IRMA-SPONGE project 11

DEVELOPMENT AND APPLICATION OF BIO-SAFE, A POLICY AND LEGISLATION BASED MODEL FOR THE ASSESSMENT OF IMPACTS OF FLOOD PREVENTION MEASURES ON BIODIVERSITY IN RIVER BASINS

Executive summary, December 19, 2001

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Table of contents

Executive summary

Keywords: policy and legislation based biodiversity assessment, flood risk reduction, floodplains, Interreg Rhine Meuse Activities, IRMA-SPONGE, nature conservation policy, riverine ecosystems

Abstract

Within the framework of IRMA-SPONGE, a transnational version of the model BIO-SAFE (Spreadsheet Application For Evaluation of BIOdiversity) for the rivers Rhine and Meuse was developed. The model was specifically designed for *policy and legislation based* impact assessment of flood risk reduction measures on biodiversity in floodplains. BIO-SAFE is an assessment model that quantifies the policy and legislation status of species in river basins for several taxonomic groups. The model uses data on presence of species and ecotopes. Results show that the BIO-SAFE method enables the user to express politically and legally based biodiversity values in quantitative terms and to compare biodiversity values for various taxonomic groups, landscape-ecological units (e.g. ecotopes) and physical planning scenarios. BIO-SAFE gives information regarding the degree to which floodplain designs, observed or predicted trends of floodplain developments or actual values meet goals set in (inter)national agreements. Assessments with BIO-SAFE, in an early stage of the planning process, of actual situations and different scenarios for an area can help direct the planning process in the stage where this is still possible. Because of its policy-based character, BIO-SAFE yields complementary information to more established ecological biodiversity indices and to single-species habitat models and ecological network analysis.

Flood defence measures can lead to an increase of policy and legislation based biodiversity values if already very valuable ecotopes are conserved and an increase of diversity of ecotopes is realised. Flood defence measures can also endanger these values. In order to achieve optimal results regarding the attuning of conservation and development of biodiversity values on the one hand and flood defence measures on the other, it is recommended to aim at a balance between creating space in width and creating space in the depth. Uniform solutions must be avoided, a diversity of influence of river dynamics and intact wet-dry gradients in floodplains should be aimed at. Lowering floodplains is best coupled with measures that enlarge the flooding area.

1 Background and scope

In the coming decades the physical structure of the river basins of north-western Europe will undergo significant changes as a result of large-scale reconstruction measures for flood defence that are currently planned. These measures include lowering of the riverbed and floodplains, removal of raised areas, river dike diversion and construction of retention basins. The measures aim at increasing the water retaining capacity, retention and discharge capacity of the catchments to prevent future damage from flooding while integrating ecological improvement and to support economical development by improvement of navigation and creating new infrastructure. The measures will have far-reaching impacts on several functions and characteristics of river basins, among which biodiversity. Flood defence measures offer opportunities to increase biodiversity in a sustainable way, but can also seriously endanger present natural values and biodiversity potential of river ecosystems. Methods are needed to assess these opportunities, taking into account policy and legislation concerning biodiversity.

1.1 Framework

The INTERREG IIC initiative of the European Union supports activities regarding flood risk reduction. The operational programme IRMA (Interreg Rhine Meuse Activities) contributes to implementation of specific measures in the field of flood risk reduction along the Rhine and Meuse. It is imperative that the consequences of the IRMA joint operational programme are prepared and evaluated on a sound scientific basis. This idea was the starting point for the umbrella project IRMA-SPONGE: a cluster of thirteen innovative, mutually consistent and complementary research projects on flood risk assessment and flood defence measures. Hydraulic effects and ecological consequences of these measures must be evaluated in a way that ensures attuning of policy goals concerning flood risk reduction and nature conservation. The IRMA-SPONGE project BIO-SAFE concerns this attuning and cross evaluation of river management strategies.

This paper summarises the construction of a transnational version of the model BIO-SAFE (Spreadsheet Application For Evaluation of BIOdiversity) for the rivers Rhine and Meuse, specifically designed for impact assessment of flood risk reduction measures on biodiversity in floodplains (De Nooij *et al.*, 2001). BIO-SAFE is a policy and legislation based assessment model that quantifies species biodiversity values in river basins for several taxonomic groups. The criteria used for quantification of the nature conservation policy status of species are (sub)national Red Lists, the EU Habitats Directive, the EU Birds Directive, the Bonn Convention and the Bern Convention. These criteria are well established documents stating which species are to be protected, deserve special attention or have difficulties maintaining healthy populations. The model uses data on presence of species and ecotopes in floodplain areas.

1.2 Policy and legislation based biodiversity assessment

Conservation of biodiversity is one of the key issues of world-wide environmental policy. According to the Convention on Biological Diversity, which resulted from the 1992 Rio “Earth Summit”, biodiversity is defined as the variability among living organisms including ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Within the context of the Convention, biodiversity has many dimensions among which social, medical, economic and political. For nature conservation purposes, the broad definition of biodiversity leads to problems in making this concept operational in every day practice.

Biodiversity assessment can be based on purely ecological criteria (e.g. rarity or naturalness) or on policy based and/or legal criteria concerning the protection of species and their habitats. Recently, the need for policy based biodiversity indicators in addition to biological indicators is acknowledged. Policy based biodiversity indicators should be regarded as tools for estimating impacts of e.g. landscape design on biodiversity with the emphasis on recognising policy goals concerning biodiversity and on simplicity. These tools can be models for impact assessment and for measuring progress towards meeting the obligations of ratified conventions. However, indicators for scientific and for policy purposes must be related. Two independent sets may end up with "nonsense" indicators used by policy makers only. Indicators for policy purposes must be based on scientific evidence and this is what policy makers require from scientists. The challenge for scientists is therefore twofold:
1. Deal with the complex issue of biodiversity in a scientifically sound way.
2. Translate the findings into messages and indicators which can be understood by policy makers and stakeholders.

1.3 Project goals

The goal of the BIO-SAFE project is the development and application of a model for policy and legislation based assessment of impacts of flood risk reduction measures on biodiversity in river-floodplain ecosystems of the rivers Rhine and Meuse, suitable for integration in a comprehensive decision support system (DSS) for large rivers.

The model development is aimed at providing an instrument for attuning of flood risk reduction measures with policy and legislation concerning protection of biodiversity and ecological improvement. The project contributes to the further elaboration of an existing Spreadsheet Application For Evaluation of BIOdiversity (BIO-SAFE), applicable to floodplains of the rivers Rhine and Meuse in the Netherlands (Lenders *et al.*, 2001), into a transnational river management tool suitable for large rivers in the Netherlands, Germany, France and Belgium. BIO-SAFE gives information regarding the degree to which floodplain designs or actual values meet goals set in (international) agreements on biodiversity. BIO-SAFE is meant to be complementary with ecological network analysis on the population level and supplementary to detailed single species models for impact assessment.

