9 Summary[1]

Improving biological diversity in waters and floodplains

In their original state, watercourses and floodplains are very dynamic and species-rich biotopes. What remains of them is still characterized by a high degree of biodiversity today. Their functional capability for the nature and landscape balance has, however, been altered as a result of centuries of water use through various types of pollutants and serious structural impairments over great expanses. One of the objectives of the EC Water Framework Directive of 2000 (WFD) is to achieve good ecological and good chemical status or, in the case of heavily modified and artificial water bodies, good chemical status and good ecological potential for all surface waters by the year 2015. In addition to good water quality, semi-natural water structure with improved passability is strived for. Decisive criteria for assessing the ecological water status are, above all, water fauna and flora. The WFD demands that other European directives, such as the Birds Directive and the Habitats Directive, are taken into consideration to create the foundations for the formation of the European habitat system NATURA 2000. Therefore, water-dependent NATURA 2000 regions must also be included in implementation of the WFD. In future, when setting up the measures and management plans demanded by the WFD, the floodplains outside of NATURA 2000 regions could also be taken more into consideration and their significance for the status assessment newly weighted, since they decisively influence the status of all waters.

In a project completed in 2008, the DRL presented the concept of the radiating effect, which calls for an integrated ecological approach in the implementation of measures on watercourses. Its implementation can make a cost-efficient contribution to attaining good ecological status or good ecological potential.

In this project, the concept of the radiating effect was again taken up to supplement the concept of the terrestrial habitat system. In addition, we present the framework conditions for the implementation of a nationwide water-oriented habitat network are presented. Furthermore, examples of renaturation measures of various types of waters were evaluated as to their effects on the water structure and the structure of the floodplains and whether radiating effects were ascertainable. The radiating effect for the widespread water type 5 (siliceous highland streams rich in coarse materials) was quantified using the example of the macrozoobenthos. In a separate chapter an attempt was made to operationalize the radiating effect for practical water development planning with regard to attaining the objectives of the WFD. The aim was to derive development corridor widths using the example of the above-cited types of water.

A stocktaking of examples of habitats, species and groups of species in Germany's river watersheds and the creation of fact sheets for plant and animal species take the concepts of the "radiating effect" and "terrestrial habitat system" into account as the basis for future action in the formation of a nationwide water-oriented habitat system. In closing, recommendations for future planning measures were compiled, which serve towards the improvement of the ecological status or the creation of good ecological potential of modified watercourses and promote the formation of a functioning water-oriented habitat system.

Ecological, programmatic and legal prerequisites for development of the subject matter

The ecological concept of a "habitat system" encompasses the conservation, the development and the re-establishment of the spatial prerequisites and functional relationships in nature and the landscape with the objective of safeguarding animals, plants, their biocoenoses and biotopes for the long term. The spatial prerequisites refer to safeguarding and providing areas for a functionally connected "network," which includes landscape-typical biotopes and biotope complexes and counteracts the effects of spatial habitat fragmentation. The functional relationships in a landscape include all ecological processes that determine and influence the incidence, the distribution and the behaviour of biocoenoses of animal and plant species.

The concept of the radiating effect presumes that semi-natural segments of water (radiating sources) have a positive effect on the ecological status of neighbouring, less semi-natural segments in the upper or lower reaches (radiating pathway). This positive effect is the result of the active or passive dispersion of animals and plants with high dispersion potential. The range of the radiating effect or the length of the radiating pathways is, in cases of active migration, primarily dependent upon the activity patterns and the migration behaviour of the organisms in question and can be lengthened by means of stepping-stones. Habitat deficits (e.g. water storage areas, transverse structures, sedimentation of the riverbed) shorten or impair the radiating pathway. The radiating effect is significant for planning measures according to the WFD because the targeted protection, the development and the creation of radiating sources also help to improve the ecological status of neighbouring segments of water and if necessary supplemental measures are implemented on the radiating pathway (e.g. removal of migration barriers, creation of stepping-stones). On principle, the concept of the radiating effect reveals that individual measures should not be considered in isolation and independent of one another, but rather that the ecological functions and mechanisms of the water must be taken into account.

