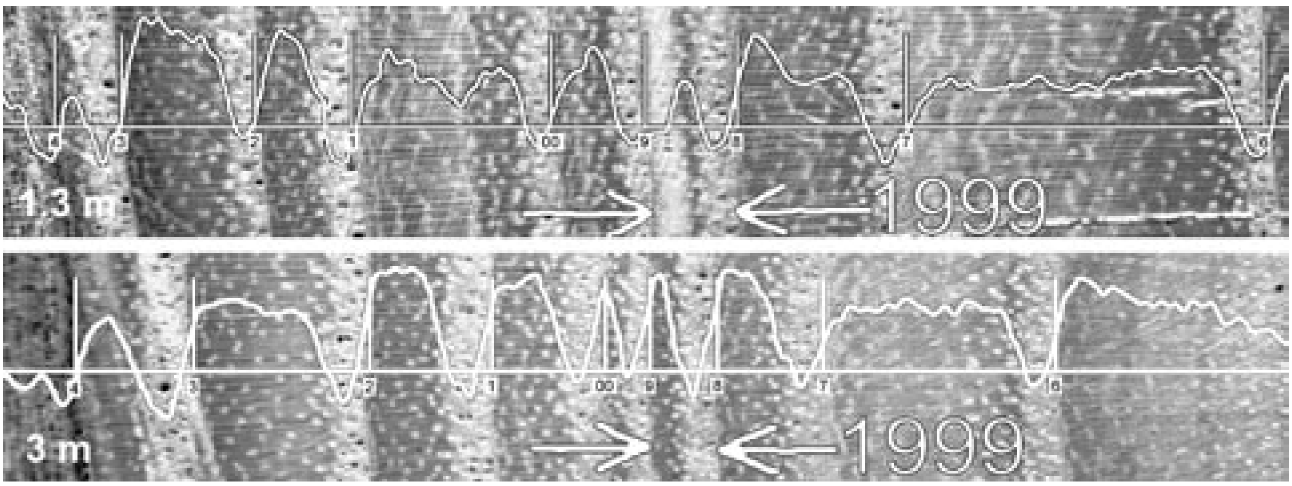


Figure C-14: *Relative wood density of an ash tree of the floodplain of the river Rhine at Rastatt at a height of 1.3 m and at 3 m. In the course of the year ring of 1999, a possible impact of the flooding can be recognised: the density of the latewood decreases rapidly and falls below a value typical only for early wood. At a height of 3 m, the same year ring does no longer show this impact*

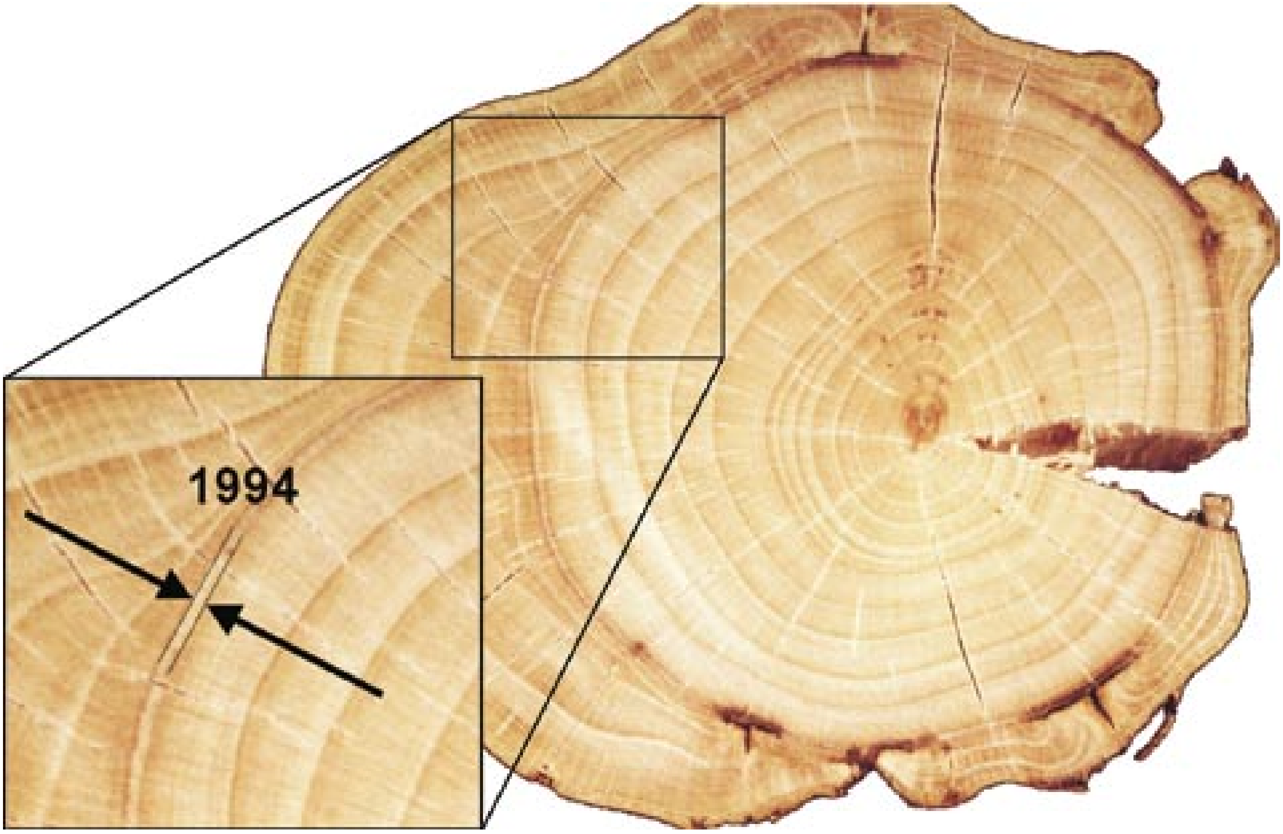


Figure C-15: Cross-section of a beech tree in the Dietenbach basin. Bark lesions on the right as a result of an inundation in 1994. Note the corresponding thin year ring (detail)

C7 - How tolerant are the current forests to floods? (River Rhine and tributary facilities)

During the last centuries, the structural changes along the river Rhine lead to an enormous loss of alluvial floodplains and of hydrological connectivity. The forests changed without being connected to the flooding of the river Rhine floodplain. In order to guarantee income from the forests, silvicultural management preferred more and more flood-intolerant tree species. Oak and elm trees decreased, whilst ash, Norway Maple and sycamore increased, especially beyond the dykes, where the forestry preferred sycamore, ash, beech, Norway Maple and other broadleafed tree species. The current forests are therefore mainly dominated by flood-intolerant tree species.

Due to flood protection use, changes in forest stands are once again necessary. Concerning hydrological conditions, the operation of retention areas along the river Rhine will bring back flooding to the forests. Statistically, every 10 years a retention area will be in operation for flood protection. Water will then flow through the forests up to a height of 2.50 m maximum. The duration will be about one week.

The years in between ecological floodings are necessary to re-establish conditions close to natural alluvial sites. These floods vary in height from a few centimetres to a few decimetres; usually it never reaches the heights of floods during retention.

Data on damage and loss of adult trees after the 1999 flood in Germany

On May 12th 1999 the discharge of the river Rhine at Basle rose from 2,000 m^3/s to 5,000 m^3/s within 24 hours. This resulted in inundations of hardwood forests in the floodplains in the south of Germany from May 12th until the end of June of 1999. In order to document the impacts on forest stands the Regional Council (Regierungspräsidium) of Freiburg decided to contract with specialists to analyse the amount of damage and loss to tree species.

During the period of 1999 to 2001, a total of 6,877 trees were annually monitored on directly flooded sites and 298 trees at Leimersheim once in 2003. The study sites along the Upper Rhine can be characterised by their location (Figure C-16). The study site "Weil-Breisach" is part of the "Rest Rhine Area". Here the hardwood forest was flooded up to 36 days with a maximum height of 4 m.

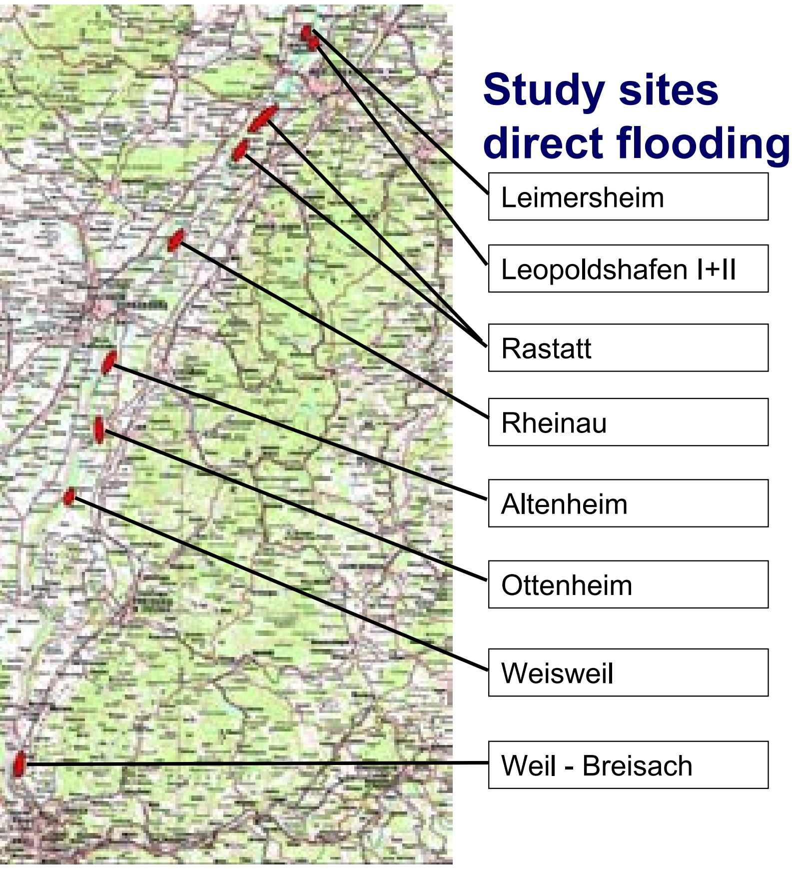


Figure C-16: *Sites studied after the 1999 flood along the Upper Rhine Valley (ILN)*

Within the study sites Weisweil, Ottenheim, and Rheinau in the so-called 'dammed up' section the water of the river Rhine is guided through by-passes (hydropower stations) and the channel itself is blocked by locks and barrages. Only during periods with high discharges some adjacent areas will be flooded. For example, in the summer of 1999 the flood lasted up to 45 days in hardwood forests.

The so-called 'free flowing' section is situated downstream of barrage Iffezheim near the study sites Rastatt, Leopoldshafen, and Leimersheim. In this section, the river Rhine regularly inundates the adjacent floodplain forests. Here the hardwood forest was flooded up to 100 days in summer 1999. Table C-4 provides an overview of the study sites and the numbers of analysed trees in 1999.

On directly flooded sites, groups of single tree species were selected on homogeneous spots where all trees grew on the same elevation. Hence, the group size varied between groups. Within a group, the lower section of the stem of each tree was visually examined and categorised as 'no damage', 'stem damage' or 'loss' (dead). On each tree the maximum flood height was recorded based on flood marks (sediment on the bark), and flooding duration was calculated based on flooding data from the nearest gauge station (Figure C-17).

Table C-4: *Overview of monitored trees in different study sites along the Upper Rhine in 1999*

	Rest Rhine	dammed up section	Polder Altenheim	free flowing section	Leimersheim*	Sum
sycamore	5	187	421	892	30	**1535**
birch	0	40	1	19	4	**64**
beech	0	77	0	26	5	**108**
oak	4	171	368	757	63	**1363**
ash	76	655	277	1141	38	**2187**
Field Maple	0	0	16	89	10	**115**
hornbeam	2	77	30	101	49	**259**
pine	0	0	0	13	0	**13**
Wild Cherry	7	66	8	13	0	**94**
lime	7	38	0	175	0	**220**
plane	0	2	0	2	0	**4**
Red Alder	0	100	2	6	24	**132**
Horse Chestnut	0	5	0	8	0	**13**
Black Locust tree	2	0	6	39	0	**47**
Norway Maple	9	193	356	142	0	**700**
Black Walnut	0	26	0	83	74	**183**
Walnut	34	5	0	71	0	**110**
Crab Apple	0	0	2	18	0	**20**
Wild Pear	0	0	2	5	1	**8**
Total trees	**146**	**1642**	**1489**	**3600**	**298**	**7175**

* The study site Leimersheim was examined in 2003 (IUS 2004). After about 100 years without any flooding, an area behind a dyke was flooded due to a dyke break in May 1999

Threshold values

Single-species tree groups situated on a wide range of elevation levels in the floodplain were studied along the Upper Rhine (Figure C-16, Späth 1988, 2002). In the field a certain elevation level could be observed below which tree damage and tree losses occurred. With a defined tolerance level of less than 5 % these elevation levels are regarded as threshold values for "no damage below" and "losses exceeding" concerning the flood height and the corresponding flood duration respectively. Those threshold values serve as a base for foresters to assure at what level they can plant different tree species without expecting tree damage and losses.

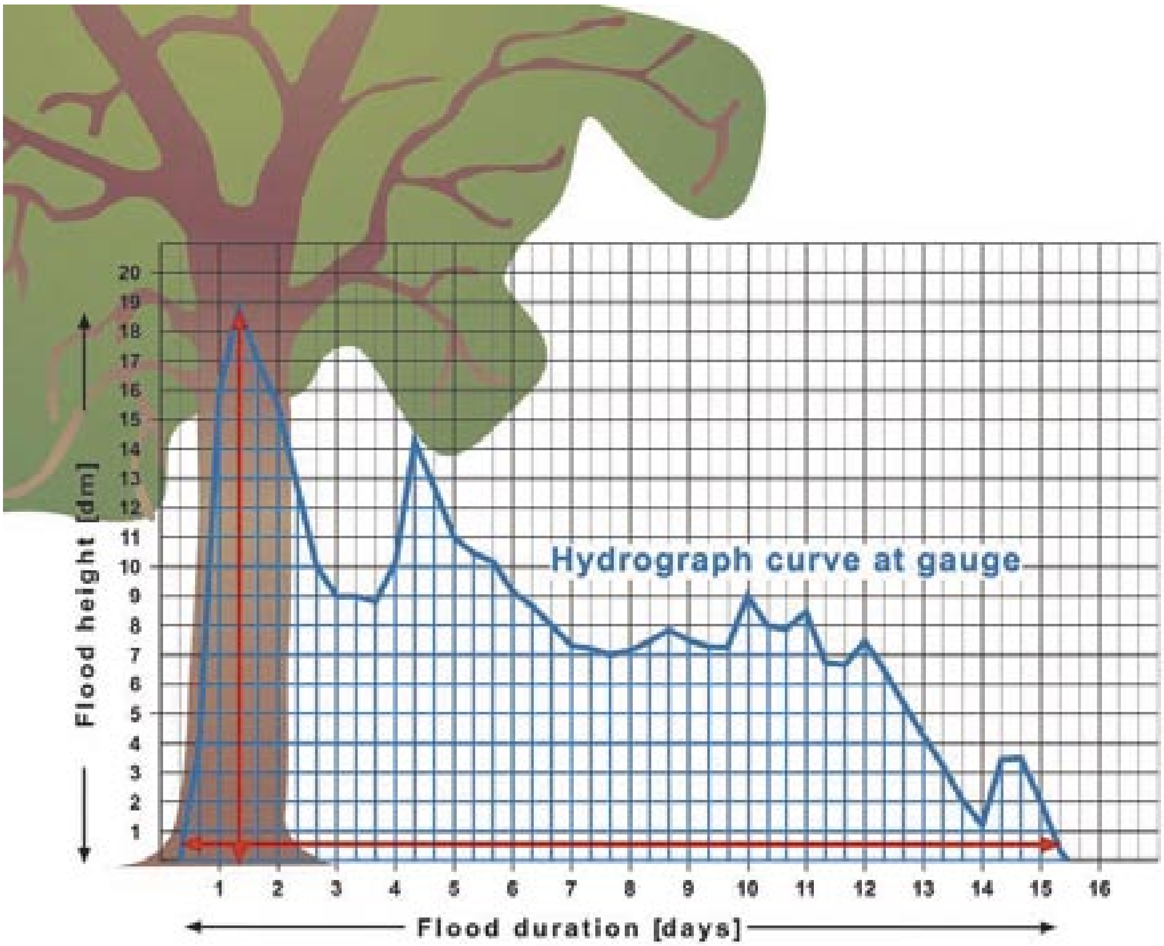


Figure C-17: *Scheme showing the maximum flood height and maximum flood duration (with red marks)*

Tree species from the softwood and the transition zone to the hardwood floodplain forest level tolerated the longest inundation periods. The highest tolerance to flooding days was found among Silver Willow, Hybrid Poplar, and Field Elm. Red Alder, birch and old individuals of oak tolerated long inundations without damage. 5-year-old Balsam Poplars reacted with early leave shedding and decreased increment of height.