1.4 Conceptual framework

The conceptual framework of BIO-SAFE (figure 1.1) concerns the nature conservation policy and legislation aspects of biodiversity on the biological level of species and the spatial levels of scale relevant to their habitats in floodplains. The key issue is the confrontation of flood risk reduction measures with policy and legislation concerning protection of biodiversity and ecological improvement. The basis of BIO-SAFE is therefore formed by the (inter)national conservation policy and legal protection status of species characteristic for river ecosystems (right hand part of figure 1.1). By describing the species habitat demands using a landscape ecological classification typology, values can also be assigned to patches in the floodplain, e.g. ecotopes or other landscape-ecological units, thus allowing the user of BIO-SAFE to valuate these landscape-ecological units or patches. This linkage of species to specific landscape-ecological units (e.g. ecotopes) is also the basis for valuation of the biodiversity potential in a particular area. Within the framework described here the concept of ecotopes is used (see section 2).

Ecotopes are landscape ecological units with which habitats of (protected) species can be described. From this relation a potential biodiversity value for each ecotope can be derived. Flood risk reduction measures alter the physical and biological conditions of a floodplain and, as a result, the potential value of that floodplain to flora and fauna (left hand part of figure 1.1). Comparison of the situation before reconstruction or a scenario for autonomous development (reference scenario), and the target situation or scenarios described in the reconstruction design (potential situations) results in an assessment of impacts of reconstruction on biodiversity.

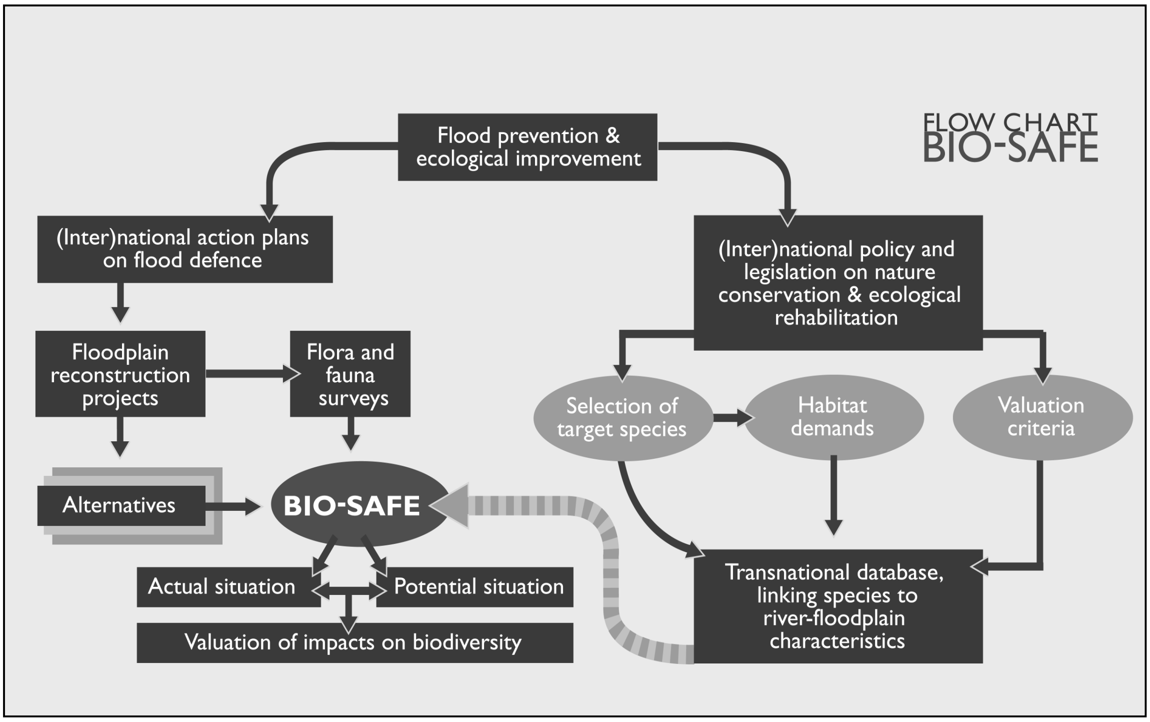


Figure 1.1. Conceptual framework of BIO-SAFE (Lenders *et al.*, 2001).

1.5 IRMA-SPONGE links

An important aspect of this study, carried out within the framework of IRMA-SPONGE, is linkage between the projects that are part of this umbrella-project. Cross-links contribute to the coherence of the IRMA-SPONGE research programme and can stimulate the separate projects as a result of exchange of data and knowledge. Links were established with the projects Cyclic Rejuvenation of Floodplains and INTERMEUSE. These links were made operational on four levels:

a. Required base materials (i.e. field data, maps, tools) are exchanged between the projects.
b. Methods (i.e. landscape ecological classification, species characterisation and mapping) are attuned as much as possible.
c. Common case studies with the project INTERMEUSE and the project Cyclic Rejuvenation of Floodplains are carried out.
d. Project members mutually participate in the advisory committees and meetings of the projects and results are communicated to other IRMA-SPONGE projects.

Co-operation consisted of common case studies for which area information and results were exchanged and combined. BIO-SAFE application within the partner projects constituted an additional analysis of scenarios and/or a tool to be incorporated in the assessment strategy. Cyclic Rejuvenation of Floodplains and INTERMEUSE provided extra case-study material and data sources for BIO-SAFE.

1.6 Study area

The study area (see figure 1.2) comprised the river basins of Rhine and Meuse. From this area, the mountainous parts of the catchments and the estuarine zones are excluded. This delineation is used because the measures aimed at flood defence taken in mountainous parts and the estuarine zones of the catchments are very different from measures taken in the rest of the catchment. BIO-SAFE was elaborated for riverine area's of Rhine and Meuse. Riverine areas are defined as: the main branch of the river and its floodplains. Floodplains are the areas between the winter dikes (including the dikes) or, when dikes are absent, the area flooded during the maximum high water level.