The radiating effect along the radiating pathway can be supported by longitudinal as well as lateral connectivity in the watercourse continuum, by diverse and largely continuous elements of the shore structure such as woody plants and tall herbs, by the creation or the initiation of type-specific diversity of substrates and microbiotopes with stepping-stone functions, so that this concept can be used alongside of that for the habitat system to form a water-oriented system.

International, European and national legal provisions – such as the RAMSAR Convention, Bonn Convention, the Birds Directive, Habitats Directive, Water Framework Directive and Floods Directive – create the foundations for the improvement of water quality and the passability of watercourses as well as for the formation of water-oriented habitat systems.

Programmatic foundations, such as the National Strategy on Biological Diversity and the Sustainability Strategy of Germany's Federal government, offer support in the form of requirements, scales and time schedules.

National law provides further possibilities for attaining the above objectives, for example

1 Translation: Faith Gibson-Tegethoff.

the Federal Nature Conservation Act, the principles of which contain statements that can be drawn on leading to improvement of the ecological status of surface waters and to the formation of a water-oriented habitat system and which promotes the formation of a nationwide habitat system. The principles of water management laid down in the Federal Water Act are aligned to comprehensive water protection according to ecological fundamentals. Flood control is implemented through existing laws such as the Federal Water Act, Federal Regional Planning Act, Federal Building Code and others. Accordingly, surface waters must be managed in such a way that floods are deterred, that ensure harmless water drainage and that the emergence of flood damages are prevented. Another important legal instrument for the formation of a water-oriented habitat system is the Federal Building Code: municipal land-use plans should contribute to safeguarding a humane environment and protect and develop natural resources.

In spite of the comparatively good programmatic and legal foundations, Germany is still far from attaining the objectives of the WFD and nature conservation. The causes for the deficiencies in enforcement are, for example, the considerations within a law and considerations of the objectives of different laws, the demands of the various types of land use, the cooperation between participating agencies due to a lack of personnel and limited funds, the long-term nature of ecological processes, the lack of area availability and the structure of ownership on watercourses.

Examination and evaluation of selected renaturation examples of representative watercourse types of German river watersheds

Based on 37 the study of renaturation measures of the watercourse types "siliceous highland rivers" (types 9 and 9.2) and "medium-large lowland rivers" (types 12, 15 and 17), the extent to which the measures have a positive effect on the structure of the waters was examined. The substrate diversity within the waters and the number of floodplain elements were considered. The renaturation measures resulted in minor improvement to substrate diversity in watercourses and in distinct improvement in the floodplain structure. This increase in habitat diversity improved the conditions for colonization. In contrast to the macrozoobenthos, the organism group macrophytes and fish reacted more positively to the studied renaturation measures on watercourses. The lack of high quality habitats (deadwood, gravel), the impacts of past or current water pollution and the strategy of dispersion are assumedly the causes for the weak reaction of the macrozoobenthos. The improvement of the floodplain structure caused an increase in the diversity of vegetation and, for example, in ground beetle species.

Renaturalized watercourse segments can act both as radiating sources to link habitats and as stepping-stones for comprehensive implementation of a nationwide habitat system. Possible radiating effects must be taken into consideration in evaluating the success of renaturation measures, for newly created structures – depending on the respective group of organisms and type of water – can only be rapidly repopulated if colonization sources are close by. Renaturalized watercourse segments can serve as stepping-stones or even as radiating sources for fast-reacting groups of organisms (e.g. fish). For other groups (in particular macrozoobenthos) the renaturalized sections can be seen more as the target area of the radiating effect, whereby in degraded floodplains colonization from outside the area must be awaited. For future renaturation measures extensive alterations in the composition of the habitat on the riverbed should be aimed at to reach characteristics conforming to the overall concept. This applies in particular to "high-quality" habitats populated by many specialist species, e.g. deadwood or gravel in lowland waters.