In the middle hardwood floodplain forest level Field Maple, pine, plane, Black Walnut, and walnut endured flooding exceeding 40 days without damage. Another group, comprised of lime, ash, hornbeam, Crab Apple, younger oak individuals, and Black Locust endured 30 to 40 days. In the summer of 1999 Common Ivy tolerated 46 days of inundation whilst being a part of the ground vegetation but died off completely after 35 to 37 days when climbing along the tree stem.

The tree species belonging to the high and highest floodplain forest level naturally reached the lowest flood tolerance. Wild Cherry, beech, and Norway Maple tolerated only 9 to 12 flooding days. Sycamore was damaged within the forest district of Rastatt thus making the threshold below 30 days. Taking all study areas into account the threshold for sycamore is found to be 18 days.

One important observation in the field was that tree species with a high flood tolerance showed stem damage rather than diebacks in case of long floods. No dieback due to flooding could be observed among Silver Willow, Hybrid Poplar, Field Elm, oak, Red Alder, birch, Balsam Poplar, plane, pine, Field Maple, Black Walnut, and walnut.

Among Black Locust, Crab Apple, hornbeam, ash, lime, and younger individuals of oak losses were recorded regularly. The threshold values for losses were in between 41 and 55 days which corresponds to 10% and 60% of the threshold value “without damage”, respectively.

Among the tree species of the high and upper floodplain forest level, the threshold values vary considerably. Beech and Norway Maple showed stem damage at floods exceeding 9 to 12 days but die-backs only occur at floods longer than 37 to 43 days.

The thresholds for tree species in the free-flowing section downstream the barrage of Iffezheim (south and north of Karlsruhe) for data taken after the flood of 1987 and 1999 (Späth 1988, 2002) are in Table C-5.

Tab. C-5: *Threshold values for tree species in the free-flowing section downstream of barrage Iffezheim*

tree species:	„no damage below“ [days]	„losses exceeding“ [days]	referred flood
Tree species of softwood zone			
Silver Willow	170	none	1987
Hybrid Black Poplar	140	none	1987
Tree species of transition zone to low-lying hardwood floodplain forest level			
Field Elm	136	none	1987
oak	113	none	1999
Red Alder	108	none	1999
birch	101	none	1999
Balsam Poplar	87	none	1987
Tree species of middle hardwood floodplain forest level			
plane	60	none	1999
pine	49	none	1999
Field Maple	48	none	1999
Black Walnut	43	none	1999
walnut	41	none	1999
Black Locust	40	55	1999
oak (pole crop)	37	41	1999
Crab Apple	35	51	1999
hornbeam	35	51	1999
ash	30	46	1999
lime	30	48	1999
Tree species of high and upper hardwood floodplain forest level			
Sycamore Maple	<30	36	1999
Norway Maple	<12	43	1999
beech	9	37	1999
Wild Cherry	10	12	1999

Tree damage development in consecutive years

The course of the damage development in 1999, 2000, and 2001 for tree losses is shown in Table C-6 and for stem damage in Table C-7.

In Table C-6 it can be seen that losses already occurred in the flood year 1999 (during and after the flood) and that no major changes occurred in the consecutive years. Only among hornbeam and Red Alder an increase in losses could be recorded. Partially young hornbeam, lime, oak, and Field Maple were regenerating by basal shoots in the following years.

Tab. C-6: *The course of development of losses between 1999 and 2001 expressed as a percentage of all trees examined along the Upper Rhine*

tree species	mean loss 1999	2000	2001
tree species with losses < 10 %			
Horse Chestnut	0	0	0
Black Walnut	0	0	0
hornbeam	0	9	8
Norway Maple	3	3	4
Red Alder	5	10	10
lime	5	9	7
beech	7	8	8
oak*	9	11	9
walnut	9	9	9
tree species with losses between 10 % and 25 %			
birch	14	14	14
Sycamore Maple	15	19	21
Black Locust	17	17	17
Field Maple*	19	23	17
Common Ash	24	24	25
tree species with losses > 25 %			
Crab Apple*	38	38	38
Wild Cherry	52	48	52

* mainly saplings

The stem damage heavily increased in the following years among nearly all tree species. For Common Ash and beech more than twice as much trees had stem damage in 2001 than in 1999. For oak, Black Walnut, Black Locust, Field Maple, and Crab Apple the stem damage was first visible in the consecutive years.

Other reasons for tree damage

In certain situations, inundation may have further impacts on forest stands, such as when flooding takes place in winter and is followed by a subsequent freezing of the water table in the basins. Although a very rare situation, the emptying of the flooding water may leave a thick icy crust on the stems, the weight of which may break young trees, as documented in the Hägenich basin, south-western Germany.

In the Freiburg-Nord and Freiburg-Haid basins it is apparent that the root systems of the non flood-tolerant trees in the lowest areas suffer severely from

Tab. C-7: *The course of development of stem damage between 1999 and 2001 expressed as a percentage of all trees examined along the Upper Rhine*

tree species	mean stem damage 1999	2000	2001
tree species with stem damage < 10 %			
birch	0	0	0
oak*	0	2	4
Wild Cherry	2	7	7
tree species with stem damage between 10 % and 25 %			
Black Walnut	0	20	20
Black Locust	0	22	22
Field Maple*	0	13	22
Crab Apple*	0	13	13
hornbeam	7	14	22
walnut	7	13	13
tree species with stem damage > 25 %			
Common Ash	14	31	36
lime	16	24	39
Sycamore Maple	28	30	34
beech	32	73	73
Norway Maple	43	60	61
Horse Chestnut	50	50	63

* mainly saplings

the permanently moist soil conditions. The roots are often decayed and their accessible space in the soil is limited to the upper layers. This results in low root stability which is shown impressively by a number of wind thrown trees in the lowest area of the basins.

Other effects may arise from driftwood and other debris, which – being transported on the surface of the flooding water – may wound the trunks of standing trees as it passes.

C8 - What are key factors for tree damage?

Flood heigth

For short floods (4 to 6 days) tree-specific threshold values were derived within a spectrum of 130 to 260 cm from an area close to Sasbach, southern Germany (Table C-8).

In the floodplain forests of Sasbach, increased damage was in line with increased flooding heights. The most sensitive tree species were Wild Cherry and Norway Maple. No damage was recorded at a flood

Tab. C-8: *Flood tolerance and threshold values for tree species in Sasbach (Biegelmaier 2002)*

tree species	flood duration	total damage	threshold for damage	losses exceeding
Sycamore Maple	4 to 6 days	30%	160 cm	261 to 270 cm
beech	4 to 6 days	11%	140 cm	171 to 180 cm
Common Ash	4 to 6 days	8%	160 cm	none
hornbeam	4 to 6 days	2%	260 cm	none
Wild Cherry	4 to 6 days	40%	130 cm	131 to 140 cm
lime	4 to 6 days	10%	180 cm	201 to 210 cm
Black Locust	4 to 6 days	17%	110 cm	191 to 200 cm
Red Alder	4 to 6 days	16%	190 cm	201 to 210 cm
Norway Maple	4 to 6 days	19%	130 cm	131 to 140 cm

height below 130 cm. Beech showed stem damage at flood heigths exceeding 140 cm and losses at flood height exceeding 170 cm.

Sycamore Maple and Common Ash tolerated flood heights up to 160 cm without damage but showed damage from 160 cm and above. Losses were recorded among Sycamore Maple with a flood height exceeding 260 cm but no losses were recorded for Common Ash.

Hornbeam may be regarded as very flood tolerant because it tolerated flood height of 260 cm. Lime did not show stem damage with flood heights below 180 cm but losses were found above 200 cm. In total, the damage degree was severe (15 to 40 %)

Flood duration

Besides the flood height, the flood duration can lead to tree damage in cases of long summer floods. The variation in tolerated flood days in summer is relatively large among the tree species thus the risk analysis cannot respect fixed threshold values as it did for the flood height.

Table C-9 shows an overview of the maximum flood duration in different river systems.

According to own studies and literature (Schaffrath 2000, Dister 1983) mature trees (especially Common Oak) are very tolerant to long flood durations (having a threshold of 113 to 150 days without damage) whereas pole crop and seedlings are a lot more sensitive to flood durations (having a threshold of 25 to 46 days without damage). Among Common Ash and Sycamore Maple the differences are not as clear as for Common Oak and the variation may be determined by other factors.

***Tab. C-9:** Comparison of flood tolerance of main tree species regarding flood duration in different river systems*

tree species	life phase	maximum tolerated flooding duration „without damage“ [days]	river system/ year of flood occurrence	reference
Pendunculate Oak	mature trees	150	Rhine	Dister 1983
	mature trees	113-129	Rhine 1987, 1999	Späth 1988, 2002
	culture	37	Rhine 1999	Späth 2002
	young stands	25	Oder 1997	Schaffrath 2000
	seedling	30-46	Rhine 1999	Späth 2002
Common Ash	mature trees	72	Rhine	Dister 1983
	mature trees	30-66	Rhine 1999, 1987	Späth 2002, 1988
	mature trees	43	Oder 1997	Schaffrath 2000
	culture/young stands	48	Rhine 1999	Späth 2002
	seedling	35	Rhine 1999	Späth 2002
Sycamore Maple	mature trees	21-30	Rhine 1987, 1999	Späth 1988, 2002
	mature trees	17	Rhine	Dister 1983
	culture/young stands	44-46	Rhine 1987,1999	Späth 1988, 2002
	culture/young stands	17-21	Oder 1997	Schaffrath 2000
	seedling	16-20	Rhine 1999	Späth 2002
Common Beech	mature trees	9-35	Rhine 1987, 1999	Späth 1988, 2002
	mature trees	9	Oder 1997	Schaffrath 2000
	culture/young stands	16	Rhine 1999	Späth 2002

Flow velocity

In literature (e.g. Biegelmeier 1993 for Common Ash) one can find out which trees are more sensitive to flooding under stagnant conditions than under flowing water conditions but precise data on flow velocities are missing. Conclusions for the negative effect of stagnant flood condition can be drawn by a comparison of observed threshold values in flooded areas with different flow velocities. The section of Leopoldshafen II is characterised by very low flow velocities. Here the threshold values for damage were 5 days for Sycamore Maple and 12 days for Common Ash and lime. Thus only 42 % of the maximum tolerated flooding duration, found in the free-flowing section of Rastatt, was reached. In briefly flooded areas with high flood heights, fast-flowing water can increase the tolerance of trees to the flooding height and duration. Whereas under slow flowing water conditions in Polder Altenheim a flooding height of about 170 cm and a flood duration of 4 days lead to stem damage among Common Ash. The same species tolerated flooding heights up to 3 m and 10 days in the fast flowing section of the Rest Rhine.

Frequency

The highest observed flood tolerance for most of the tree species along the Upper Rhine occurred in combination with a high flooding frequency. While comparing two sites with the same flood parameters concerning height, duration and velocity but different flooding frequency, the flood tolerance of tree species (ash, Field Maple, oak) is a lot higher in frequently flooded areas.

Only half of the flood days were tolerated without damage in study site Leimersheim than in study site Leopoldshafen II among ash (50%), Black Walnut (66%), hornbeam (82%) and Field Maple (18%) (Table C-10). Some of the old oak trees had damage only after 27 days of flooding in Leimersheim while in the frequently flooded site Leopoldshafen II up to 70 days were tolerated without damage.

***Table C-10:** Comparison of flood tolerance and threshold values in study sites Leimersheim and Leopoldshafen II*

study site	Leopoldshafen II			Leimersheim*		
flooding frequency	1-19 inundation days / year			no flooding for many years		
tree species	no stem damage below	stem damage exceeding	losses exceeding	no stem damage below	stem damage exceeding	losses exceeding
mature oak trees	no stem damage	no stem damage	no losses	< 27	27	-
oak saplings	33	41	-	< 26	26	-
ash	12	13	33	< 6	6	6
Field Maple	33	-	-	< 6	6	-
hornbeam	< 33	33	-	< 27	27	-
Black Walnut	41	48	-	< 27	27	-
Wild Pear	33	-	-	66	-	-

* source: IUS (2004) Vegetationskundliche Untersuchungen im Überflutungsgebiet Kahnbusch/Langerohr bei Leimersheim

Hence the frequency seems to be another key factor for the tolerance which is one reason for frequent ecological flooding.

Suppressed vs. dominating trees

As a result of the studies concerning the floods in 1987 and 1999 a higher tolerance of suppressed trees to flooding were recorded among ash, sycamore, and ivy. Physiological reasons were discussed for these phenomena (Späth 1988, Biegelmaier 1993). Dominant and therefore sun-exposed trees might have a higher metabolism rate than suppressed trees.

What symptoms are associated with prolonged exposure to floods?

Based on visual observations made in retention basins and in some other specific situations (extraordinary floods), a prolonged exposure to flooding may mainly induce bark lesions and wounds primarily on the lower part of the trunk, as can be seen in Figure C-18. These wounds are sometimes linked to sap exuding from the lesions. Another response to flooding may include precocious leaf senescence. In extreme cases, such lesions may even become lethal.

Figure C-18: *Bark lesions on the trunk of a beech as documented in Dietenbach basin as a result of the first flooding. Despite such heavy visual impacts, this tree displays still vitality of the crown more than 10 years having first been affected*

Different patterns may be salient, depending on the species and the roughness of the bark. The greatest susceptibility is exhibited by beech and to a lesser degree Red Oak, two species generally not found in floodplain habitats. A large intra-species variability in response to flooding may be common, such as in ash. In the case of trees with rough barks, the impacts are generally less visible.

The extent and development of these symptoms may, however, be different under specific conditions (retention basin or other site context) and need to be addressed separately.

Monitoring in retention basins (mainly basin Dietenbach) has shown that while the first exposure to a prolonged inundation will affect trees in the way described above, there is some evidence to suggest that subsequent inundation occurring at some interval may not harm trees to a similar degree. This means that they will not necessarily induce a worsening of the existing damage.