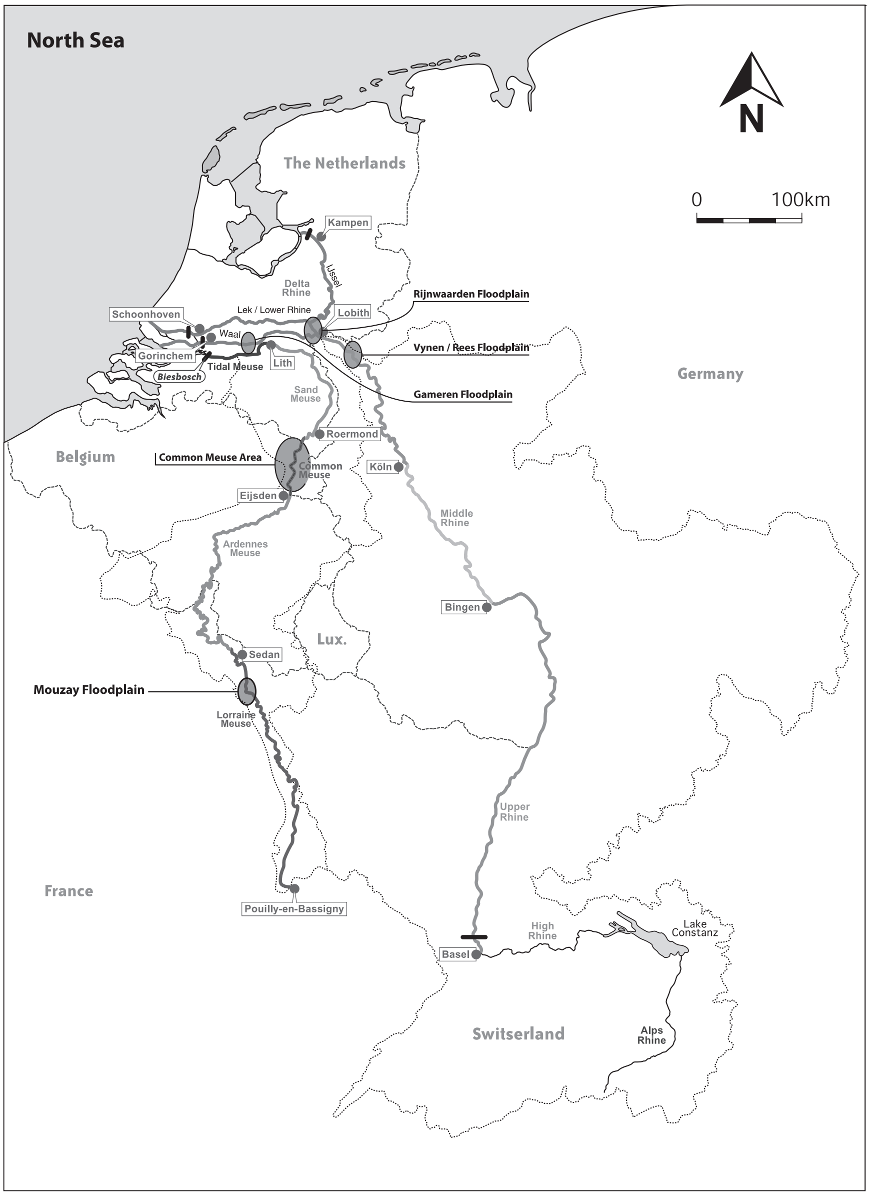


Figure 1.2. Catchments of Rhine and Meuse (**I** : longitudinal delineation of the study area, shaded areas: locations of the case study areas).

2 Components of BIO-SAFE

BIO-SAFE consists of a database on politically and/or legally relevant, river characteristic, flora and fauna species, a transnational ecotope typology for the rivers Rhine and Meuse and a weighted set of policy and legislation based valuation criteria for biodiversity. Their habitat demands were linked to ecotopes on four levels of scale (i.e. 1:100,000, 1:50,000, 1:25,000 and 1:10,000). This allows to up and down-scale input data as well as output data. The policy status of the species selected was quantified. The research activities were structured as follows:
1. Construction of a database on flora and fauna species for each country.
2. Development of a transnational ecotope typology.
3. Determination of policy based valuation criteria for biodiversity.
4. Implementation of the model in a user-friendly spreadsheet environment.
5. Application of BIO-SAFE in case-studies.

2.1 Database on riverine species

Species to be selected for the database had to be:
1. Relevant in terms of policy and/or legislation, according to instruments for species conservation that are well established.
2. Indigenous to and characteristic of riverine areas in north-western Europe.

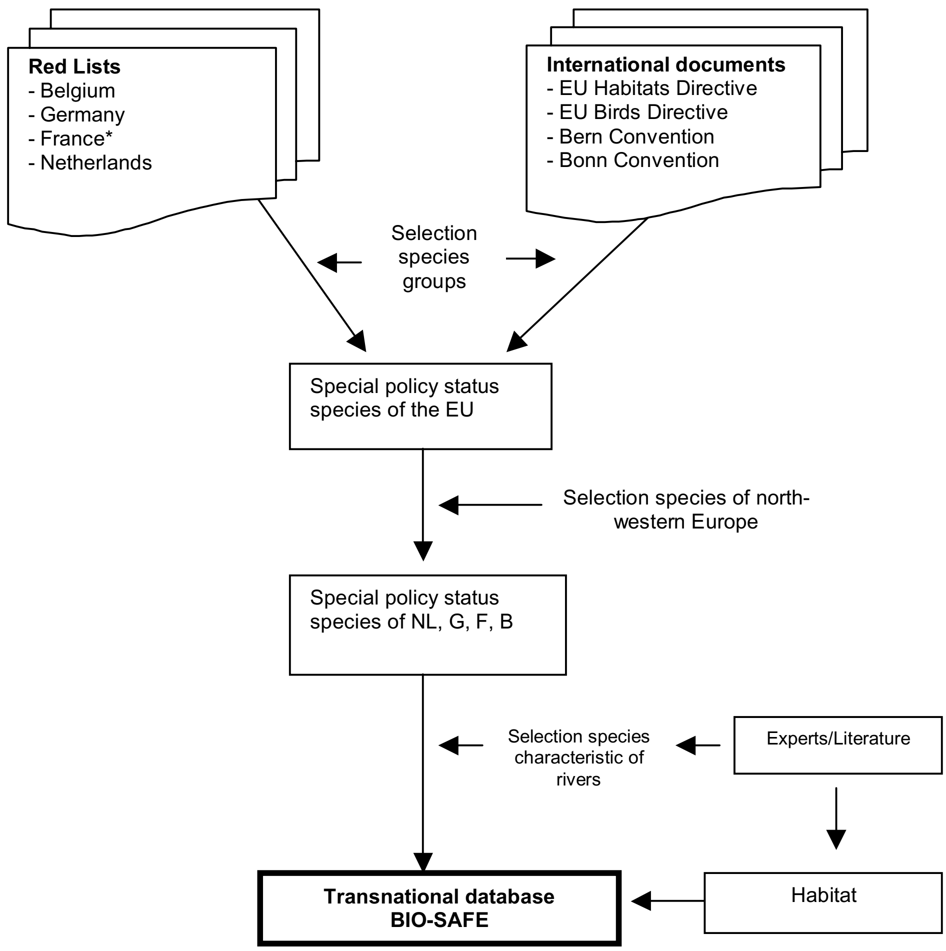


Figure 2.1. Schematic representation of the database construction (* also regional protection).