The significance of the radiating effect for the formation of a habitat system on watercourses

Using statistical methods it was examined whether semi-natural water segments (radiating sources) have a positive effect on the ecological status of neighbouring, less semi-natural segments (radiating pathway), what factors this radiating effect depend on and the necessary features of the radiating source and radiating pathway.

For the biological quality component of macrozoobenthos and watercourse type 5 (siliceous highland streams rich in coarse materials), it was ascertained that in a habitat system on watercourses radiating sources can be linked in direction of water flow, but not against the direction of water flow. The radiating sources should not be further than approx. 2.5 km from one another. Even beyond linking the radiating sources, the creation of radiating sources and of a habitat system on watercourses can lead to a distinct ecological upgrade in the radiating pathways lying between the radiating sources. This applies in particular to radiating pathways that possess certain minimum habitat characteristics. For those radiating pathways featuring relevant stepping-stones the radiating effect has similarly high significance as renaturation measures for improving local habitat quality. Water segments in upper reaches with a Habitat Metric[1] of 1-2 function as radiating sources; only these semi-natural segments possess a distinct radiating effect. In order to function as upgradable radiating pathways in a habitat system, water segments need to exhibit minimum habitat characteristics (Habitat Metric 3-5). The negative effect of strongly degraded segments in upper reaches (Habitat Metric 6-7) is at least as significant as the radiating effect. When creating a habitat system on watercourses these negative effects should therefore also be taken into consideration.

The question of what processes the influence of neighbouring water segments is based cannot be conclusively clarified using statistical methods: whether the above-described influence of the upper reaches (radiating effect) really is the result of a biological effect (e.g. drift of organisms) or of an abiotic effect (e.g. input of fine substrate in the upper reaches and sedimentation at the sample sites) requires further investigation. However, the results suggest that the influence of the upper reaches is at least in part a biological effect, i.e. a radiating effect as defined by the DRL (2008).

Insofar as the above-detected radiating effect of the upper reaches is based on a biological effect, the passive migration of macrozoobenthos organisms through drift is probably the most important dispersion mechanism. Periodical drift depends on the habitat conditions or the colonization density, catastrophe drift depends on the force of flooding and the existing refuge habitats, i.e. primarily from the drainage system, the slope, the size of the water body and the interstice (system of gravel fissures). Therefore, the results are best transferable to the watercourse types (WCT) similar to watercourse type 5, WCT 7 (carbonaceous highland streams rich in coarse materials), WCT 16 (gravelly lowland streams) with a comparatively steep valley floor incline, WCT 3.1 (young moraine watercourses of the alpine foothills, subtype 3.1 brooks) with comparatively low drainage fluctuation

1 The Habitat Metric was calculated from selected water structure parameters and describes the habitat quality of a water body specifically for macrozoobenthos. The values range from 1 (semi-natural) to 7 (heavily modified).

and with restrictions to WCT 5.1 (siliceous highland streams rich in fine materials) with a comparatively steep valley floor incline and larger drainage fluctuation. In lowland watercourse types, due to the lesser flow speed, there is possibly greater active migration against the direction of water flow. It is, however, doubtful whether active migration from semi-natural segments in the lower reaches (radiating sources) is sufficient to distinctly upgrade the local ecological status on less semi-natural water segments further upstream (upgradable radiating pathways with stepping-stones).

Since the radiating effect for macrozoobenthos probably is based chiefly on the passive drift of organisms, for this group the radiating pathway must chiefly be passable, i.e. not backed up, to attain linking effects. By contrast to the macrozoobenthos, fish actively spread both in the direction of water flow and against the direction of water flow. Since they consume energy during active migration against the water flow, small refuge and resting areas may play a major role for fish, so that the range of the radiating effect for the fish can possibly be distinctly increased by offering them resting areas along the migration corridor.