As a rule, damage resulting from inundation of less than one week (generally applicable in the case of retention basins) will not lead to the stands dying off. Although the trees will survive, their scars even healing, stem lesions do affect timber quality and render trees prone to indirect or secondary stress (pathogens).

Due to the topography gradients, stands covering the lower zones near the outlets are, of course, most prone to the damage described above (longer duration of inundation and greater inundation heights, Figure C-19).

In 1999, an exceptional flood event of the river Rhine resulted in some situations providing an unparalleled opportunity to document the effects of a prolonged exposure (up to one month) of trees in alluvial zones. Single individuals among many tree species died spontaneously after the flood. The dead trees lost all leaves (e.g. Wild Cherry) or the leaves dried out and turned brown (e.g. ash). In the consecutive year, several trees died among ash, Red Alder, and Norway Maple species.

Spontaneous sap flow was observed among sycamore, beech, Horse Chestnut, Red Alder, Norway Maple, walnut, and partially Wild Cherry. For sycamore, beech and Norway Maple rips and detached bark occurred additionally.

Whereas ash developed bark rips immediately (Figure C-20, Figure C-21), Field Maple, hornbeam, lime, Black Locust, Horse Chestnut, oak of pole crops, walnut, and Crap Apple/Cultivated Pear developed those with a time lag.

Sycamore, beech, Wild Cherry, Black Locust and walnut especially showed spontaneous leaf loss and change in colour to yellow. Later changes were found among ash, Red Alder, and Norway Maple.

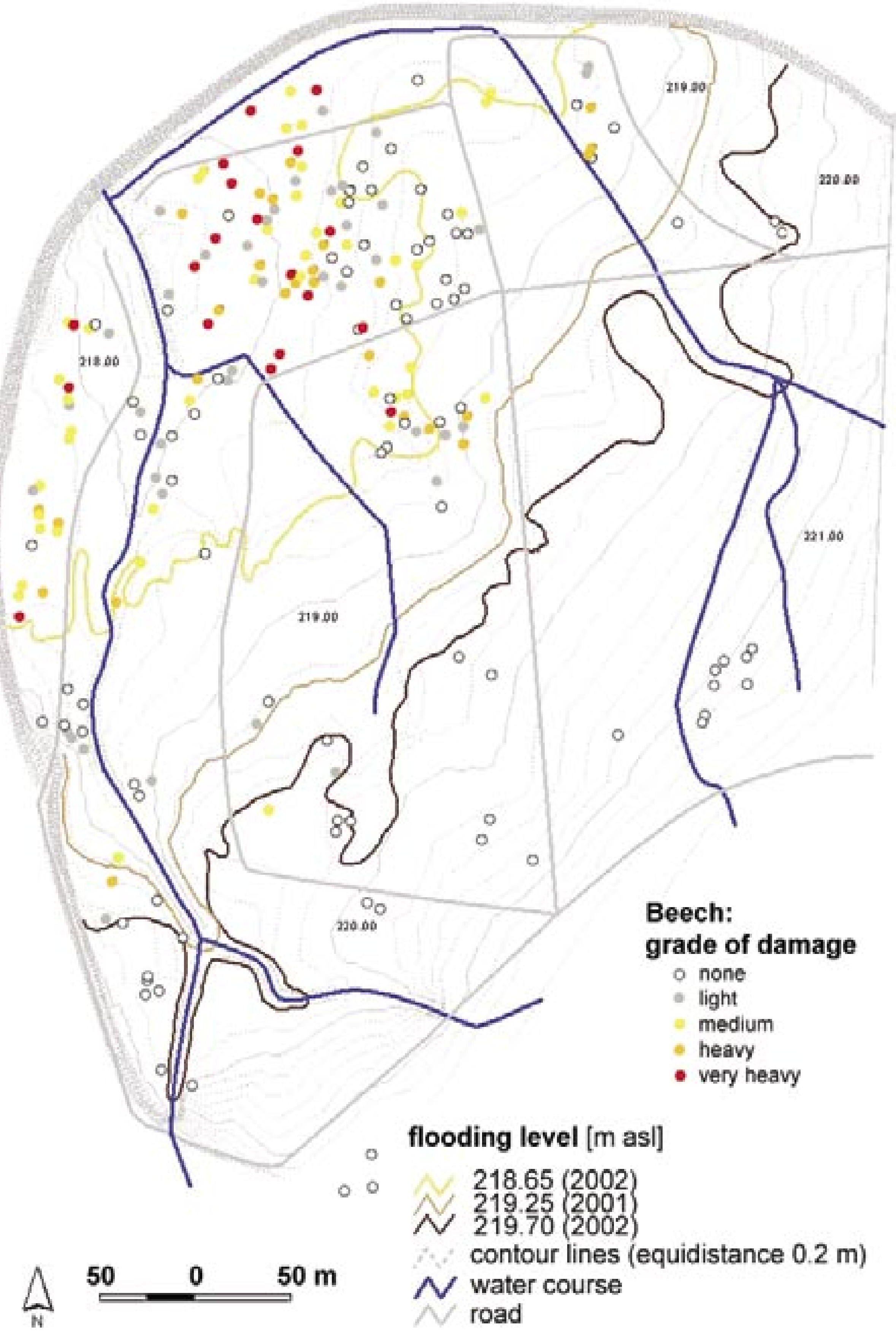
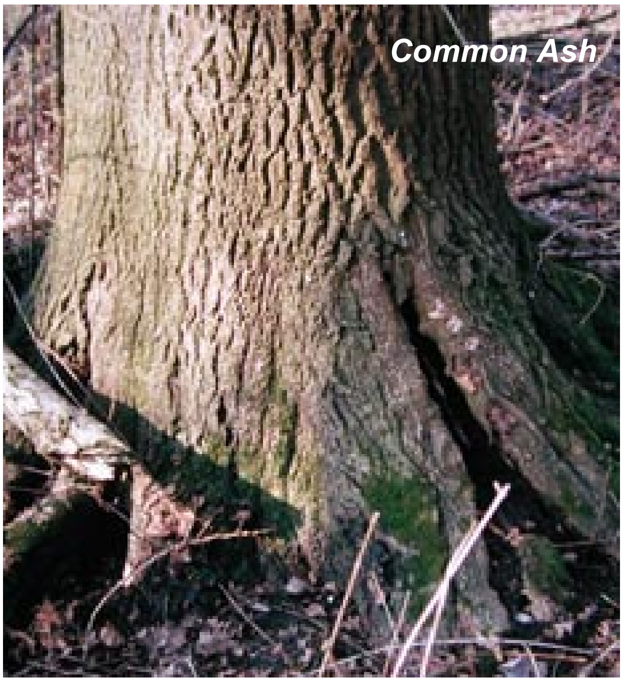


Figure C-19: Assessment of symptoms revealed by monitoring of beech trees within Dietenbach Basin

Au am Rhein, Niederwald, 2004
Pole crop
Old 2 dimensional damage, Rips with occlusion, Break of stem by damage of cambium caused by seepage water

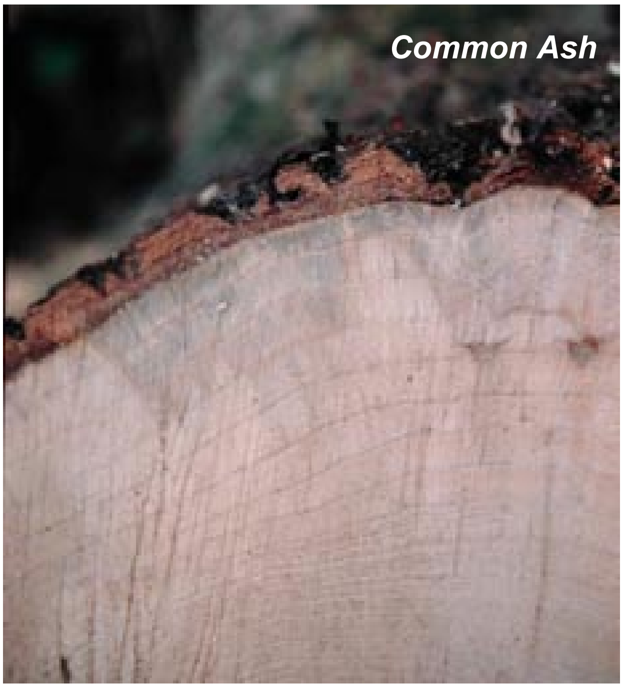
Au am Rhein, Veldesgrund, 1999
Slender mature tree
Flood height: 200-230 cm, Flood duration: 43-56 days
Numerous small Rips, one 2 dimensional damage

Au am Rhein, Veldesgrund, 1999
Mature tree
Flood height: 230 cm, Flood duration: 56 days
Decay spot and Rips

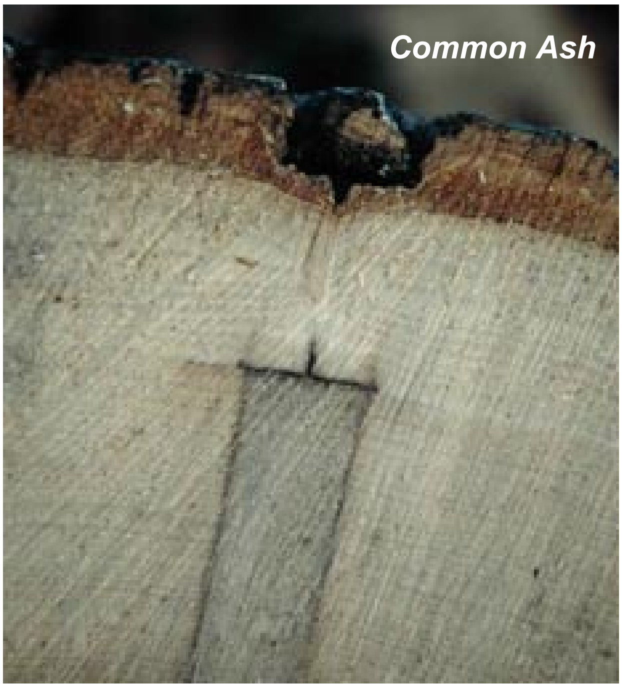


Leimersheim, 2001
Mature tree
Flood height: 172 cm, Flood duration: 30 days
2 dimensional damage on root stem transition
Situated on landsite of a dyke; Flooded due to dyke-break

Figure C-20: *Characteristic wood damage of common ash*



November 1999
Detail of flood damage from 1999. Since the cambium and conduction bast are damaged, the storage cell which are running radial to the stem centre changed in colour. Besides old damage the summer flood of 1999 has caused a die back of new cambium- and conduction bast areas



November 1999
Detail of cambium damage resulting from flood in 1987. Occlusion processes which started in 1987 could prevent further wood damage. The old damage is still visible at the conduction bast tissue. Those spots were frequently leading to dry bark rips without sap flow in 1999

November 1999
Detail of cambium damage resulting from the flood in 1987 and died back storage cells which are running radial to the stem centre. The tree rings built following 1987 show different formed occlusion

Figure C-21: *Characteristic damage of common ash*

C9 - What are the reasons for different flood tolerance of tree species?

Trees differ widely in their sensitivity against oxygen deficiency. The development of visible damage must be a consequence of severe internal plant disturbances such as impacts on photosynthetic activity, carbon and energy metabolism (Kreuzwieser et al. 2004).

How do plants cope with flooding?

Adaptation of plants to waterlogging includes strategies helping the plant to avoid oxygen shortage in the root system. Important morphological and anatomical traits include the formation of hypertrophied lenticels and adventitious roots rich in aerenchyma enabling the diffusion of oxygen into root tissue. Another form of adaptation is enhanced shoot growth as seen in Amazonian tree species (Parolin 2002) and also in herbaceous plants also in temperate areas (Blom & Voesenek 1996). Woody species naturally present in temperate riparian forests, such as Pendunculate Oak, Common Ash and poplar species have a high potential to develop hypertrophied lenticels and adventitious roots. However, besides changes in morphology, several physiological adaptations are known to be important to the survival of plants under flooding. Physiological adaptations mainly include changes in carbon, nitrogen, and energy metabolism.

How can plants deal with flooding at the physiological level?

The capability of plants to form ethanol under conditions of oxygen shortage is a prerequisite for plants to survive periods of flooding (Drew 1997). The onset of alcoholic fermentation and the production of ethanol has been shown in the FOWARA project for several species of riparian forests such as in Pendunculate Oak, different ash genotypes and poplar. These findings are consistent with results for numerous species of temperate and boreal forests such as different pine, poplar and oak genotypes (see Kreuzwieser et al. 2004) but also for tropical trees (Joly 1991). However, the fact that both, flood-tolerant (e.g. poplar) and flood-intolerant (e.g. beech) species produce ethanol suggests that aspects other than alcoholic fermentation in the roots must be of significance where flooding tolerance is concerned. For example, flooded beech seedlings contain more ethanol in the roots than Pendunculate Oak seedlings (Schmull & Thomas 2000) although beech is considered much less flood-tolerant than oak. Similar findings have been obtained in herbaceous plants where ethanol production was studied. In general, it is assumed that the steady supply of carbohydrates that is required in order to maintain alcoholic fermentation over prolonged periods, as well as the capacity to detoxify the highly phytotoxic acetaldehyde and ethanol produced in roots, are important additional physiological features of flooding tolerance in plants (Vartapetian & Jackson 1997). Although the toxicity of ethanol is much lower than previously assumed, the removal of ethanol from the roots may nonetheless be important. This is because of an expected accumulation of high concentrations concerning the occurrence of millimolar ethanol concentrations in the xylem sap of flooded trees as shown in the frame of the FOWARA project. In addition, low ethanol concentrations in the roots may be required to maintain the concentrations of acetaldehyde; a highly phytotoxic intermediate of alcoholic fermentation, at a low level.

The switch from respiration to fermentation implies a considerably higher demand for carbohydrates in the waterlogged roots of trees than in roots with normal oxygen supply which may become critical for the survival of plants under prolonged hypoxic conditions. Reduced carbohydrate concentrations in roots of flooded trees have been reported in several studies (Angelov et al. 1996, Vu & Yelenosky 1991). Investigations in the frame of FOWARA with flood-tolerant and flood-intolerant tree species have also exhibited strong differences in root carbohydrate concentrations. In the roots of flood-sensitive beech seedlings, the total amount of carbohydrates dramatically decreased as compred to control samples. In contrast, flooding did not affect root carbohydrate concentrations of flood-tolerant poplars (Kreuzwieser & Papadopoulou, unpublished results). Surprisingly, in beech roots the starch concentrations remained constant compared to controls and starch was obviously not used as an energy source even under prolonged periods (14 days) of flooding. In contrast, the maintenance of high root starch concentrations may enable continued growth and survival of flood-tolerant species under hypoxic conditions. The maintenance of high starch contents in beech roots despite reduction in soluble carbohydrate contents may be explained by two reasons: Firstly, the reduction of energy dependent processes (see Vartapetian & Jackson 1997) such as root growth (Schmull & Thomas 2000) and nutrient uptake (Kreuzwieser et al. 2002) in order to limit energy consumption, and secondly, a lack of activation of glycolytic enzymes under flooding.