Species groups that were taken into account are: higher plants, birds, mammals, reptiles, amphibians, fish, butterflies, dragonflies and damselflies. The process of species selection is represented by figure 2.1. Determination of whether a species is characteristic for river ecosystems was based on: 1) expert judgement (the methodology for selection of river characteristic species involved many experts from the Netherlands, Germany, France and Belgium); 2) ecological literature describing species characteristics and habitats and 3) historical-geographic distribution maps of species.

The end results of the species selection process are given in table 2.1. The transnational database consists of 257, 171, 160 and 173 species for the Netherlands, Germany, France and Belgium, respectively. The total number of different species is 486. In many cases there is an overlap between the countries regarding the species selected.

Table 2.1. Numbers of river characteristic, special policy status species, per taxonomic group, per country.

Taxon	End selection			
	NL	G	F	B
Higher plants	136	60	12	90
Birds	60	58	113	38
Reptiles & Amphibians	9	11	7	4
Mammals	9	11	7	5
Fish	20	17	10	16
Butterflies	17	9	7	15
Dragon- and Damselflies	6	5	4	5
Total	257	171	160	173

2.2 Transnational ecotope typology for river systems

In order to define and value landscape ecological units within the floodplain and river, and to determine the potential value of a given area, a methodology for landscape ecological classification, an ecotope typology, is required. The typology is used to link species to landscape ecological characteristics of river-floodplain systems and forms the basis for comparing different scenarios or alternatives for future development of a floodplain area. Various typologies from Belgium, France, Germany and the Netherlands were evaluated. A selection of compatible and transnationally applicable typologies was used to construct the BIO-SAFE typology. The typology also serves as a mapping legend and was made compatible with generally accepted and used typologies in river management and typologies of IRMA SPONGE projects Cyclic Rejuvenation of Floodplains and INTERMEUSE.

The BIO-SAFE transnational ecotope typology for river systems is presented in table 2.2. The typology consists of five layers, each applicable to a different level of scale:

1. CORINE land cover typology, level 3 (1:100,000);
2. ICPR biotope typology, (1:50,000);
3. River Ecotope System, level 1 (1:25,000);
4. River Ecotope System, level 2 (1:10,000);
5. Plant Sociological Units (1:5,000), (not given in table 2.2, for level 5 see final report De Nooij *et al.*, 2001).

Table 2.2. BIO-SAFE transnational ecotope typology for river systems.

Level 1	Level 2	Level 3	Level 4
CORINE level 3 1: 100,000	**Biotope typology ICPR** 1: 50,000	**River Ecotope System (RES)** 1:25,000	1:10,000
S Stream courses	S1 Aquatic parts of stream courses	Sd Deep summer bed	Sd Deep summer bed
		Ss Shallow summer bed	Ss-1 Gravel bed
			Ss-2 Sand bed
		Ws Side channel	Ws-1 Sandy side channel
			Ws-2 Clayey side channel
			Ws-3 Gravel side channel
	S2 Amphibian parts of stream courses	Sb Beach, Bank, Bar	Sb-1 Gravel
			Sb-2 Sand
			Sb-3 Clay[1]
			Sb-4 Eroding steep bank
			Sb-5 Groin, quay, stone bank
W Water bodies	W1 Floodplain waters	Wf Floodplain channel	Wf-1 Semi-connected floodplain channel
			Wf-2 Isolated floodplain channel [2,3]
			Wf-3 Stagnant floodplain channel [2,3]
			Wf-4 Seepage floodplain channel [2,3]
			Wf-5 Floodplain Brook
		Wl Lake	Wl-1 Connected lake
			Wl-2 Isolated lake
			Wl-3 Small deep lake, e.g. Dike breach scouring hole
M Inland marshes	M1 Marsh	Mh Herbaceous marsh	Mh-1 Rough marsh
			Mh-2 Reed marsh
			Mh-3 Seepage marsh
D Dunes and gravel deposits	D1 Dry pioneer situations (wood-free biotopes)	Lh-1 River dune	Lh-1 River dune
		Lh-5 Gravel deposit	Lh-5 Gravel deposit
N Natural grassland/ pastures	N1 Moist floodplain grassland	Mg Marsh grassland	Mg-1 Rich marsh grassland
			Mg-2 Marshy production grassland
		Fg Moist grassland	Fg-1 Rich floodplain grassland
			Fg-2 Floodplain hayfield
		Fh Herbaceous moist floodplain	Fh Herbaceous moist floodplain
	N2 Dry wood-free biotopes (including dikes)	Lg Levee pastures	Lg-1 Natural levee pasture
			Lg-2 Hay land
			Lg-3 Production grassland
		Lh Herbaceous levee or dike	Lh-2 Rough levee or dike
			Lh-3 Arable Levee
			Lh-4 Built up/paved levee or dike
		Hg High-water-free grassland	Hg-1 Poor grassland
			Hg-2 Rich grassland
			Hg-3 High-water-free production grassland
		Hh High-water-free herbaceous area	Hh-1 High-water-free rough area
			Hh-2 Arable land
			Hh-3 Built up/paved land

Table 2.2 (continued). BIO-SAFE transnational ecotope typology for river systems.

Level 1	Level 2	Level 3	Level 4
CORINE level 3 1: 100,000	**Biotope typology ICPR** 1: 50,000	**River Ecotope System (RES)** 1:25,000	1:10,000
T Transitional woodland/shrubs	T1 Shrubs (woodland fringes)	T1-F Shrubs in floodplain	Ff-2 Hardwood shrubs
			Ff-4 Softwood shrubs
			Mf-3 Marshy softwood shrubs
		T1-L Shrubs on levee	Lf-2 Hardwood shrubs on levee
			Lf-4 Softwood shrubs on levee
B Broad-leaved forest (deciduous and mixed forest)	B1 Dry forested biotopes	Lf Forested levee	Lf-1 Hardwood forest on levee
			Lf -3 Softwood forest on levee
			Lf -5 Production forest on levee
		Hf High-water-free forested area	Hf-1 High-water-free forest
			Hf-2 High-water-free shrubs
			Hf-3 High-water-free production forest *(occasionally coniferous forest)*
	B2 Softwood alluvial forest	B2 Softwood alluvial forest	Ff-3 Softwood forest
			Ff-6 Softwood production forest
			Mf-2 Marshy softwood forest
	B3 Hardwood alluvial forest	B3 Hardwood alluvial forest	Ff-1 Hardwood forest
			Ff-5 Hardwood production forest
			Mf-1 Moist hardwood forest
	B4 Other characteristic forested biotopes in floodplains	B4 Other characteristic forested biotopes in floodplains	B4-1 Coppice wood with autochthone species
			B4-2 Willow pollards
			B4-3 Extensively used orchards
			Mf-4 Carr wood

1: Low dynamic banks, **2:** Oxbow lakes, **3:** Clay pits.
Legend level 1&2: S: Stream course, H: High-water-free, W: Water, L: Levees, M: Marsh, F: Floodplain, D: Dunes/deposits, S: Summer bed, N: Natural grasslands, W: Water, T: Transitional, M: Marsh, B: Broad leaved forest.
Legend level 3&4: s: side channel/shallow bed, b: bare, l: lake, h: herbaceous rough vegetation, g: grassland, f: forest.