The radiating effect cannot be considered in isolation, but must always be seen in its connections with other important influencing factors. For instance, it is apparently also dependent on the local habitat quality and does not lead to any distinct upgrade of strongly degraded water segments. In addition, for the creation of a habitat system of course the general status of the watershed and the (re-) colonization potential over a large area must also be taken into consideration.

Operationalization of migration effects on the ecological water status of siliceous highland streams rich in coarse materials (watercourse type 5) taking habitat system aspects into consideration

The radiating effect or the effect of migrations in general were operationalized for practical water development plans to attain good ecological status according to the WFD.

Based on the findings referring to the migration effects of macrozoobenthos in watercourses of type 5 (siliceous highland streams rich in coarse materials), a rule system was developed to estimate the ecological status of partial segments and for the aggregation of this segmental evaluation to a representative aggregate value on the water body level. Initially, this can only be applied to this biological quality component and exclusively for this water type. It could be demonstrated that for this watercourse type, occurring only in comparatively narrow valleys, one can assume that the attainment of good ecological status of whole bodies of water is also accompanied by an effective habitat system for strengthening non-aquatic species over a wide area of the water-dependent biotope.

Following an in-depth description of the three-dimensional depiction of migration effects (whereby one has to differentiate between initial and permanent as well as positive and negative migration effects), the derivation and description of the rule system to evaluation the potential ecological status categories of partial segments of a body of water on the basis of habitat qualities (5-stage evaluation) and migration effects (habitat quality + permanent migration effect = potential ecological status) is presented.

Using aggregation one can derive a representative overall evaluation of the ecological status of entire bodies of water of rule-based potential ecological status categories of partial segments. Due to the connections between the course development, area required and habitat qualities of macrozoobenthos using the example of watercourse type 5 (siliceous highland streams rich in coarse materials) the necessary development corridor widths can be deduced.

In this way, the expected habitat suitability for macrozoobenthos can be derived from the area potentials for independently dynamic developments available from each water segment. These can then be added to the rule system to evaluate the potential ecological status category of partial segments taking the radiating effect into consideration. Using the aggregation rule to ascertain a representative evaluation of the potential ecological status of the entire body of water one can assess how much water development area is ultimately needed in which segment in order to achieve good ecological status overall.

Stocktaking: biotopes, species and groups of species in Germany's river watersheds

The stocktaking of existing data on the river/floodplain habitats is based on the Red Data Book of Biotopes in Germany[1]. In the biotope type group "watercourses" 22% of the biotope types are threatened by complete destruction (category 1), 37% are heavily endangered (category 2), 22% are endangered (category 3) and 19% cannot be categorized due to a lack of data. The continued existence of all but three of the 52 biotope types and biotope type groups, the watercourses with their floodplains, are threatened. Of these, the existence of three-fourths of the biotope types (29) is dropping. A river/floodplain habitat system would offer the possibility to safeguard the existence of the 52 biotope types described and hence 19 biotope types from the Habitats Directive.

In addition, plant and animal species from the river/floodplain biocoenosis were chosen that demonstrate different biotope demands and dispersion strategies and, as a whole, make use of a broad spectrum of ecological niches. The species were presented in fact sheets citing their protection status, descriptions of their habitats, their present distribution and their manner of dispersion and reproduction. In closing the relevance of a watercourse habitat system, including its floodplains (longitudinal and lateral), for the population and dispersion of each species is explained.

An attempt was made to extract the specific demands of the respective species on a river/floodplain habitat system. For instance, certain ground beetle species demand a certain quality of structures (dry gravel banks with large interstice, loam, sand or deadwood islands) and often possess an indicator function for the quality of this minor structure, while for many bird species the complexity of the system is the primary factor.

The 51 selected plants (water plants and pioneer species, herbage and trees) and animals (mammals, birds, amphibians, reptiles, fish, butterflies, caddisflies, ground beetles, grasshoppers, dragonflies, mayflies, crustaceans, molluscs) are examples of the great species diversity typical of river beds. These also include neobiota (non-indigenous and/or introduced species), which can deal well with modified waters and compete with indigenous species in part because of their size or their dispersion speed.