Effects on gas exchange

It may be assumed that an enhanced demand for carbohydrates in the roots of waterlogged or flooded trees may be compensated by higher rates of net assimilation in the leaves. However, several studies with herbaceous and woody species demonstrated that leaf gas exchange is usually strongly reduced by flooding. Reduced net CO_2 assimilation has been described in numerous studies with both, flood-tolerant and intolerant woody species (Kreuzwieser et al. 2004) although the extent of reduction is sometimes much less in flood-tolerant compared to flood-sensitive species (Wagner & Dreyer 1997). It has been proposed that reduced stomatal conductance, also observed in studies with beech and Pendunculate Oak (Schmull & Thomas 2000), limits photosynthetic CO_2 assimilation under hypoxic conditions (Pezeshki et al. 1996). The high carbohydrate concentrations found in the leaves of flooded trees may further inhibit net assimilation (Goldschmidt & Huber 1992). The signals mediating stomatal closure are thought to be generated in the roots and have been identified as phytohormones such as abscisic acid (ABA).

Conclusions for the reasons for different flood tolerance of tree species

Soil oxygen deficiency strongly affects the carbon and energy metabolism of both flood-tolerant and flood-sensitive tree species. Due to the lack of oxygen, the roots of trees must switch from respiration to alcoholic fermentation for generating energy equivalents.
It can be stated that the ability to switch from respiration to alcoholic fermentation is a key factor in flood tolerance in plants. However, in addition to this capability, flood-tolerant species succeed in maintaining alcoholic fermentation by a steady supply of carbohydrates and additionally avoid the accumulation of phytotoxic intermediates (acetaldehyde) and end products (ethanol). Besides these physiological features, morphological adaptations also play a role. This becomes obvious by the discovery that individuals of flood-tolerant species are damaged by single flood events if they grow in usually non-flooded areas (Späth 1988). An acclimation occurs during the development of the trees at frequently flooded sites.

C-10 Can pathogen agents be involved as causes of stress factors in trees after flooding?

Widespread bark necroses with subsequent trials for wound closure can be observed (Figure C-22) in the lower parts of tree trunks in the Dietenbach basin. After some time, large numbers of fruit bodies of Armillaria species (honey or shoestring fungi) can be frequently observed on or close to the damaged trees (Figure C-23). According to our investigations, there is a consistent pattern between the occurrence of these pathogenic fungi and the final decline and death of affected trees. Beech seemed to be particularly sensitive, whereas oak is more resistant and ash seem to remain relatively unaffected.

Figure C-22: *Necroses on lower part of beech stem some time after a flooding event*

Figure C-23: *Fruit bodies of the honey fungus (Armillaria spp.) at flooding site*

These observations may be consolidated by controlled inoculation experiments with potted tree seedlings which were subjected to flooding and inoculation with Armillaria species, separately or in combination. From these experiments it became evident that the flooding makes the trees more susceptible to subsequent fungal infections that may lead to the death of the trees. Flooding or fungal infection alone can also weaken the trees, but usually do not kill them (Figures C-24, C-25). Here, the same differential sensitivity of the tree species could be observed as in the field.

Figure C-24: *Controlled flooding and fungal inoculation of potted young beech trees*

Figure C-25: *Controlled flooding and fungal inoculation of potted young oak trees*

Armillaria spp. are among the most common fungi in forest soils and occur worldwide. Originally considered as one species *(A. mellea),* today 5 different species are distinguished in Europe. Among these, *A. ostoyae* and *A. mellea* (sensu stricto) are responsible for parasitic damage in different species of fruit trees, shrubs, shade and forest trees. Affected trees show symptoms of reduced growth, dieback of twigs and branches, and bark necroses, up to the gradual or sudden death of the tree. White mycelial mats appear between the bark and the wood, where they kill the cambial layer and may cause white rot decay when penetrating into the sapwood. Cord-like threads of mycelium (rhizomorphs) spread from the bark into the soil. Many honey-coloured, speckled fruit bodies grow from trunks, stumps or near infected roots on the ground. The fungi spread by basidiospores, rhizomorphs, or root contacts, preferably under moist environmental conditions.

In our investigations it became evident that flooding events alone may already cause bark necroses, but these are enhanced and aggravated by subsequent colonisation with *Armillaria spp.* which may finally lead to the death of the trees.

Can the frequency of fungal infections be actively controlled on retention sites?

Fungi, such as Armillaria species, are a part of the natural ecosystem. Hence, they cannot be regarded as the ‘culprits’ for the decline and death of trees. It is rather an indication that those trees are subjected to other stresses which exceed their potential for tolerance, or that they are growing on inappropriate sites.

Theoretically, fungal infections can be controlled by the application of fungicides. However, their widespread application on large areas, as in the present case, is neither economically feasible nor environmentally acceptable. It is also prohibited by law. Consequently, trees can only be protected by avoiding the predisposing factor, i.e. prolonged flooding, which, however, is not practicable in retention sites.

Is there a practical way to reduce damage to trees?

The most important factor seems to be the choice of the appropriate tree species. The most sensitive – beech - should be avoided, whereas oak seems to be more adapted, and flood-tolerant species like ash should be promoted.

In the case of our experiments with controlled flooding of potted tree seedlings with and without Armillaria inoculation, there seems to be a low probability that repeated ‘ecological flooding’ may reduce the sensitivity of trees to fungal infection. In contrast, they may help in the building up of fungal populations and sensitive trees may just die at an earlier stage. However, this may eventually become a desired feature, as there would then be a more rapid conversion of the stand/tree composition to trees which can tolerate flooding events.

C11 - References

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Chapter D
Recommendations to manage forested water retention areas

D - Recommendations to manage forested water retention areas

Jost Armbruster, Alexandra Muley-Fritze, Ulrike Pfarr, Benoît Sittler, Volker Späth

D1 - How to estimate damage to current forest stands caused by flooding?

Alexandra Muley-Fritze, Ulrike Pfarr

The main objective of the recommendations given below is to preserve or to develop a most natural forest community including nature close site conditions for fauna and flora. Based on the information on alluvial zones along the river Rhine natural regeneration should be used wherever possible. As far as seedlings and young stands are more sensitive to floods than older stands planting of trees will be needed as well. The choice of tree species should be oriented on future flood conditions, site conditions, and most importantly on the alluvial zones and their characteristic tree species.

Managers of forested water retention areas therefore need:

information on
- **the future flood regime**
- **flood tolerance and threshold values respectively for suitable tree species**
- **the estimated risk for the current forest stands**

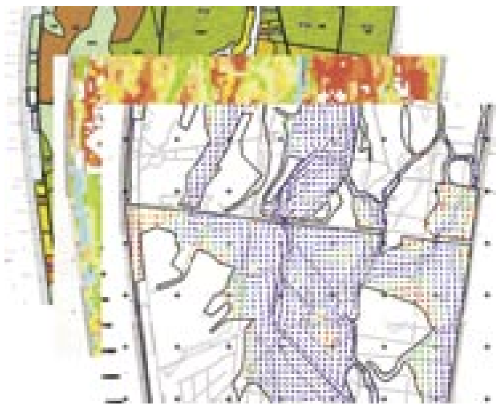
and

recommendations on
- **tree species suitable to future water regime and site conditions**
- **management of forest stands**

Which data will be required in order to estimate the risk of tree damage?

In order to properly estimate the risk of damage to forest stands inside a water retention facility it is suggested to use the following data:

- detailed mapping of forest stands (tree species, percent share in stand, average age, and stand structure)
- map with information on future flood heights during retention
- concerning retention facilities: map with information on future flood duration during ecological flooding
- map with information on flood velocity during operation
- data on average retention occurrence
- table containing suitable tree species for different alluvial zones and different site conditions



How to classify tree species and forest stands due to their risk of getting damaged?

The results shown in Chapter C concerning the data collected after the extreme floods of the river Rhine in 1999 serve as a wide base to classify tree species relating to their sensitivity to flooding. With this knowledge Späth (2002) developed a method to estimate the risk of damage to forest stands inside an applied water retention area. On the occasion of the FOWARA project this method was generalized as follows:

According to an increasing amount of damage to trees caused by increasing flood heights five risk classes were defined. On the assumption that there are pure stands (forest stands with 100% of a single tree species) the amount of damage to trees is given in percent. In risk class 1 less then 2.5% of the trees will sustain damage. Silvicultural measures are not necessary. In risk class 2 the amount of damaged trees will be between > 2.5% and < 15%. Up to 5% dead trees can be included in this risk class. In Table D-1 the 5 risk classes are defined.

Table D-1: *Definition of risk classes for individual trees*

risk class	flood heights above observed threshold values [cm]	amount of damage [%]	included dead trees [%]
1	depending on tree species	≤ 2.5	0
2	30 - 50	> 2.5 - < 15	≤ 5
3	60 - 90	15 - 40	5 -10
4	80 - 110	41 - 75	15 - 25
5	> 280	> 75	≤ 30

Due to the observed increase of damage according to flood heights, several tree species have been assigned to the different risk classes. Table D-2 conveys an overview of the flood tolerance of 18 different tree species. The flood tolerance shown depends only on flood heights; it has to be mentioned that their response to flood duration might be different.

Not only specific tree species but also whole forest stands can be classified in 5 different risk classes (Table D-3). Similar to the classification of single tree species the classes depend on the amount of estimated damage and losses.

How could a valuation matrix look like?

In order to provide a structured handling for the combination of all necessary data a valuation matrix was developed. The single steps to calculate a risk class are shown in Table D-4.

For a selected stand the different tree species and their share (%) can be obtained from the forest stand mapping (step 1). Also known will be the flood heights during retention (step 2). With these data the tree species' risk class can be taken from Table D-2 (step 3). The average percentage of tree species' risk class is related to Table D-1.

Table D-2: *Classification of tree species in risk classes according to flood heights*

tree species	flood heights [cm] < 130	131 - 170	171 - 210	211 - 250	251 - 580	> 280
White Willow	1	1	1	1	1	1
Poplar	1	1	1	1	1	1
Field Maple	1	1	1	1	1	1
Pendunculate Oak	1	1	1	1	1	1
Pine	1	1	1	1	2	2
Birch	1	1	1	2	2	2
Plane	1	1	1	2	2	2
European Hornbeam	1	1	1	2	2	3
Nut	1	1	1	2	3	4
Small-leaved Lime	1	1	2	3	3	4
Common Alder	1	1	2	3	3	4
Black Locust tree	1	1	2	3	4	5
Horse Chestnut	1	1	2	3	4	5
Common Ash	1	1	2	3	4	5
Sycamore	1	1	2	3	4	5
Common Beech	1	2	3	4	5	5
Norway Maple	1	2	3	4	5	5
Wild Cherry	1	3	4	5	5	5

Table D-3: *Definition of risk classes for flooded forest stands*

risk class	damage	extent of loss/damage to each stand	estimated damage (mean %)
5	extreme to very intense	stand damage > 75%	87,5%
4	very intense to intense	stand damage between 41-75%	58%
3	intense to temperate	stand damage between 15-40%	27,5%
2	marginal	stand damage < 15%	7,5%
1	just marginal	just marginal stand damage	< 2,5%

Table D-4: *Example for the calculation of the risk class of a single forest stand as recommended by* Späth *(*Regierungspräsidium Freiburg *2006)*

Tree species of a single forest stand	syca-more	ash	beech	cherry	maple	lime
(1) flood heights during flooding (cm); *use stand mapping information*	171-210					
(2) percentage of tree species (%); *use stand mapping information*	30	20	15	15	10	10
(3) tree species' risk class; *use data from Table D-2*	2 ↓	2 ↓	3 ↓	4 ↓	3 ↓	2 ↓
(4) average percentage of tree species' risk class (%); *use (3) and take respective data from Table D-3*	7.5	7.5	27.5	58	27.5	7.5
(5) calculated percentage of damage to each tree species (%); *for each column: (5) x (3)/100*	2.25	1.5	4.13	8.7	2.75	0.75
(6) Calculated percentage of damage to the forest stand (%); *sum of step (5) results*	20.08					
(7) risk class of the forest stand; *Table D-3*	3					

In a next step (5) the following calculation can be done:

$$\frac{\text{percentage of tree species concerned} \times \text{average percentage of tree species' risk class}}{100} = \text{percentage of damagespecie}$$

Finally the addition of tree species damage percentages (step 6) enables to get the risk class for the selected forest stand out of Table D-3 (step 7). In order to estimate carefully for a number of special stand or site characteristics (e.g. in case of permanent high groundwater table or in case of young forest stands) it is suggested to switch to the next higher class.

Due to a lack of definite threshold values it is by now not possible to use this method for the estimation of damage caused by flood duration. In this case it is reasonable to check whether flood heights during retention and flood duration during ecological flooding compare to the alluvial zones given in Table C-1.

D2 - Which tree species will be suitable for retention areas?

Alexandra Muley-Fritze, Ulrike Pfarr

Long-term experiences and measurements after two extreme floods in 1999 enabled to precise the definition of alluvial zones and their characteristically inundation conditions. Depending on these observations the alluvial zones along the river Rhine are characterised as shown in Chapter C. The species mentioned in Table C-1 are the most characteristic ones for each zone. Due to varying site conditions they are accompanied by a couple of further suitable species. A special table of characteristics was created in order to provide all these information in a comfortable and easily readable structure to forest managers. These characteristics for Common Ash, sycamore, Norway Maple and Pendunculate Oak are shown in Tables D-5 to D-8. Characteristics for further tree species will soon be available in German (Regierungspräsidium Freiburg 2006).

The chosen structure for the abstracts allows a quick overview on site requirements, flood tolerance and compatibility with further forest stands. The reader will find the common and the scientific names as well as the French and English names of the species. All information is mainly addressed to alluvial forest sites comparable with the situation along the Upper Rhine valley.

For adopted silvicultural management inside flood protection facilities special tree combinations can be advised. Descriptions given by the Forestry Research Institute of Baden-Wurttemberg serve as a sound base. Complementary advices are the result of more than 16 years of experiences in forest management in the polders of Altenheim. In correlation to given site conditions and future water regime (leading to different alluvial zone conditions) different kinds of silvicultural treatment and different tree species are suggested.