2.3 Policy and legislation based valuation of biodiversity

Quantification of species policy status was based on policy instruments that are considered indicators for the status of the species selected in policy and legislation (valuation criteria). The criteria chosen for valuation were: Red Lists of the Netherlands, Germany, France and Belgium, the EU Habitats Directive, the EU Birds Directive, the Bonn Convention and the Bern Convention. In France also regional species protection was used. In order to express politically and legally based biodiversity values in quantitative terms and to compare biodiversity values for various species, relative weights were assigned to the conservation instruments (see figure 2.3). These weights were given on the basis of expert judgement by an international expert panel. The results of the distribution of weights are presented in table 2.3.

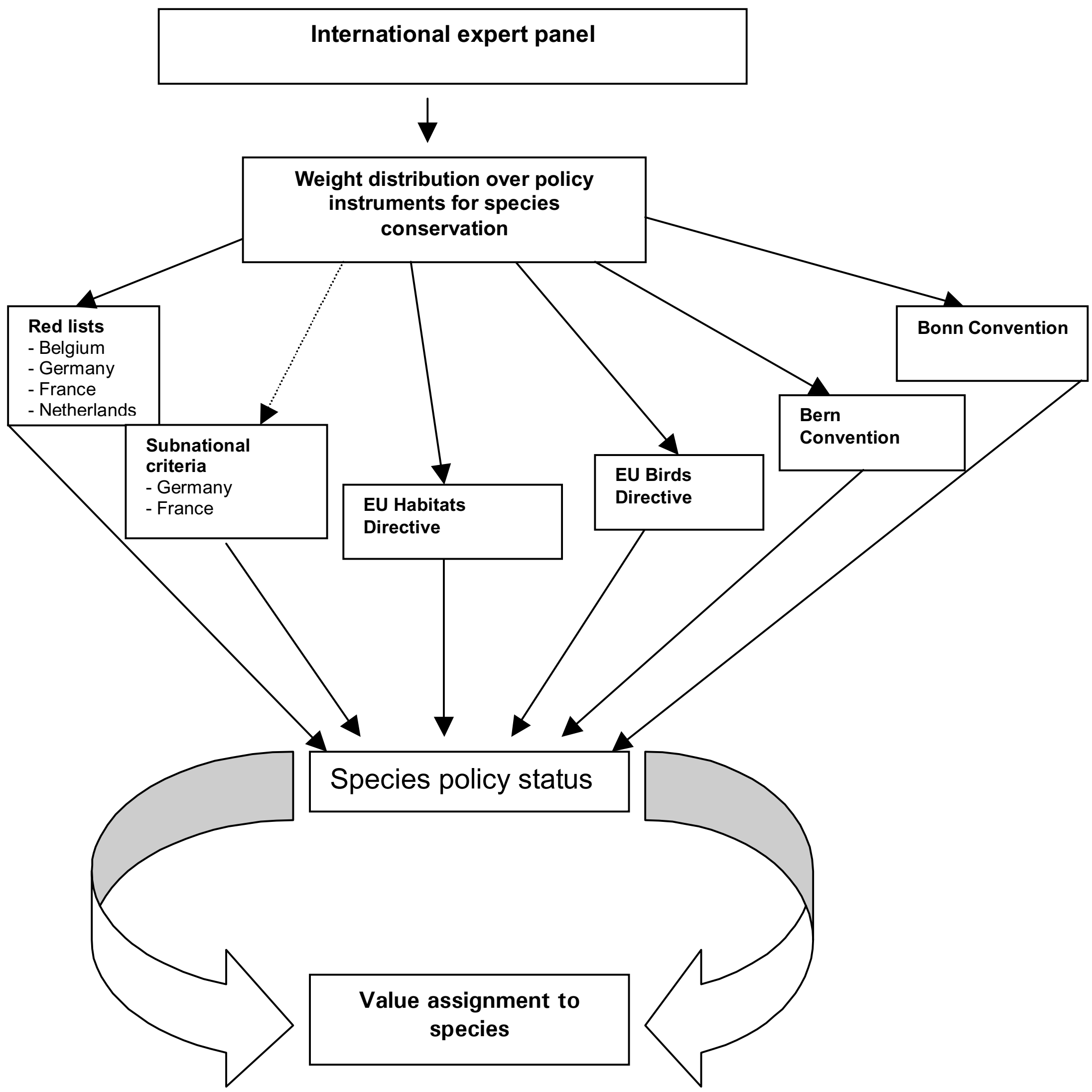


Figure 2.3. Schematic representation of weight distribution by the expert panel and value assignment to species.

Table 2.3. Valuation criteria applied and their weight distribution (% of maximum possible weight) according to an international expert panel.

Criteria	Weight distribution%				Comments
	NL n=17	G* n=6	F* n=7	B n=5	
Red Lists	17	35	17	14	(IUCN-criteria 'extinct', 'critical', 'endangered' or 'vulnerable' 'susceptible')
Bern Convention	14	6	12	12	
Bonn Convention	14	7	12	13	
EU Birds Directive	25	25	27	32	EC-Birds Directive and EC-Habitats Directive are complementary.
EU Habitats Directive	29	27	24	30	EC-Birds Directive applicable to birds only; EC-Habitats Directive applicable to all other species.

* corrected for subnational criteria (n = number of experts)

3 Application of BIO-SAFE

3.1 Types of assessments and case study areas

BIO-SAFE was constructed for the Netherlands, Germany, France and Belgium, allowing policy and legislation based biodiversity assessment for each separate country. It was applied to floodplain reconstruction projects aimed at flood risk reduction in these four countries and used for four types of assessments: (a) valuations of ecotopes and transitions between ecotopes, (b) valuation of the actual situation (on the level of species groups, ecotopes and on the floodplain level), (c) evaluative analysis of different scenarios or designs for reconstruction of a floodplain, allowing assessment of impacts of different reconstruction measures and a ranking of scenarios according to their value for biodiversity conservation (on the level of species groups and on the floodplain level) and (d) trend analysis, showing the biodiversity value patterns in time. Different strategies for biodiversity valuation using BIO-SAFE are:

1. EU legislation: Only the policy status according to the EU Habitats and Birds Directives are taken into account.
2. International legislation: All the international instruments for species conservation (EU Habitats and Birds Directives and the Conventions of Bern and Bonn) are used for valuation.
3. International habitat protection: value assignment is done using the instruments for species conservation that have a habitat/area protection component in their legislative framework.
4. Red List: Only the Red List species are taken into account for valuation, giving information on values on a more scientific basis, regarding species that are selected for reasons of rarity and negative abundance trends.
5. Integrated strategy: All the criteria used for valuation of the policy status of species are used.