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1 RIECKEN, U.; FINCK, P.; RATHS, U.; SCHRÖDER, E.; SSYMANK, A., in collaboration with HEINZEL, K.; SCHLUMPRECHT, H.; BOEDEKER, D.; KRAUSE, J.; RACHOR, E. & ZETTLER, M. L. (2006): Rote Liste der gefährdeten Biotoptypen Deutschlands. Second updated version. - Bundesamt für Naturschutz (editor) Bonn, Naturschutz und Biologische Vielfalt 34, 318 pp.

Conclusions and recommendations

In order to improve the unsatisfactory ecological status of watercourses and their floodplains and to achieve the European and national objectives for water and nature conservation, there are, on principle, two options: either the water is "left to its own resources" (desist from any maintenance and management) or a favourable development is initiated through more or less profound reshaping. Both options should be considered and, if needed, also be combined, taking into account the diverse demands and uses of the waters and their surroundings, for these are incorporated in a complex system of rights, permissions and tolerances, multifaceted interests of associations, lobbies and individuals and not least social life on the water.

A watercourse should be able to compensate for disruptions, for example by construction interventions or discharges, up to a small extent (elasticity). Uses should be sustainable in order to ensure the water a high degree of naturalness and functionality.

Based on this situation, improvement of the ecological status and of the ecological potential of watercourses can only be achieved if they are not merely enhanced in sections, but seen as a whole as the WFD specifies. The DRL presents a model that not only links natural biotopes as islands to a functional overall region or habitat system, but also involves cultivated biotopes with habitat or system functions for the indigenous animal and plant world.

A river/floodplain habitat system encompasses the aquatic and the amphibian and terrestrial areas, thus bodies of water, the shore area and floodplain. The habitat system model has a lateral effect – from water to the land – and a longitudinal effect along the waterway in the recent floodplain. Through this, natural and semi-natural biotopes can evolve into core areas of the habitat system as long as sufficient space for water development and a sufficiently large shore and floodplain area are available.

To set up and develop a river/floodplain habitat system the concepts of the terrestrial habitat system and the aquatic radiating effect can be combined. The radiating effect approach enables development of targeted areas (radiating sources), which also contribute to the ecological enhancement of other areas of deficient habitat quality due to active or passive dispersion of organisms. The distances both between semi-natural floodplain biotopes on land and semi-natural areas in watercourses that can serve as terrestrial core biotopes or aquatic radiating sources must be bridgeable for the respective organisms in order to enable and promote exchange. It is important for river/floodplain biocoenosis that core biotopes and terrestrial stepping-stones are situated directly at aquatic radiating sources in order to optimize the lateral connection of the water and floodplain.

An abundance of measures lend themselves to fulfilling the prerequisites cited here in the various areas with regard to the biotopes of the plants and animals and to uses. The special importance of neobiota, the important aspect of involving the public, the consideration of the recommended measures in planning and financing and the residual need for research, especially for lowland waters are pointed out.

Conclusion:

The concept of the radiating effect presented by the DRL to supplement the habitat system concept (DRL 2008) was at first considered too scientific and not feasible for operationalization by some critics. Moreover, its proposed measures were based only on selective solutions in order to accommodate land users and also to lower costs. The further developed study approaches presented here as well as the results of the Eifel-Rur project now provide proof of the possibility of operationalizing the radiating effect concept. The model presented by the DRL is aligned to an integrated approach to watercourse watersheds and enables its implementation nationwide. The Water Framework Directive in conjunction with the Bird Directive, Habitats Directive and Floods Directive gives new weight to ecological improvement of the status of watercourses and the formation of a water-oriented habitat system in respect of land users and land-use planners (shipping, fishing industry, flood control, agriculture and forestry as well as regional planning). This opportunity needs to be taken advantage of, integrating available experiences and new findings optimally and with regard to efficiency; the project aims to make a contribution to this.