Table D-5: *Characteristics for Common Ash (Kramer 1987, Leibundgut 1991, Michiels 2001, Späth 2002)*

tree species	**Gewöhnliche Esche**				**Common Ash**				**Frêne commun** **Fraxinus excelsior**		
distribution in alluvial zones of Baden- Wurttemberg	Common Ash is present in all floodplains: Rhine, Danube, Neckar and along rivers in the Alpenvorland.										
site requirements valid for the Upper Rhine Valley	Within the alluvial zones of the river Rhine the Common Ash has its optimum in damp hardwood forests. Ash grows well on fresh to damp or well drained, chalk rich, basic to slightly acid loam and clay soils. Soils with continuing stagnant water are problematic.										
flood tolerance	Less sensitive to stagnant inundations and to inundations by groundwater with inundation heights > 60 cm. Tolerant towards several weeks lasting, shallow inundations < 30 cm (e.g. Black Cherry-alder-ash stands). Tolerance towards flood variance is high within its tolerated alluvial zone. Natural rejuvenation and stool shoots are more tolerant than planted trees.										
	total number of observed trees	2,437	shared number: 364			shared number: 1,342			shared number: 731		
	data from		landsite of dyke - seepage water			section dominated by hydropower stations			free flowing section		
	damage		none	stem	loss	none	stem	loss	none	stem	loss
	flood height [cm]	min.	< 20	20	-	100	110	160	150	160	190
		max.	26	30		130	160	180	< 170	170	200
	flood duration [days]	min.	< 20	20	-	9	13	33	30	36	43
		max.	70	70		21	35	37	< 38	38	46
damage symptoms	culture		losses								
	pole crop		rips, rotten spots at stem foot, leave loss, losses								
	mature trees										
recommended alluvial zone	ash as main tree		middle hardwood			e.g. for site specific stand: Ash-elm-oak-forest on silt Ash-Small-leaved-Lime-oak-forest on sand					
			high hardwood			Ash-sycamore-forest on silt Ash-sycamore-Small-leaved-Lime-forest on sand					
	ash as additional tree		upper hardwood			Hornbeam-beech-lime-forest on gravel					

Table D-6: *Characteristics for Sycamore Maple (Kramer 1987, Leibundgut 1991, Michiels 2001, Späth 2002)*

tree species	**Bergahorn**				**Sycamore Maple**				**érable sycomore de montagne** **Acer pseudoplatanus**		
Distribution in alluvial zones of Baden- Wurttemberg	Sycamore is present in all floodplains: Iller, Danube, Argen, Schussen, Neckar and Rhine.										
site requirements valid for the Upper Rhine Valley	Sycamore grows on profoundly sandy or loamy, nutrient and base rich, moderate fresh to fresh, humus soils with basic to moderate acid reaction. Sycamore avoids stagnant soils with less oxygen and is highly sensitive to drought.										
flood tolerance	Sensitive to stagnant inundations and to inundations by groundwater. Several weeks lasting inundations > 25 cm lead to damage and losses. Natural rejuvenation is more tolerant than planted trees.										
	total number of observed trees	1,538	shared number: 38			shared number: 733			shared number: 767		
	data from		landsite of dyke - seepage water			section dominated by hydropower stations			free flowing section		
	damage		none	stem	loss	none	stem	loss	none	stem	loss
	flood height [cm]	min.	20	25	-	< 70	70	120	130	> 130	150
		max.				130	160	200	> 140	140	190
	flood duration [days]	min.	5	7	-	< 5	5	13	< 30	30	36
		max.				17	35	46	32	> 32	43
damage symptoms	culture		losses								
	pole crop		rips, wider damaged spots, sap flow								
	mature trees										
recommended alluvial zone	sycamore as main tree		high hardwood			Ash-sycamore-Forest on silt Ash-sycamore-Small leaved Lime-Forest on sand					
			upper hardwood			Ash-hornbeam-sycamore-Forest on silt					
	sycamore as additional tree above natural rejuvenation		middle hardwood			Ash-Small-leaved-Elm-oak-Forest on sand					

Table D-7: *Characteristics for Norway Maple (Kramer 1987, Leibundgut 1991, Michiels 2001, Späth 2002)*

tree species	**Spitzahorn**					**Norway Maple**			**érable plane** **Acer platanoides**		
distribution in alluvial zones of Baden-Wurttemberg	Norway Maple naturally is present in precious broad-leafed forests with appropriate climate conditions. Forest stands in the alluvial zones of the river Rhine were planted.										
site requirements valid for the Upper Rhine Valley	Naturally spread on steep hillsides, in canyons, and on the edge of floodplains. On dry to fresh, nutrient and base rich, loose-packed soils with basic to slightly acid reaction.										
flood tolerance	Sensitive to stagnant inundations and to inundations by groundwater. Several weeks lasting inundations > 10 cm lead to damage and losses. Natural rejuvenation is recognizable more tolerant than planted trees.										
	total number of observed trees	718	shared number: 27			shared number: 574			shared number: 117		
	data from		landsite of dyke - seepage water			section dominated by hydropower stations			free flowing section		
	damage		none	stem	loss	none	stem	loss	none	stem	loss
	flood height [cm]	min.	5	10	-	100	110	-	-	-	170
		max.				< 120	120	140	< 100	100	230
	flood duration [days]	min.	5	7	-	< 5	5	29	< 12	12	43
		max.				17	37	-	-	-	58
damage symptoms	culture		losses								
	pole crop		rips, wider damaged spots, sap flow								
	mature trees										
recommended alluvial zone	Norway Maple as maintree		upper hardwood			Hornbeam-beech-Small-leaved-Lime-forest on sand					
	Norway Maple as additional tree above natural rejuvenation		high hardwood			Ash-sycamore-Small-leaved-Lime-forest on sand					

Table D-8: *Characteristics for Penduncculate Oak. (Kramer 1987, Leibundgut 1991, Michiels 2001, Späth 2002)*

tree species	**Stieleiche**					**Penduncculate Oak**			**Chêne pedonculé** **Quercus robur**		
distribution in alluvial zones of Baden-Wurttemberg	Oak is spread over all alluvial areas in Baden-Wurttemberg.										
site requirements valid for the Upper Rhine Valley	In the river Rhine's floodplains the ecological optimum of the oak is on soils close to groundwater, sands with tendency to getting wet, loam, and clays with tendency to getting wet or alternatively being damp or dry. In the hardwood zone oak dominates stands with ash.										
flood tolerance	Highly tolerant to long lasting and high reaching inundations. Less tolerant on irregularly flooded sites. Also cultures and pole crops are less tolerant. Less sensitive to sites with stagnant groundwater inundations.										
	total number of observed trees	1,301	shared number: 5			shared number: 576			shared number: 720		
	data from		landsite of dyke - seepage water			section dominated by hydropower stations			free flowing section		
	damage		none	stem	loss	none	stem	loss	none	stem	loss
	flood height [cm]	min.	-	-	-	200 (pole)	240 (pole)	-	160 (pole)	240 (pole)	190 (saplings)
		max.	99 (old)					-	340 (old)		
	flood duration [days]	min.	-	-	-	23 (old) 33 (pole)	No damage (old) 41 (pole)	No damage (old/pole)	113 (old)	55 (pole)	41 (saplings)
		max.	63 (old)			43 (pole)	45 (pole)	No damage (old/pole)	37 (pole)		
damage symptoms	culture		Saplings: up to 50 % losses								
	pole crop		rips and stripes in bark								
	mature trees		Rips (only on irregularly inundated sites)								
recommended alluvial zone	oak as main tree		lower hardwood			Elm-oak-forest on silt					
			middle hardwood			Ash-elm-oak-forest on silt Ash-Small-leaved-elm-oak-forest on sand Small-leaved-Elm-oak-White-Poplar-forest on gravel					
			high hardwood			Oak-Small-leaved-Elm-forest on gravel					
	oak as additional tree		between soft and hardwood			Ash-Small-leaved-Elm-oak-forest on sand Small-leaved-Elm-oak-White-Poplar-forest on gravel					

D3 - How to minimize tree damage in water retention basins?

Benoît Sittler

Recommendations for the sustainable management of forests in retention basins primarily depend on the prevailing flood regimes. In this regard, observations from Dietenbach and other basins in Baden Wurttemberg suggest that flooding may occur at any time of the year and is therefore not limited on the vegetation period.

Because each basin is unique in many respects (as well as each flood) not all recommendations formulated on the basis of observations from a few situations will apply. In addition, one should keep in mind that due to topographic gradients within such basins, not all parts do experience similar situations and therefore deserve differentiation. Because of these gradients that generally exhibit a greater downward inclination in the basins (1 %) than in the greater polders (around 0.1 %) longer lasting and frequent inundation may occur only on small surfaces. Further, in contrast to polders in floodplains, the design and operating of retention basins offers little opportunity to shift from stagnant water to running water (which is less harmful to vegetation).

Cases where basins are planned to receive longer lasting inundation (more than 10 days)

Despite uncertainties related to the lack of observations in such situations (that indeed seem to remain very exceptional: only one basin known!), one may expect quite heavier impacts than those observed in Dietenbach. Therefore, sensitive species could no longer be maintained from an economic point of view, even if heights of inundation could be kept low.

In such cases, the most realistic option would certainly be to give up any economic forest use, at least in the depressed areas near the outlet. As long as safety aspects are respected, priority in these parts could be given to biodiversity aspects, for example through fostering natural succession.

Cases where basins are planned to receive an inundation lasting 5 to 10 days

Part of trees in such stands may indeed be affected by the inundation and the most exposed ones may die. Promoting natural regeneration in the gaps would certainly be a better option than planting, since there is no guarantee that young trees will not suffer from a later flood.

Because the low-lying areas surrounding the outlet are often subject to depot of driftwood and debris accumulation, it seems questionable to give priority to forest exploitation for this zone.

Cases where basins are planned to receive an inundation length up to 5 days

For cases where floods are not expected to last longer than 5 days, stands composed only from deciduous species can generally cope with such inundation, but in case of replanting, sensitive species (beech, Red Oak) should be avoided.

D4 - Which tree species will be suitable in water retention basins?

Benoît Sittler

Recommendations for the use of tree species in water retention basins focus primarily on situations where the flooding does not exceed one week of continuous inundation (since very little is known on the reaction of trees having experienced longer duration inundation in such closed basins).

Recommendations expressed here differentiate according to ownership objectives, i.e. whether high timber quality is requested or whether the focus could be on other functions like biodiversity or recreation. To some extent, relative sensitivity levels of trees species as documented for floodplains (Späth 1988, 2002) may be regarded as also relevant for retention basins.

1. In the case ownership objectives for the forest stands are giving priority to sustainable timber harvesting, the following recommendations could be made:

a) Converting coniferous stands into broad- leafed stands

Whenever planned retention basins should encroach coniferous forests (a rare case!), a conversion into broad-leafed stands should be considered, at least for the most low-lying areas, since generally, spruce or most pine trees can hardly cope with inundation (Gill 1970). For the future replacement forest, prevailing site conditions (soil, exposition, frequency of inundation, groundwater) will be relevant for planting options that should of course refrain from using sensitive species, that means no beech, Red Oak or cherry (Gill 1970, Sittler & Zähringer 1999, Späth 1988 & 2002). In most exposed areas, promoting a natural succession as a no cost approach should be preferred, instead of a costly and risky planting of nursery grown trees. In other situations, alder-ash (with some other species like aspen) or ash-oak-hornbeam communities with a rather broad ecological range could fit, but when planting, provenance aspects should always receive special attention. In higher parts of the basin, more sensitive species that may also include lime trees or sycamore could be used. In the most elevated parts, mixed forests still including coniferous trees in addition with beech may be regarded as a possible option, as inundations here are always of shorter duration and with heights never exceeding 50 cm.

b) Options for broad-leafed forests devoted primarily to timber harvesting

It is advisable to remove any full grown sensitive species such as beech and Red Oak for salvage harvesting in the lowest lying areas close to the outlet, in an early stage before these trees get damaged. The management of the stands should then be directed towards promoting less sensitive species, especially whenever these are already present in the stands as young trees. As a whole, similar approaches as those recognized above could also apply here (preference for natural succession). A great diversity of species could contribute to reducing risk whenever particular inundation patterns would harm a single species. Depending on other site characteristics alder-ash communities including oak could be options.

For the trees growing on the riparian banks of the river, they should of course be maintained as far as possible for erosion protection purposes (removing only those that would show signs of die back).

2. In the case where ownership objectives would favour promoting other functions of the forests such as biodiversity and recreation, species with less economic value could be selected.

In such situations, changes in forest composition will be more readily acceptable, even if a die off of the stands should be avoided. Trees displaying minor damage can be maintained since they will survive anyway, even if bark lesions will then affect timber quality. For biodiversity considerations, one may even keep a few dying trees since dead wood provides important components to promote nature close processes (as long as dead wood does not constitute any hindrance to the operation of the basin!)

In gaps that will appear in the stands, natural regeneration including the establishment of pioneer species (so called softwood species) should be promoted as a low cost

D5 - Which silvicultural advices can be given?

Jost Armbruster, Volker Späth

Flood sensitive tree species like beech, sycamore, Norway Maple and Common Ash show a high variety of their tolerance to flooding. Hence inundation damage does not necessarily appear in 100% of the stands. Therefore silvicultural measures should be applied only if damage occurs and not as a preventive measure.

Additionally to the information on flood tolerance and site requirements given with the description of tree characteristics (Table D-5 to D-8) the following advices can be given for a future management of forested water retention areas:

- If forest stands cover low-lying areas and temporarily flooded site channels, forest stand types of the next more flood tolerant alluvial zone are recommended.
- Forest stands with rich understorey, autochthonous poplar stands, and pine or oak and elm stands on low lying sites should not be managed intensively. Here succession is recommended.
- Mixed cultures (< 10 years) can adapt to the future situation without any management. Special silvicultural treatment is not necessary.

Detailed silvicultural recommendations for forested water retention areas will soon be available in a German guideline for flood risk analysis (Regierungspräsidium Freiburg 2006). This will include recommendations about stand compositions, growing-stock structure and tolerance to the flood regime.

On sites with temporarily critical flood conditions for hardwood tree species, the so-called "Re-insurance Type" can be applied. This approach is used successfully in the Upper Rhine floodplain south of Karlsruhe since more than 20 years. For this approach, mixed stands of poplar and hardwood forest tree species (e.g. oak, Crab Apple, Wild Pear and Field Maple) are used.

This provides several advantages:

- If an exceptional inundation damage the young hardwood trees, the stand can still be developed to a pure poplar stand with understorey of the surviving hardwood tree species.
- If however no such exceptional inundation occurs, the stand can be developed to a pure hardwood stand by harvesting the poplar.
- No repair plantings are necessary.

For the formation of the stands according to the "Re-insurance Type" the following recommendations can be given:

- Planting of 100-120 poplars and 1,500-2,000 hardwoods/ha.
- Hardwood saplings should be used (Height: 160-180cm)
- Pruning of oak and Crab Apple in order to produce high-class timber.

The present situation within the floodplain is characterized by a high planting activity. Especially in low lying sites with rich understorey vegetation a sufficient natural rejuvenation is missing. As a result mainly saplings are planted.

Foresters along the Upper Rhine near Karlsruhe recommend:

- Tall saplings should be used (height: 160-180cm)
- Use sapling with high quality, i.e. sufficient stored carbohydrates (e.g. by self breeding) from alluvial provenances
- Planting in autumn in order to allow root growth before floods

In contrast to planting the use of rejuvenation has several advantages concerning tolerance to flooding:

- Flooding leads to the selection of tolerant species and individuals, i.e. on frequently flooded sites no sensitive tree species can establish
- Flooding might lead to morphological adaptation and even to an increased storage potential for carbohydrates.
- Shading by dominant trees increases the tolerance to flood duration.

In floodplains rejuvenation should be in the focus of forestry on all suitable sites. In floodplain zones above the middle hardwood zone Common Ash and in the high hardwood zone maple, lime and hornbeam can easily be rejuvenated. The canopy cover should not fall below a third of a full cover in order to enhance a mixed, stepped, multi-aged and wellstructured permanent forest stand.

D6 - References

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Chapter E
Recommendations for public participation in the planning of retention areas

E - Recommendations for public participation in the planning of retention areas

Regina Rhodius

E1 - Introduction

The following chapter deals with questions of public participation in the planning of flood retention areas. It is designed for planning authorities, which will go further beyond the legally stipulated procedures by using offers of participation. It is also designed for all interest groups and persons who want to participate actively in a planning process or those who want to understand the background of communication problems, which might occur. With the experiences, ideas and helpful suggestions for the following questions and topics it tries to contribute to a fair participation process and a better mutual understanding of different interest groups:

- Why additional public participation?
- Which fundamental requirements have to exist before the beginning of a participation process?
- Working steps towards successful public participation

Additionally to the explanation there is a check–list for the evaluation of the own participation process as well as links to secondary literature.

Figure E-1: During the planning approval procedure, a date for argument takes place where all relevant topics are discussed. The photograph by Regierungspräsidium Freiburg is showing the date for argument for the retention area Kulturwehr Breisach

E2 - Why additional public participation?

Public participation (often synonymously called public involvement or participation) comprises the inclusion of the general public which means private persons as well as the general public organised in citizens´ initiatives, organisations and chambers in a planning process (ÖGUT & Lebensministerium 2005). To ensure a minimum amount of participation, public participation in planning procedures is legally stipulated (text box Planning approval procedures).