Case study areas and types of assessments applied are given in table 3.1.

Criteria for area selection were:

1. The area must be the subject of a reconstruction design aimed at flood risk reduction with measures that will alter the abiotic and biotic characteristics of the floodplain and/or the summer bed of the river.
2. If possible: the area must be a case study of another IRMA-SPONGE project.

Table 3.1. Selection of case study areas and types of assessments applied.

Case study area*		Assessment:		
		Valuation actual situation	Scenario study	Trend analysis
NL	Gameren floodplain**	-	-	+
	Rijnwaarden floodplain**	+	+	+
D	Vynen-Rees floodplain	+	+	-
F	Mouzay Floodplain***	+	-	-
B	Common Meuse***	+	+	-

* = Geographic locations of the case study areas are given in figure 1.1.
** = common case study area with IRMA-SPONGE project Cyclic Rejuvenation of Floodplains
*** = common case study area with IRMA-SPONGE project INTERMEUSE.

Rijnwaarden floodplain
The Rijnwaarden floodplain area is located at the eastern end of the River Rhine delta in the Netherlands, where the river bifurcates into the River Waal and the Channel of Pannerden (figure 1.1). This floodplain area, with a total surface area of approximately 1,100 hectares, includes about 53% of agricultural land, about 43% of more or less natural elements and about 4% of built-up area. Plans for reducing flooding risks in combination with ecological rehabilitation of this floodplain area comprised four scenarios for reconstruction and a scenario that comprises no reconstruction measures.

Gameren floodplain
In the Gameren floodplain, located along the river Waal in the Netherlands (figure 1.1), three secondary channels have been created for the purpose of a combined flood risk reduction and nature rehabilitation plan. After the flooding of 1995, dike improvement was carried out. Large amounts of clay and sand were excavated from the area creating three secondary channels. The management goal is to create the right conditions for characteristic, river-bound flora and fauna as part of nature development. The area is a nature reserve with a surface area of 144 hectares. In the IRMA-SPONGE project Cyclic Rejuvenation a floodplains, a 2-dimensional hydrodynamical, morphological and ecological model was applied to investigate the flow of water and transport of sand in relation to the development of vegetation. Results of this study were used as input for BIO-SAFE.

Vynen/Rees floodplain
The Vynen/Rees study area is located on the German Lower Rhine close to the Dutch border (figure 1.1). This floodplain consists of large pasture areas and arable land as well as gravel/sand pits, either operating or recultivated. The study area covers approximately 120 ha. In the context of plans for reducing flooding risks, which will be followed by changes of mean water levels, the Federal Institute of Hydrology (BfG) launched a project in order to study impacts on the floodplain caused by varying mean river-stages. Results of this study were used as input for BIO-SAFE.

Mouzay floodplain
The Mouzay floodplain is located 40 km downstream of the town of Verdun (France) just before the Ardennes (figure 1.1). In this sector the river Meuse follows a meandering course with many abandoned meanders. The valley is 3 km wide and is relatively flat. The Mouzay area covers 570 ha. The landscape is mainly composed of semi-natural meadows and cultivated land. The area is a case study within the IRMA-SPONGE INTERMEUSE

Common Meuse
The Common Meuse case study area, located in the Northeast of Belgium on the Dutch-Belgian border (figure 1.1), used to be a stretch with islands, sandy and gravel riffles and branches with dynamic banks. The study area covers approximately 2,365 ha. Reconstruction of this stretch of the Meuse comprises construction of side channels and gravel pits and deepening of the main channel, removal of summer dikes and lowering of floodplains for the purpose of flood risk reduction and nature rehabilitation. The area is a case study within the IRMA-SPONGE INTERMEUSE project.

3.2 BIO-SAFE output

BIO-SAFE output gives information on biodiversity in floodplains on three levels of integration (these represent spatial and biological levels of scale, see table 3.2):

1. Taxonomic groups and ecotopes: these indices reflect the importance of an ecotope for a species group (e.g. birds) and the degree to which the maximum potential value of an ecotope for a species group has been achieved in an actual situation.
2. Taxonomic groups and floodplains: these indices give information on the degree to which the biodiversity potential of a particular species group has been realised in the floodplain, and reflect the potential of a scenario for each species group.
3. Overall biodiversity of floodplains: these indices are aggregations of the indices of type 2, representing an overall image of the biodiversity situation of the floodplain and the overall values of scenarios.

Table 3.2. Output of BIO-SAFE on different levels.

	Assessment:		
	General values	Actual values/trends	Scenarios/trends
Level of information:			
Ecotopes for taxonomic groups	TEI	ATEI, TES	-
Floodplains for taxonomic groups	-	TBS	TFI, ATFI
Overall biodiversity	-	BS	FI, AFI

TEI: **T**axonomic group **E**cotope **I**mportance constant, importance of each ecotope per taxon (0-100)
ATEI: **A**ctual **T**axonomic group **E**cotope **I**mportance score, actual importance of each ecotope per taxon (0-100)
TBS: **T**axonomic group **B**iodiversity **S**aturation index, degree of realisation of biodiversity potential of the area per taxon (0-100)
TES: **T**axonomic group **E**cotope **S**aturation index, degree of realisation of biodiversity potential of each ecotope per taxon (0-100)
TFI: **T**axonomic group **F**loodplain **I**mportance score, potentials per taxon for each scenario
ATFI: **A**ctual **T**axonomic group **F**loodplain **I**mportance, potentials per taxon for each scenario based on species actually present
BS: **B**iodiversity **S**aturation index, degree of realisation of biodiversity potential of the area (0-100)
FI: **F**loodplain **I**mportance score, total potential for each scenario
AFI: **A**ctual **F**loodplain **I**mportance score, total potential for each scenario based on species actually present

3.3 Application results

The types of analysis and index calculations were illustrated by applying BIO-SAFE for the purpose of policy and legislation based biodiversity assessment to the case study areas mentioned above. In this section the results of application of BIO-SAFE are presented. Applying BIO-SAFE yielded general results (potential values of ecotopes and ecotope transitions § 3.3.1), and detailed results concerning the case study areas (§ 3.3.2 - § 3.3.4). Application of the model was meant to show the possibilities and limitations of the model. Therefore, the results are presented as examples that illustrate the types of assessments that are possible using BIO-SAFE.