Planning Approval procedures and public participation in Germany:

Flood retention areas require an execution of a planning approval procedure (UVPG and VwVfG, see list of abbreviations in end of this chapter) and the concluding approval by a planning approval decision. The institution of the procedure is the planning approval authority (e.g. District Office / Regional Office). In cases, which are meaningful to the regional planning a regional planning procedure is required in advance (ROG and LplG). By this it will be checked if the planning considers the superior aims of the regional planning. Both procedures offer the public (e.g. the affected technical authorities, the institution of public concerns, the affected municipality and citizens) opportunities to take part in the planning. The respective planning documents are to be displayed publicly in the affected municipalities. After that, the citizens have the opportunity to submit their statements. In planning approval procedures a public discussion takes place with the objectors. There is the possibility to sue against the final planning approval decision, for those whose own rights are harmed (one can find out more by looking in the quoted acts and by asking the responsible institutions).

Experiences show that legally stipulated procedures often are not sufficient to fulfil the increased demand in society for participation and involvement in the creation of the own environment. Because of the different clashing interests, which are shown in Part B-9, there are often conflicts which delay considerably the planning and realisation of a measure. At the same time this leads to a loss of confidence in the long run between citizens, interest groups and the planning authority.

In many planning conflict fields (e.g. airport- and road construction work), so-called informal participation processes gained more and more importance. Those procedures are carried out additionally to the legally made guidelines.

E3 - "Pros and Cons" of additional participation

Of course there are difficulties concerning additional participation processes, and they should not be concealed (HarmoniCOP 2005, Hahne 2004):

- Participation is expensive and time-consuming and a professional process management is needed.
- The openness to unexpected results, which is a key condition for successful participation, is limited in the case of the planning of retention areas due to legal and technical conditions.
- Agreement solutions are not automatically a guarantee for the best practice solution. Due to search of a compromise between different interests, sometimes conflict – prone questions are cut out.

However by comparing the costs arising from a participation process with the ones from a long – term delay of measures because of court procedures, the advantages of additional participation highly prevail (BBR 2003):

- Through the integration of different interest groups a better basis of knowledge is acquired.
- The integration of different interest groups guarantees a greater certainty about one´s legal position.
- Measures can be translated quicker into action.
- The growing confidence between citizens, interest groups and authorities has a positive effect on the general climate of society.

Additional participation is primarily necessary when complex factual decisions are at stake, which touch diverse interests and thus cannot be decided by individual institutions. It is to be proven very carefully where and to which degree additional participation could be initiated. Especially in the field of disaster prevention it has to be ensured that decisions should not be delayed and "flogged to death", but the government should be able to act and carry out unpopular measures for the protection of the general public. This means, in the case of the planning of flood retention areas, that the planning authority will occupy an exceptional status and will represent positions which are negotiable only to a certain extent.

E4 - Which basic conditions must be given before the beginning of a participation process?

To have a successful solution of political conflicts of interest that occur in the planning of flood retention areas, a general political conflict solving strategy is needed. In political science there are three political instruments of regulation to be distinguished: legal, financial and informational (Prittwitz 1994). So e.g. it is crucial for the acceptance of a planning to provide funds for compensation of impairment of use (Table E-1).

***Table E-1:** Conflict solving strategies adopted in the planning of retention areas in Germany*

Conflict solving instruments	Examples of plannings in flood retention areas in Germany
Legal	• Regional planning procedure • Planning approval procedure • Contracts made under public law • Framework agreement
Financial	• Compensation catalogues for agricultural and forestry areas • Acquisition of areas for property exchange • Cost-free lease of retention areas • Planning of measures as a compensation for local recreation area affected by retention areas • Planning of agro-structural development • Integration of compensation measures in (landscape management) accompanying planning or technical planning
Informational	*(Tab.E-3, Choosing participatory methods)* • Brochures & flyers, nature trail, excursions, citizens´ meetings, Internet • Moderation processes/ round tables • Polder advisory committee

Thus public participation as an informational instrument has always to be embedded in a general political conflict solving strategy. Furthermore fundamental principles have to be considered in the design of participation processes. They will be shown in the following and will be explained in the text boxes by means of experiences from the case studies. The recommendations of how to act are to be found in short and compact form in a concluding check-list.

Cooperative self – conception

Successful participation begins with a cooperative personal attitude towards the planning process and the affected stakeholders. The readiness to cooperate means respecting values and perceiving problems of the vis-a-vis, an open and serious feedback to suggestions and fears of affected stakeholders and a sensible exposure to emotions. Using "killer phrases" like the assumption of lacking solidarity of affected municipalities should be abandoned. Of course it sometimes occurs that any kind of efforts made by the authorities are interpreted negatively. According to this, where there is a lack of the will of cooperation of the involved parties and the solution via moderation is not successful, it will be more reasonable to dislocate the conflict in the formal planning procedure than to repeat an informal trial once again.

Experiences from the case studies:

The interviewed planning authorities approved an intensive discussion process with the municipalities, but showed thereby a different understanding of their role. One representative as being an expert felt obliged to answer quickly all occurring questions asked by citizens and thus confronting opposition. Citizens felt that they should only be convinced quickly by the given answers, and therefore opposition was even more strengthened. In contrast to this, elsewhere representatives pursuit the strategy of not having a complete expert position, but showing their own uncertainty and preliminary considerations in a discussion. This expatiated to respond openly to critic and requests and after initial scepticism it found acceptance in the municipality. "To approach people, as if we were affected ourselves" – is the motto of another representative of the administration.

Personal credibility

Strong opposition against planned retention areas is often accompanied with intense personal conflicts. This personification is a general phenomenon of social conflicts (Giesen 1993). Credible key persons are therefore decisive for the course of a planning process. By choosing representatives of the respective parties, apart from their professional competences and communicative abilities, their personal credibility should also be considered. In cases of successful participation the acting representatives attached special importance to establishing a good basis of confidence by intense dissemination of information to stakeholders and good public relations.

Openness to unexpected results

To be open to unexpected results is described in planning literature as a key condition for successful participation (Bischoff et al. 1996). Due to legal and technical conditions, participation in the planning of retention areas is restricted. Communities often demand changes and involvement, when the planning authorities have only little room for negotiation or are determined by a preliminary procedure. Analysing the appointed participation methods, it becomes apparent that they are mainly classified in the sector of information and consultation. Cooperation, that is collective decision making, does barely take place, though it is expected by the affected stakeholders when they are invited to take part in planning processes. If the area of a real influence is defined too closely, the stakeholders normally loose their interest in cooperation; they have the feeling of alibi cooperation and being pocketed. If, in the stakeholder's view, important issues are not at stake, they may decide to ensure their own interests and to switch to a strategy of confrontation instead of cooperation.

Political will

The political will to support a measure and the subsequent preliminary political decision have considerable influence for the acceptance of a planning and its translation into action.

Experiences from the case studies:

For a factual – orientated and quick planning which is also open to concerns of affected stakeholders, the following aspects turned out to be beneficial:

- national and international agreements underline the necessity of retention areas and create political pressure
- political representatives of a higher level support the measures on site even in case of local opposition
- at the same time the planning authority receives sufficient scope of negotiation from the higher level so that it can flexibly react to the local needs.

Especially during election campaigns, one can notice that planning conflicts are exploited for own political profiling. Certainly, this cannot be entirely avoided, but could be mitigated by offering open working structures for political decision - makers.

Time limit

Participation processes require a time limit and efficient procedures to maintain the motivation of all participants. Long-lasting controversial political discussions leading to no solutions and replacing of political incumbents during a long participation process moreover weaken the determination and the allocation of resources for the planning and the implementation of measures.

Experiences from the case studies:

A planning process which has been developing over several decades, as in the case of the Integrated Rhine Programme (IRP) in Baden-Wurttemberg might become complicated because of a changing social „zeitgeist“. The concept of the IRP which was conceived in the 1980s and which set great value upon the conservation of nature, is now undergoing a minor social backup and has been partially challenged.

Interlocking with additional participation methods

Informal participation offers have to be interlocked with procedures regulated by law. For instance, there must be a guarantee that negotiated compromises will be recovered in the planning procedure documents. Otherwise there will be a considerable loss of confidence on the part of the involved stakeholders. Furthermore an involvement of the planning approval authority in the informal process is recommended.

Experiences from the case studies:

The approval authority by its cooperation in an informal participation process could in one case point at method errors and considerable factual aspects at an early stage. At the same time the approval authority was informed about the required backgrounds for a later evaluation of the decisions made by the planning authority. Both led to a quicker planning approval procedure and avoided a second display of the planning documents, which would have been necessary if the documents had been too late adapted in the procedure.

A proceeding of this kind requires a planning approval authority which does not only completely remain uninvolved until the official application in order to meet the required neutrality but which is ready to cooperate also at an early stage

Once these fundamental principles have been taken into account, it is possible to continue with the concrete definition of a participation process, which is explained in the next chapter.

E5 - Working steps towards a successful public participation

In the following the basic working steps for planning and implementation of an informal participation procedure are described. There is no claim of completeness and the list only provides components that proved to be helpful in the examined case studies and in the final discussion with planning authorities. These are shown and explained in the following text boxes on the basis of experiences from the case studies. The final check-list resumes in a compact form the concrete recommendations on how to handle. Within this guideline concrete hints on how to organise and moderate meetings as well as communication techniques could not be considered. On this subject a manifold literature is available, and listed at the end of this chapter. Figure E-2 shows the central working steps, which not always have to take place one after another, but also parallel and in successive loops.

Context analysis

As described in B-9, the planning of a retention area interferes with existing land use. It is therefore important to make a context analysis which allows to realistically evaluate the conflict potential and to adequately react upon that. This should include the problem characterisation, which is common for the making of a plan (e.g. data of the areas characteristics, guidelines of the regional planning, competing sectoral planning) and also soft factors (e. g. the relationship of the citizens to the area). Starting from the experiences of the case studies, Table E-2 shows how particular factors can affect the planning process.

The analysis can show where a particular demand for discussion and emotional reaction are to be expected. At the same time it gives the possibility to embed the polder planning in a bigger context. In the background there should always be the question, which of the regional problems could be meaningfully linked

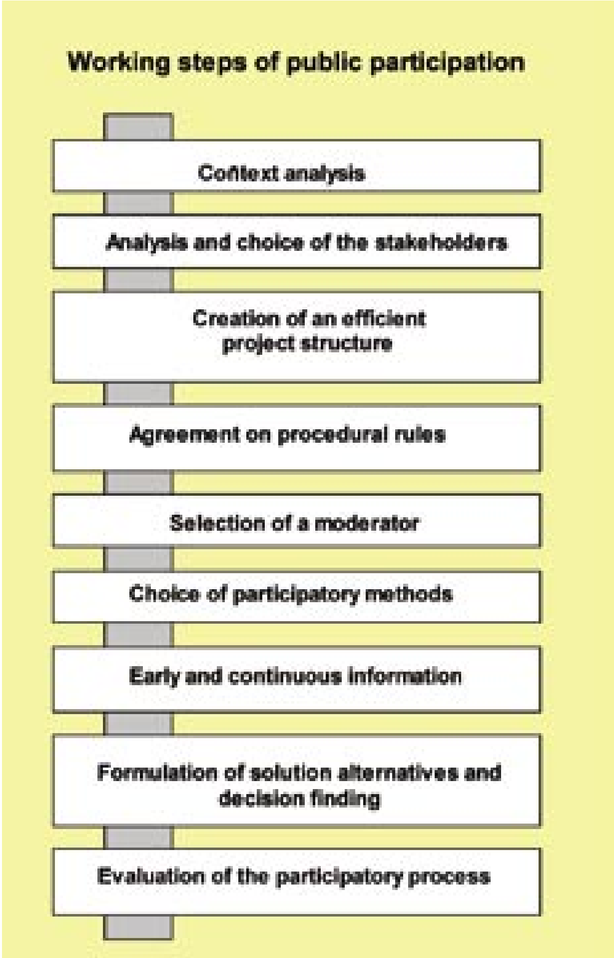

Figure E-2: *Working steps of public participation*

with the water management project so that the region can make a profit (text box). This requires a long term consideration of the regional planning, which should be carried out together with the stakeholders of the participation process. By choosing the problem fields for such synergy effects, it is important "to hit the nerve of the region" (conclusion of a representative of a planning authority).

> **Experiences from the case studies:**
>
> Every region brings along different connecting factors for the design of the planning of a flood retention area: while it could be interesting for an urban region to provide compensation areas to municipalities within the polder, in rural regions this could be of less interest because of the lower needs for compensation areas.

Table E-2: *Effects of selected factors on the planning process*

Features	possible effects on the planning process
Characteristics of the area	
• close proximity to a residential area	• superior brisance of seepage water / fear of damage to buildings
• form and intensity of land use	• different demand of compensation, different necessity of ecological flooding, which are often controversially disputed
• great importance of the area for the further settlement development	• higher resistance of the municipality, need for alternatives for further settlement development
• importance of the area for recreation and tourism	• higher resistance of the municipality, need for alternatives for further recreational development
Attitude of the population	
• more experiences with floods	• often higher readiness for cooperation and acceptance of use restrictions
• high emotional bond to the area	• often higher public interest, emotionalitation of the debate (e.g. if the area has been already “defended” several times against using requirements from outside)

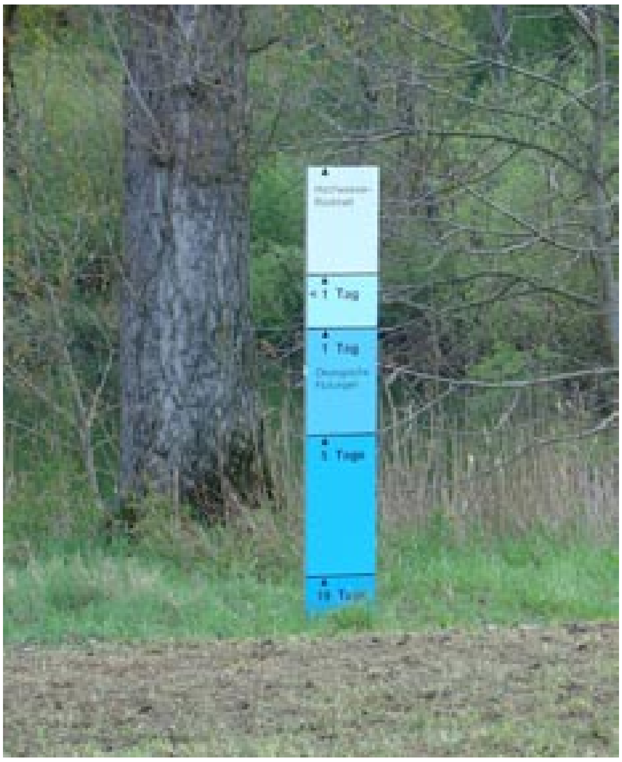

Figure E-3: *A nature trail shows the expected duration and height of flooding events*

Analysis and choice of the stakeholders

The aim of a stakeholder analysis is to provide an overview of the acting groups participating in the planning process (e.g. the affected population, social interest groups, experts, political decision-makers, authorities involved in the implementation). Based on the measures which affect the time and financial resources of the particular groups, very different interest and demand/need in participation can be detected (UMWELTDACHVERBAND 2004):

- Information: the stakeholder wants to be informed regularly about the state of the project, but does not take part actively in it.
- Consultation: the stakeholder brings along expert knowledge selectively, but does not take part regularly.
- Cooperation: the stakeholder takes actively part in the planning process.

After considering these needs and in consultation with the stakeholders, it will be decided, who will be involved in the planning and to which degree. For this the following questions should be considered (HARMONICOP 2005):

- Which relations exist between the stakeholder groups?
- How do the different groups perceive the problem?
- Which own goals do they pursue?
- How can they be motivated to take part constructively?

After doing a first internal stakeholder analysis, it is recommendable to call in an external consultation and together with already established actors to further develop the circles. Since the latter could lead to a social selectivity, it is important to remain open to changes during the process and to new actors.

Experiences from the case studies:

Citizens´ initiatives often constituted in an advanced stage of planning and found themselves in a defensive position because of the already made arrangements. In order to get heard, they felt constrained to present themselves in an aggressive and demanding manner. A constructive cooperation was successful, where the process was opened again and the newly constituted initiative was allowed to take part actively in the planning process.

While composing committees it has to be made sure that the invited actors are authorized by their institutions to make decisions. In addition, a manageable size of the group and a continuous circle of participants help to guarantee a good working process.

Creation of an efficient project structure

The project structure should allow flexible and quick decisions. Since public participation is intensive in resources, sufficient financial capacity and human resources are needed. If several representatives of the authorities and the planning bureaus work together in an organizational team, institutionalised forms of cooperation should be set (e.g. regular "jour fixe" meetings). In the case of a high conflict potential in the planning and a challenging level of participation, professional external process facilitation is recommended.

Arrangement on procedural rules

On the basis of the context and the stakeholder analysis now the detailed structuring of the participation process and the determination of the procedural rules together with the participation actors. Thereby the following aspects should be pointed out:

- Tackled issues and the scope of acting and deciding
- Time table (regarding the availability of the actors)
- Choice of participatory methods
- Modus of determination of decisions and how to deal with the results in the further course of the planning
- Dealing with applications (e.g. information and research application, which should not be used to delay the process)
- Dealing with media (due to different interests, it can happen that one doen´t come up with a common strategy)
- Agreements on the information management

The transparency of these rules plays an important role. All participants should be aware of their role (e. g expert status, role of the moderator). It could be helpful to arrange exit rules. This could eliminate the fears of the interest groups of being treated by prejudices, which could lead otherwise to an attitude of blockade (HarmoniCOP 2005).

Choice of moderation

A neutral moderator who is "obliged to all participants" (ÖGUT & Lebensministerium 2005) could contribute basically to the objectification of the discussion and to a constructive solution finding. Especially in cases of a high conflict potential and of complex participation methods, the deciding institution should thereof prescient from moderation by itself and should invest in a professional moderation from the very beginning of the planning. The moderator should be informed continuously and in real time about the planning progress. Appropriate moderators are persons who (Gothe 2006):

Figure E-4: A Moderator helps the participants in the process of solving problems

- are accepted by all discussion parties because of their personal integrity and their neutral attitude
- bring along experiences with procedures of public participation and political negotiations
- dispose of an adequate insight to the professional matter and knowledge of the affected area
- have good communicative competence (e.g. can translate complex circumstances into a simple language and arise understanding for competing interests)

As a rule, a moderator helps the participants in the process of solving problems, but he does not relieve the decision finding by giving them his own solutions. In the practice there may be a taking over of roles, which goes beyond this classical action of a moderator and which is constituted on the personality of the particular moderator (e.g. institutional anchorage, especially expert knowledge or experiences, textbox below). It is important, that this changed role is transparent to the participants and that they approve it. It has to be ensured, that parallel negotiations and decision processes, which are initialised by the moderator, should leave out the participants of the actual participation process.

Experiences from the case studies:

Using a neutral moderation, which is a top-ranked method in technical literature, was judged differently by the asked stakeholders. Several representatives of municipalities disapproved professional, neutral moderation. Instead of professional moderators already employed trustworthy persons being already involved in the planning should cover this role. They could contact persons on site. In the case studies, these persons were e.g. chairmen of citizens´ initiatives or representatives of agricultural associations, who already enjoyed public respect within the association and who were trustworthy for the particular planning institution. They were forwarding information and could minimise conflicts within their own organisations. They also lobbied for the observance of the procedural rules and the intermediate agreements. It can also be an advantage if it is a representative of the approval authority who takes over the role of the moderator.

Choice of participatory methods

The choice of the participatory methods highly depends on the wished possibilities of influence of the public on the planning process. According to this, the three levels of participation can be distinguished, i.e. information, consultation, and cooperation (Bischoff et al. 1996, ÖGUT & Lebensministerium 2005). The aim of the information discussed in the following chapter is, to make the planning known and understandable to people without influencing any decision. Consultation means that stakeholders give their view on planning contents and that they can bring up their ideas and proposals. Unlike cooperation, where the public is involved in the decision finding process, consultation means that the decision about the entry of propositions in the planning lies within the planning authority, and/or the approval authority decide whether or not to accept the proposals submitted by the public. In the planning of flood retention areas the focus is on information and consultation. Real cooperation seldom takes place because of the narrow legal and technical framework. It could be also observed that other functional departments and organised interests are often very well included, while laypersons only have the possibility of taking part in formal procedures. This leads to a high conflict potential, which complicates the planning and often delays the implementation.

Table E-3: *Overview of methods of participation in the planning of flood retention areas*

Category	Examples of methods in the planning of flood retention areas
Information	Brochures & flyers, nature trail, excursions, citizens´ meetings, Internet
Consultation	Objections / hearings in regional planning and planning approval procedures advisory working groups
Cooperation	Planning workshops (textbox / Table E-4) Committees of representatives of affected interest groups, municipalities, politics, science: round table, working groups with the authority to decide, polder advisory committee

Especially in urban and regional development, where planers and administration are dependent on an active cooperation with the affected citizens, a multitude of cooperative participation forms for citizens was created. Because of the narrow legal and technical framework, these participation forms are only suitable to a certain extent for the planning of a flood retention area. But it is worthwhile to exactly analyse at the beginning, which issues are adequate for public participation and to check which classical participatory methods can be integrated in in the own participation process (Table E-4). In order to do this, it is important to know, which are the issues that leave the space (openness to unexpected results) for common decisions and are as well of enough interest for the affected stakeholders. Participation should not be sensed as a red herring from one of the really important topics. The aim should not be the insertion of methods with tuneful names, but the serious effort to find a common solution. Sometimes a good moderated discussion is more helpful than a filed method, which is foreign to the actors and which might raise exaggerated expectations at the same time.

Experiences from the case studies:

In Rhineland – Palatinate, before the planning of the Polder Ingelheim a dialogue was initiated with the motto “A region under discussion”. This dialogue was taking place in planning workshops, in which representatives from agriculture, industry and trade, associations and federations, local authorities, as well as interested citizens acquired an approach for the development of the river Rhine floodplains in the area of Mainz – Ingelheim (for more information see Ministerium für Umwelt und Forsten, Rheinland – Pfalz 2000/2001). The importance of this dialogue process for the subsequent planning of the flood retention area in Ingelheim was rated differently by the asked stakeholders, but it was clear, that with this dialogue process a first base of confidence as well as working structures could be created for a further cooperation. During the process, representatives of agriculture initiated the process of an agricultural development planning, which could be completed during a constructive cooperation between the water management and agriculture.

Figure E-5: *During an excursion, planning problems can be discussed in a good way*

Table E-4: *Chosen methods of participation and possibilities of transferability to the planning of flood retention areas (description of participatory methods: Fischer et al. 2003, ÖGUT & Lebensministerium 2005, Bischoff et al. 1996, Sellnow 2003, Reinert 2003)*

Participatory method / brief description	Applicability
Methods for the integration of representatives and decision makers	
Moderated processes	
The course of a moderated process is not standardised, but it is mostly coordinated by a neutral moderator in agreement with the participants.	An adequate form to find a balance of interests between the affected stakeholders and for decision making. Due to the lack of standardising the procedure could be well adapted to the particular situation. Especially in cases of a high conflict potential moderation should be introduced from the very beginning of the planning.
Example: Round table	
The representatives of the affected interest groups who take part in the process, discuss concrete factual questions on an equal footing and they develop solutions together. The meetings are mostly in camera meetings.	Compared to other methods, in this case an advantage is the publicity and the confidence of the stakeholders in such discussion rounds. The principle of the round table is partly applied in polder advisory committees and working groups.
Mediation	
Mediation is an instrument of conflict solving out of court which is mostly applied in relationship conflicts (e.g. within partnership, neighbourhood or a company). The affected meet voluntarily in camera and search for amicable solutions under the guidance of a mediator.	In the 1980s, the process of mediation was introduced into the field of environmental planning in Germany. But the way how it is applied in this field is not like in the original mediation. Due to a wider scope of acting, in the original mediation the participants develop results which are of direct legal responsibility. In the field of environmental planning, where the authority to make decision belongs to politics and administration, the results can mostly only be seen as recommendations. Therefore it is more suitable to use the term of moderation for such processes. Mediation in the original way should be only used only to clarify advanced interest and relationship conflicts which are a burden for the planning process.

Methods for the involvement of the whole public	
"Planungszelle" (adapted from Peter Dienel)	
Citizens, who are randomly chosen, are grouped to approx. 25 persons and make an expertise to a certain question. Experts familiarise them in advance with the basic factual questions.	The method offers the possibility to integrate a representative group of citizens and is adequate for the development of concepts, where everyday life and expert knowledge should complement one another. The topic should cover an aspect of the planning which concerns the general public (e.g. regional approaches, concepts of recreation) and should not intervene in the conflict of the really affected of a concrete planning.
Planning workshop	
In a planning workshop there is no standardised course. Often the concern is that experts, interest groups and citizens are brought together, in order to obtain a broader basis of ideas for the planning. Designed variants of planning do not substitute the creation of factual plans, but could provide a fundament.	Adequate for the development of concepts where every day life and expert knowledge should add to each other, but not adequate for the solving of conflicts of interest. The topic should cover an aspect of the planning which concerns the general public (e.g. regional approaches, concepts of recreation, aesthetic design of buildings) and should not interfere with the concrete aspect of planning.
"Zukunftwerkstatt" (adapted from Robert Jungk)	
The "Zukunftswerkstatt" should mainly enable an atmosphere which promotes creativity. It passes through 3 phases: the phase of critics to analyse ongoing problems, the utopia phase to develop visionary ideas and the realising phase to plan concrete steps of action. A method for establishing a new project.	
Open space conference	
A method especially for large groups, where the topic is given only in rough lineaments. The participants work in smaller changing groups with topics which were introduced by them. A lively method to develop ideas.	Due to the humble structure requirements it is not suitable for clarifying controversial questions and for decision making. The openness of the procedure can though be integrated e.g. in citizens´ meetings to collect helpful suggestions and critic or as entrance in a forum for the regional development which should be activated before the concrete planning process starts.

Early and continuous information

According to the context and stakeholder analysis the dissemination of information can also be planned: Who is affected by the planning? Which demand for information exists among the different stakeholders? How should information be elaborated? While there is often a good institutionally arranged flow of information with other factual resorts and organised interests, the information of the local population requires special efforts. If the planning is still in the beginning and does not come across much interest, consternation should be raised (textbox below). It is therefore helpful, to approach local associations and, in cooperation with them, to offer decentralised informational meetings. Moreover, the responsibilities for the transmission of information should be decided in time.

Experiences from the case studies:

All parties asked, recommend an early and step by step involvement of all groups which take part in the process. The difficulty of approaching municipalities with plans which are still unready was felt to be less problematic by the planning authority than the non – existing consternation of the population in the beginning of the planning. E.g. one planning authority introduced a project very early, but did not come up with interest in the offered event. Not until the residents were affected by floods, the attention for a planned retention measure was raised. The citizens´ initiative was founded at a stage where the planning was already advanced. Misunderstandings dominated about the question of who has the duty to inform the general public. The municipality thought it was the duty of the planning authority. But those thought it was the duty of the mayor to forward the given information to the public. Due to this misunderstanding there were partly vacancies of information and also loss of confidence.

The information flow does not have to be a one – way street: with their local knowledge the local residents can contribute much to the success of the planning. Thus inquiries (e.g. in the frame of an information event or by separate questionnaires) should be included at the beginning of the planning in order to allow the affected to gain their own expert status.

For the elaboration of information, which can often be very complex, the citizens´ associations can be asked for cooperation, e.g. checking whether the already elaborated information is understandable for laypersons. To cover the different needs of information, several levels of information should be offered. It is important to have continuous information about the planning steps and detailed justifications for plan changes. The local media as well as multipliers should therefore be especially considered with ongoing and continuous information (e.g. via email distributor or regular information letters). In the forwarding of the planning preliminary results, it should be already revealed via layout, that these are not the end results but preliminary planning results (information letters instead of high glossy brochures). Circulating misinformation should be rectified by comments in the media as well as in one-on-one interview with multipliers. It is recommended to hold direct contact to local journalists and – where those represent merely unilateral local interest – to show high profile in national media in order to get a balanced picture in the public. In addition to the information about the concrete project, public measures should be included in order to reach a sensitisation for flood protection concerns (textbox below). Also in the construction phase, which follows the planning, good public relations should have an important role. Regular press release, working group meetings during the construction works or annual construction celebrations offer good chances for sharing information.

Generally it should be considered, that it is mostly not through the accompanying information such as internet, brochures, flyers etc. that a measure receives acceptance, moreover thanks to the direct contact with the affected and the kind of involvement reached. It is therefore much wiser to invest into concrete offers of participation than into complex information material.

Experiences from the case studies:

With excursions to already realised flood retention areas, very different experiences were made. In one case, one succeeded in making the own planning more comprehensible, due to the knowledge from experiences made elsewhere. But the measurement, seen in another case, could not convince the sceptic of another planning, due to another type of geographical classification circumstances in the excursion area. Seldom positive aspects of other plannings are transferred to the own situation, mostly the affected return quickly to their old controversies.

The exchange with other regions e.g. in the frame of the Hochwassernotgemeinschaft Rhein, a federation of municipalities, cities and citizens´ initiatives in the Mid Rhine and Lower Rhine area, can contribute to the sensitisation for flood retention measures. Such committees, which unite the one who live upstream and downstream along the river Rhine and therefore are perceived in another way as a planning authority, can initialise actions such as photography and drafting competitions, bicycle tours and excursions and such contribute to a positive atmosphere.

Formulation of solution alternatives and decision making

For the common development of solutions first of all a common understanding of the problem and the aim definition (joint fact finding) are necessary. Often this phase is left out because people think one knows enough of the particular positions. To avoid being stuck too early in the discussion of a conflict, it can be helpful to broach the objectives instead of the issue of a fundamental conflict. This can lead to a reality check of overlapping aims and common approaches. The stakeholder analysis already offers starting points for the search of solutions which can provide benefits for all participants (win – win solutions). For the decision making, sufficient solution alternatives must be available and they should be transparently evaluated (e.g. in the form of a costs/benefits analysis). Therefore it should be decided in every case about which could be the worst possible situation and how to adapt the planning in such a case ("worst case").

Experiences from the case studies:

Largely known is the necessity to create win – win situations, from which every participant can profit. This kind of case was achieved in Cologne. Due to a changed planning (higher retention volume due to a higher dyke) the municipality of Niederkassel can - by constructing a retention area for the benefit of those who live further down the river Rhine - also get a better protection for their own settlement area and receive a cheap dyke reeinforcement. Due to this, the citizens´ initiative accepted the planning result on the additional condition that negative consequences of the retention measure on their own houses are going to be minimised. In the example of Ingelheim, a worst case scenario was used by the authority during the presentation of the planning. This scenario explained the consequences of a 200 year flood (HQ 200) and therefore went beyond the original agreed planning basis. The municipality felt that their fears have been taken seriously, which lead crucially to the acceptance of the planning.