3.3.1 General valuation of ecotopes

Ecotope importance
BIO-SAFE calculates values for each ecotope (see § 3.2) that reflect the importance of an ecotope type with respect to nature conservation policy and legislation based values for species

belonging to a particular taxonomic group (TEI see figure 3.1). Ecotope values can be calculated for each country specifically, for four levels of spatial scale, following five different valuation strategies (see § 3.1). On top of that, it can be done per species group or for all groups. Figure 3.1 presents just one example of ecotope valuation, using BIO-SAFE. There is not *one* single table with ecotope values because these values are strongly determined by the country of concern, the spatial and biological scale and the policy and legislation criteria that are used for valuation. The results of the example of ecotope valuation shown here are only valid for ecotopes of level 2 of the Netherlands, using the complete set of valuation criteria.

Ecotopes	TEI-HP	TEI-BI	TEI-HF	TEI-MA	TEI-FI	TEI-BU	TEI-DD	SUM
Sd Deep summer bed	0	13	0	28	73	0	0	**114**
Ss Shallow summer bed	1	10	10	44	85	0	61	**212**
Ws Side channel	1	25	15	69	45	0	38	**194**
Sb Beach, Bank, Bar	14	13	0	56	47	0	69	**199**
Wf Floodplain channel	3	64	100	69	44	0	31	**310**
Wl Lake	1	40	100	69	27	0	0	**238**
Mh Herbaceous marsh	19	42	76	59	3	5	23	**225**
D1 Lh-1 River dune	17	0	44	0	0	9	0	**70**
D1 Lh-5 Gravel deposit	1	0	0	0	0	14	0	**14**
Mg Marsh grassland	5	32	85	34	0	36	61	**253**
Fg Moist grassland	11	33	40	34	0	36	61	**215**
Fh Herbaceous moist floodplain	5	1	42	18	0	32	61	**158**
Lg Levee pastures	43	8	44	17	0	32	0	**143**
Lh Herbaceous levee or dyke	18	8	59	5	0	5	61	**156**
Hg High-water-free grassland	28	7	0	21	0	32	61	**148**
Hh High-water-free herbaceous area	6	7	59	5	0	5	61	**142**
T1-F Shrubs in floodplain	1	9	52	35	0	9	69	**175**
T1-L Shrubs on levee	4	1	67	18	0	18	69	**177**
Lf Forested levee	5	8	67	46	0	23	8	**158**
Hf High-water-free forested area	3	5	67	46	0	14	69	**204**
B2.3 Softwood alluvial forest	1	11	52	35	0	14	8	**122**
B3.3 Hardwood alluvial forest	2	5	67	46	0	14	8	**143**
B4.3 Other characteristic forested biotopes in floodplains	0	5	52	30	0	0	8	**96**

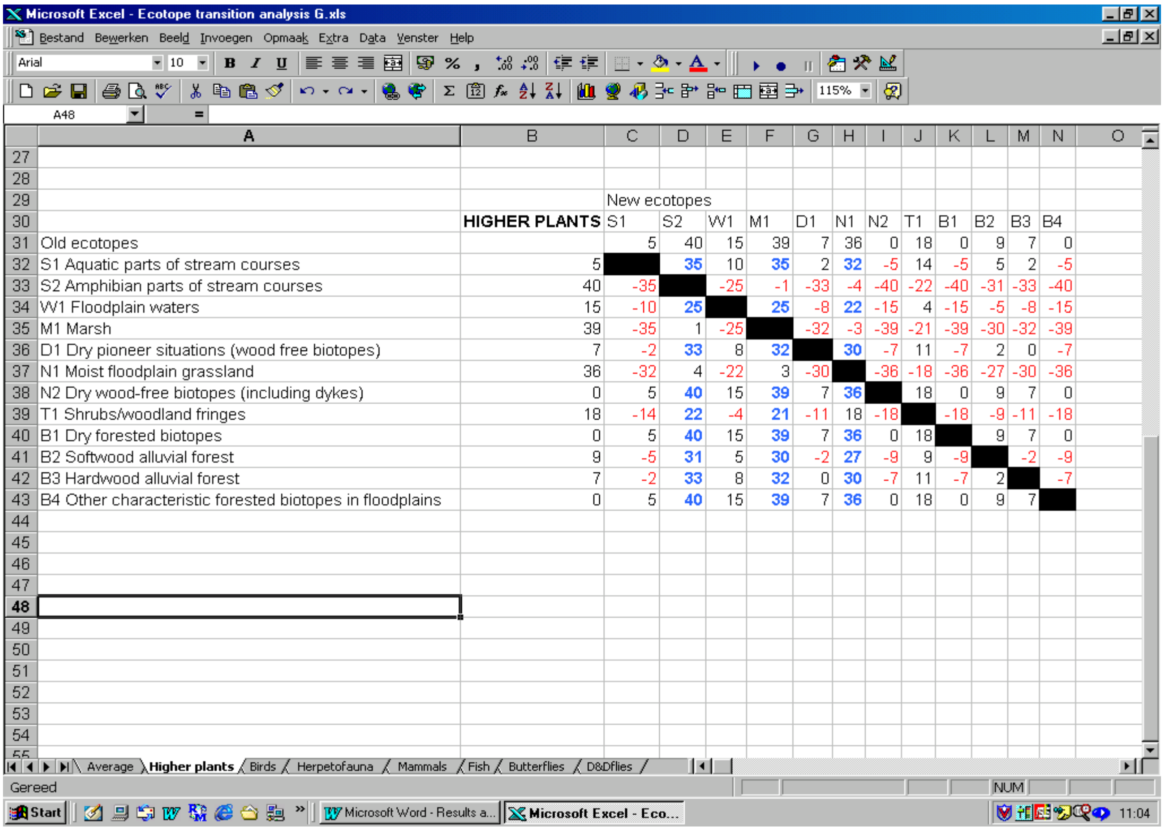
Figure 3.1. TEI constants for the Netherlands, reflecting the importance of ecotopes of level 2 (1:50,000) with respect to conservation values for species belonging to a particular taxonomic group according to the integrated valuation strategy (range 1 – 100). HP: Higher Plants, BI: Birds, HF: Reptiles and Amphibians, MA: Mammals, FI: Fish, BU: Butterflies, DD: Dragon- and Damselflies.

When the values in figure 3.1 are summed, the most important ecotopes (in this specific example) are:

- *Aquatic parts of stream courses* (especially the shallow parts and the side channels);
- *Floodplain waters* (especially *isolated lakes* and *floodplain channels* like oxbow lakes, cut-off meanders etc.)
- *Moist floodplain grasslands* (except the production grasslands).