When external expert knowledge is included in the search of solutions it has been often observed that experts are exploited by the particular stakeholder groups. To avoid minor settings and the feeling of concealment of alternative solutions, it is advisable in such a case to officially involve the different circulating expert views into the planning process and to evaluate them with the help of commonly accepted criteria. That should not be misused by the stakeholders as a mere strategic inflation of the planning process (see agreement on procedural rules). If there are no new arguments, but there is only a repetition of the known ones and the planning is in a rut, the time is ready to make a decision. The attention should be turned to the compliance of the rules of decision making, which were arranged in the beginning.

Evaluation of the participatory process

Already in the course of a participation process an accompanying evaluation should be carried out in order to make sure that any necessary adjustment of the concept can be done in time. This allows to quikkly integrate additional stakeholders and unforeseen conflicts into the participation process or, if required, to choose another method of participation. There is the possibility of executing the evaluation internally or of authorising an external consulting, which often assures an impartial view. Of course stakeholders can be involved in many different ways into the evaluation process (questionnaire, interview and workshop). Generally it is wise to involve stakeholders into the planning because this way they receive the possibility of influencing the process themselves and they can get closer to the process. However, planned evaluations are often too extensive, taking too much time and this taxes the patience of the stakeholders. Therefore it is necessary that the evaluation is well prepared and limited to the basic questions. Before the evaluation, certain indicators have to be established in order to recognise whether the objectives have been reached or not. As a general rule, three issues can be recommended for the basic questions (Extensive questionnaires e.g. in HarmoniCOP 2005):

- Contribution of the participation process to the solution finding and factual quality of the decision (e.g. number and quality of the propositions which were suggested in the planning)
- Contribution of the participation process to a better relationship between the stakeholders (e.g. acquaintance and comprehension of the different perspectives, confidence in stakeholders, being keen on further cooperation)
- Satisfaction with the course of the process and the methods (e.g. time and effort compared to profit, transparency of the procedure, suitability of methods)

Participation processes can be sometimes over-charged with expectations and the hope of a quick conflict solving. People are often disappointed when the desired results can‘t be achieved or stakeholders leave the process. An accurate evaluation is helpful, not just because one doesn‘t generally doubt the sense of a participation process, but moreover because it helps acquiring the knowledge on the causes of the failure for the creation of future processes (e.g. missing political support, too little possibilities of influence or too much time expenditure for the stakeholders).

Table E-4: *Checklist for the evaluation of a participatory process*

Basic conditions for a partici-patory process	Criteria of success
Cooperative self-conception	• The participants accept the values, roles and problem perceptions of their vis-a-vis and are prepared to question their own role. • Fears of affected stakeholders are taken serious by the planning authority. • In the discussion a common language is appreciated (e.g. abdication of “killer phrases“).
Personal authenticity	• By choosing representatives of the particular parties, apart from their professional competences and communicative abilities, also their personal authenticity are considered. • Via continuous information of stakeholders and good public relations a good basis of confidence is created.
Openness to unexpected results	• A real influence on the planning is possible. • A step to step advancement in the creation of the plan is carried out instead of the presentation of an already completed plan. • The scope of action and decision making is transparent to all participants. • The planning authority engages itself to a respectful exposure to the results. This does not mean that all propositions have to be accepted but there must be a argumentative justification for the denial or acceptance of proposals.
Political will	• A broad political basis stands behind the planning and the participation process. • Political decision makers are integrated into the working structures (e.g. polder advisory committee).
Time limit	• A time limit of the participation process in the sense of a realistic, flexible time “corridor” is arranged. Thereby the temporal availability of the stakeholders is considered.
Interlocking of additional participation to formal procedures	• Negotiated compromises are included into the planning documents. • The planning approval authority is involved in the informal process at an early stage.

Working steps	Criteria of success
Context analysis	• The conflict potential is evaluated with the help of a context analysis (characteristics of the area: e.g proximity of a settlement, form and intensity of landuse, previous history of planning, attitude of the population towards flood events). • Based on this, regional fields of problems are integrated within the polder planning to create a benefit for the region.
Analysis and choice of the stakeholders	• Analysis of potential stakeholders of the participation process (internally or together with stakeholders / external consulting), taking into account the different situations, role and problem understandings as well as claims for a participation. • On the basis of the previous point, it will be decided together with the stakeholders, who when and how will be informed / involved. • The representatives of the participating interest groups are authorised to decide. • The participants group is continuous and manageable. • The planning process is open to stakeholders coming at a later stage.
Creation of an efficient project structure	• Clear decision structures enable an effective project management. • Sufficient financial and human resources are available. • There are regular internal meetings. • In case of a high conflict potential in the planning and a high level of participation, professional external process facilitation is invited.
Agreement on procedural rules	• Precise arrangements are made concerning: - the scope of action and decision making - schedule - participatory methods - modus of decision making and how to deal with the results - how to deal with propositions - how to deal with media - information management - exit rules • The particular roles are transparent to all participants (moderator, experts, and stakeholders).
Selection of a moderator	• The chosen moderator is accepted by the participants. • His/her role in the participation process is transparent. • The moderator will be continuously and timely informed on the ongoing state of planning.
Choice of partici-patory methods	• Space for real cooperation is created starting from the analysis of possible issues which allow an active participation. • After having checked their suitability, classical participatory methods will be integrated into the planning process.

Early and continuous information	• The dissemination of information is built up on the stakeholder and context analysis. Different levels of information are offered according to the specific target groups. • In order to reach the local population, local associations are involved early in the planning of decentralised information meetings. • There are clear responsibilities for the dissemination of information. • The dissemination of information is not considered a one-way street. This means that the expert knowledge of the local population is accepted and will be integrated into the planning (e.g. through interviews). • Laypersons are asked for cooperation for the evaluation of the designed information material (e.g. citizens associations). • There is continuous information about planning proceedings. Changes in planning are extensively explained. The optical preparation of planning results is adapted to the state of the planning (e.g. information letters with notes about preliminary results). • Misinformation will be rectified via statements in the media and in vis-a-vis conversations with multipliers. • Representatives of the media and multipliers get special information material (e.g. via email distribution or information CDs). • The planning authority shows presence in regional and national media. • Public relations work includes measures for the general sensitisation for the concerns of flood protection (e.g. exchange between people living upstream and downstream of the river). • Public relations work will be continued during the construction phase (e.g. press releases, resume of working groups, annual construction celebrations).
Formulation of solution alternatives and decision finding	• In order to show the possibilities of win-win-solutions, a common definition of problems and objectives takes place within the participation process. • There is a wide choice of solution alternatives. A “worst case” scenario is taken into account. • Opposite expert views are explained transparently and are examined, considering whether they could be integrated into the solution alternatives or not. • The criteria for the evaluation of the solution alternatives are transparent to all. • The decision making is based on the rules formulated in the beginning.
Evaluation of the participatory process	• There is an accompanying evaluation (internally or with external consulting) which enables early process changes. • The stakeholders are integrated into the evaluation without being overstrained. • The extent, questions and indicators for the accompanying and concluding evaluation are clarified before the participation process.

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List of abbreviations

UVPG	Environmental Impact Assessment Act
ROG	Regional Planning Act
VwVfG	Administrative Procedures Act
LplG	State Planning Act

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Annex 2: Scientific plant names and their English, French, and German counterparts

Herbaceous Plants – Plantes herbacées – Krautige Pflanzen

Scientific name	English	Français	Deutsch
Aegopodium podagraria	Ground Elder	Herbe-aux-goutteux	Giersch
Alliaria petiolata	Garlic Mustard	Alliaire étiolée, Herbe-à-l'ail	Knoblauchsrauke
Allium ursinum	Ransoms	Ail des ours	Bärlauch
Anemone nemorosa	Wood Anemone	Anémone des bois	Buschwindröschen
Brachypodium sylvaticum	Slender False-Brome	Brachypode des bois	Wald-Zwenke
Carex acutiformis	Lesser Pond-Sedge	Laiche	Sumpf-Segge
Carex brizoides	Quaking Grass-Sedge	Crin vegetal, herbe-à-matelas	Seegras
Carex sylvatica	Wood Sedge	Laiche des forêts	Wald-Segge
Circaea lutetiana	Enchanter's Nightshade	Herbe de St Etienne	Gewöhnliches Hexenkraut
Clematis vitalba	Traveller's Joy	Clématite vigne blanche	Waldrebe
Convallaria maialis	Lily of the Valley	Muguet	Maiglöckchen
Equisetum hyemale	Scouring Rush Horsetail	Prêle d'hiver	Winter-Schachtelhalm
Festuca gigantea	Giant Fescue	Fétuque géante	Riesen-Schwingel
Hedera helix	Common Ivy	Lierre grimpant	Efeu
Impatiens glandulifera	Ornamental Jewelweed	Impatiente glanduleuse	Drüsiges Springkraut
Impatiens noli tangere	Touch-me-not	Impatiente n'y-touchez-pas	Rühr-mich-nicht-an
Oxalis acetosella	Wood Sorrel	Oxalis petite oseille, surelle	Wald-Sauerklee
Paris quadrifolia	Four-leaved Paris	Parisette à quatre feuilles	Vierblättrige Einbeere
Ranunculus ficaria	Lesser Celandine	Ficaire	Scharbockskraut
Rubus fruticosus agg.	Bramble	Ronce	Brombeere
Stachys sylvatica	Hedge Woundwort	Epiaire des bois	Wald-Ziest
Stellaria holostea	Greater Stitchwort	Stellaire holostée	Große Sternmiere
Tamus communis	Black Bryony	Herbe-aux-femmes-battues	Schmerwurz
Thalictrum aquilegifolium	Meadow Rue	Pigamon à feuilles d'ancolie	Akeleiblättrige Wiesenraute
Urtica dioica	Stinging Nettle	Grande ortie	Brennnessel

Trees and Bushes – Arbres et Arbustes – Bäume und Sträucher

Scientific name	English	Français	Deutsch
Pinaceae	**Pine Family**		**Kieferngewächse**
Pinus sylvestris	Pine	Pin sylvestre	Waldkiefer
Fagaceae	**Beech Family**		**Buchengewächse**
Fagus sylvatica	Common Beech, beech	Hêtre, Fayard	Rotbuche
Castanea sativa	Sweet Chestnut	Châtaignier	Edelkastanie (Marone)
Quercus ilex	Evergreen Oak	Chêne vert	Stein-Eiche
Quercus robur	Pendunculate Oak, oak	Chêne pédonculé	Stiel-Eiche
Quercus petraea	Sessile Oak	Chêne sessile	Trauben-Eiche
Quercus pubescens	White Oak	Chêne pubescent	Flaum-Eiche
Quercus rubra	Red Oak	Chêne rouge	Rot-Eiche
Tiliaceae	**Lime Family**		**Lindengewächse**
Tilia cordata	Small-leaved Lime	Tilleul à petites feuilles	Winter-Linde
Tilia platyphyllos	Large-leaved Lime	Tilleul à larges feuilles	Sommer-Linde
Ulmaceae	**Elm Family**		**Ulmengewächse**
Ulmus glabra	Wych Elm	Orme de montagne	Berg-Ulme
Ulmus minor	Small-leaved Elm	Orme champêtre	Feld-Ulme
Ulmus laevis	Fluttering Elm	Orme pédonculé	Flatter-Ulme
Salicaceae	**Willow Family**		**Weidengewächse**
Salix fragilis	Crack Willow	Saule fragile, saule cassant	Bruchweide
Salix alba	White Willow	Saule blanc	Silberweide
Salix cinerea	Grey Willow	Saule cendré	Grauweide
Salix purpurea	Purple Willow	Saule pourpre	Purpurweide
Populus balsamifera	Balsam Poplar	Peuplier baumier	Balsampappel
Populus alba	White Poplar	Peuplier blanc	Silberpappel
Populus nigra	Black Poplar	Peuplier noir	Schwarzpappel
Populus canescens	Grey Poplar	Grisard, peuplier gris	Graupappel
Populus tremula	American Aspen	Tremble	Zitterpappel
Populus X canadensis	Hybrid Black Poplar	Peuplier	Kanadische Pappel
Rosaceae	**Rose Family**		**Rosengewächse**
Prunus padus	Bird Cherry	Merisier à grappes	Traubenkirsche
Prunus spinosa	Blackthorn	Prunellier, épine noire	Schlehdorn
Prunus avium ssp. avium	Wild Cherry	Merisier, cerisier sauvage	Vogelkirsche
Sorbus aria	Whitebeam	Alisier blanc, Alouchier	Mehlbeere
Sorbus aucuparia	Rowan	Sorbier des oiseaux	Eberesche
Sorbus torminalis	Wild Service Tree	Alisier terminal	Elsbeere
Pyrus communis	Cultivated Pear	Poirier	Gartenbirne
Pyrus pyraster	Wild Pear	Poirier sauvage	Wildbirne
Malus sylvestris	Crab Apple	Pommier sauvage	Wildapfel
Crataegus monogyna	Hawthorn	Aubépine ou épine blanche à un style	Eingriffeliger Weißdorn

Crataegus laevigata	Midland Hawthorn	Aubépine ou épine blanche à deux styles	Zweigriffeliger Weißdorn
Fabaceae	**Pea Family**		**Schmetterlingsblütler**
Robinia pseudoacacia	Black Locust tree	Robinier faux acacia	Gew. Robinie, Falsche Akazie
Cornaceae	**Dogwood Familiy**		**Hartriegelgewächse**
Cornus sanguinea	Common dogwood	Cornouiller sanguin	Blutroter Hartriegel
Aquifoliaceae	**Holly Family**		**Stechpalmengewächse**
Ilex aquifolium	Common Holly	Houx	Stechpalme
Celastraceae	**Spindle Tree Family**		**Spindelbaumgewächse**
Euonymus europaeus	European Spindle	Fusain d'Europe	Europäisches Pfaffenhütchen
Hippocastanaceae	**Horse-Chestnut Family**		**Kastanien**
Aesculus hippocastanum	Horse Chestnut	Marronnier d'Inde	Roßkastanie
Aceraceae	**Maple Family**		**Ahorngewächse**
Acer pseudoplatanus	Sycamore Maple, sycamore	Erable sycomore	Bergahorn
Acer platanoides	Norway Maple	Erable plane	Spitzahorn
Acer campestre	Field Maple	Erable champêtre	Feldahorn
Acer negundo	Ash-leaved Maple	Erable à feuilles de frêne	Eschenblättriger Ahorn
Juglandaceae	**Walnut Family**		**Walnußgewächse**
Juglans regia	walnut	Noyer	Walnuß
Juglans nigra	Black Walnut	Noyer noir	Schwarznuß
Araliaceae	**Ivy Family**		**Efeugewächse**
Hedera helix	Common Ivy	Lierre grimpant	Gemeiner Efeu
Oleaceae	**Olive Family**		**Ölbaumgewächse**
Fraxinus excelsior	Common Ash, ash	Frêne commun	Gewöhnliche Esche
Fraxinus angustifolia	Narrow-leaved Ash	Frêne à feuilles étroites	Schmalblättrige Esche
Fraxinus pennsylvanica	Red/Green Ash	Frêne rouge ou frêne de Pensyl-vanie	Pennsylvanische Esche
Fraxinus ornus	Flowering Ash	Frêne à fleurs	Manna-(Blumen-)Esche

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