Valuation of ecotope transitions

Using the ecotope importance constants, the value change resulting from a transition between ecotopes (e.g. when reconstruction measures are carried out) can be calculated (see figure 3.2). The effect of a transition between ecotopes, e.g. the conversion of one ecotope into another as a result of flood protection measures can be valuated by calculating the change of value, using the *Taxonomic group Ecotope Importance* (TEI) values. This can be used to quickly assess the effect of a particular measure in a floodplain, e.g. converting grassland into a lake as a result of floodplain lowering. Again just one example of all possible approaches is given in figure 3.2.



	HIGHER PLANTS	S1	S2	W1	M1	D1	N1	N2	T1	B1	B2	B3	B4
		New ecotopes											
Old ecotopes		5	40	15	39	7	36	0	18	0	9	7	0
S1 Aquatic parts of stream courses	5		35	10	35	2	32	-5	14	-5	5	2	-5
S2 Amphibian parts of stream courses	40	-35		-25	-1	-33	-4	-40	-22	-40	-31	-33	-40
W1 Floodplain waters	15	-10	25		25	-8	22	-15	4	-15	-5	-8	-15
M1 Marsh	39	-35	1	-25		-32	-3	-39	-21	-39	-30	-32	-39
D1 Dry pioneer situations (wood free biotopes)	7	-2	33	8	32		30	-7	11	-7	2	0	-7
N1 Moist floodplain grassland	36	-32	4	-22	3	-30		-36	-18	-36	-27	-30	-36
N2 Dry wood-free biotopes (including dykes)	0	5	40	15	39	7	36		18	0	9	7	0
T1 Shrubs/woodland fringes	18	-14	22	-4	21	-11	18	-18		-18	-9	-11	-18
B1 Dry forested biotopes	0	5	40	15	39	7	36	0	18		9	7	0
B2 Softwood alluvial forest	9	-5	31	5	30	-2	27	-9	9	-9		-2	-9
B3 Hardwood alluvial forest	7	-2	33	8	32	0	30	-7	11	-7	2		-7
B4 Other characteristic forested biotopes in floodplains	0	5	40	15	39	7	36	0	18	0	9	7	

Figure 3.2. Valuation of ecotope transitions concerning higher plants for Germany of ecotopes of level 2 according to the integrated valuation strategy.

The example in figure 3.2 shows that (for Germany, using all criteria) plants are almost always favoured by creation of *moist floodplain grasslands*, *marshes* and *amphibian parts of stream courses*. Creation of *aquatic parts of stream courses* and *dry wood-free biotopes* usually has negative effects on the biodiversity of plants in terms of policy and legislation in German floodplains.

3.3.2 Valuation of the actual situation

Valuations of the (actual) situation of a number of floodplain areas, or the situation at a given moment in time, on the basis of species data are given in table 3.3. These valuations concern the level of the whole floodplain (table 3.3) as well as the level of ecotopes (table 3.4). A comparison between the areas is not given because of differences in scale and river (section).

Table 3.3. Biodiversity saturation of floodplains.

Taxonomic group	Taxonomic group Biodiversity Saturation			
	Rijnwaarden	Common Meuse	Vynen/Rees	Mouzay
Higher plants	19.2	58.2	6.0	50.0
Birds	62.9	58.4	48.9	56.6
Reptiles and amphibians	42.0	-	0.0	36.3
Mammals	52.2	-	-	0.0
Fish	24.1	22.6	-	-
Butterflies	0.0	-	-	-
Dragonflies & damselflies	8.5	-	-	0.0
Total (mean value)	**29.8**	**46.4**	**18.3**	**28.6**

-: not assessed

From table 3.3 it can be concluded that the indices calculated differ greatly over the taxonomic groups and between the areas. Part of the differences between taxonomic groups may be due to possibly incomplete distribution surveys of some groups (especially butterflies, damselflies and dragonflies, and fish). It appears that the present value of the Rijnwaarden floodplain can be attributed largely to birds, closely followed by mammals and reptiles and amphibians. Remarkably low are the indices for higher plants and, especially, butterflies. The Common Meuse area contains high values for plants and birds (58.2 and 58.4). For fish, the value was lower: 22.6. The overall value was 46.4. The value of the Vynen/Rees study area for birds was high, 48.9, the values for plants, reptiles and amphibians low (6.0 and 0.0 respectively). Results (see table 3.3) show that the Mouzay floodplain area contains high values for birds (56.6) and plants (50.0). For reptiles and amphibians the value was 36.3, for mammals and dragon- and damselflies 0.0.

Actual values on the level of ecotopes are given and discussed only for the Rijnwaarden floodplain and are meant as an example (table 3.4). These figures give an impression of the degree to which the potential value of each ecotope type has been achieved (TES) and of the actual value of ecotopes (ATEI) in the Rijnwaarden floodplains for the taxonomic groups involved. Only results for higher plants and reptiles and amphibians are commented on here. Some ecotope types in the Rijnwaarden floodplain area are saturated up to a relatively high degree and should be conserved if possible (see also discussion section). Concerning higher plants, the ecotope type *High-water-free production grassland* in the Rijnwaarden floodplain area is saturated up to a relatively high degree. The ecotope, however, does not represent a very valuable type according to the information in BIO-SAFE. Furthermore, the relative high ecotope saturation index for the ecotope type *Natural levee pasture* corresponding with a, also relatively, high ecotope importance score catches the eye. Although saturated up to a lower degree, this ecotope type represents a higher value compared to *High-water-free production grassland*, due to a considerably higher Taxonomic group Ecotope Importance constant. As far as reptiles and amphibians are concerned the two most important ecotope types (*Floodplain channel* and *Herbaceous marsh*, see annex III) score relatively high regarding their saturation indices. As a consequence, the ATEI-scores, reflecting the actual significance of these ecotope types, are also high.

Table 3.4. Saturation of ecotopes of the Rijnwaarden floodplain: *Taxonomic group Ecotope Saturation* (TES) indices and *Actual Taxonomic group Ecotope Importance* (ATEI) scores.

Ecotope	Higher plants		Birds		Reptiles & amphibians		Mammals		Fish		Dragon- & damselflies	
	TES	ATEI	TES	ATEI	TES	ATEI	TES	ATEI	TES	ATEI	TES	ATEI
Lh-1 River dune	25.0	4.3	0.0	0.0	66.0	29.2	0.0	0.0	-	-	0.0	0.0
Lg-1 Natural levee pasture	35.6	14.9	60.0	3.6	66.0	29.2	71.2	11.8	-	-	0.0	0.0
Hg-3 High-water-free production grassland	50.0	0.7	51.3	2.5	0.0	0.0	71.2	11.8	-	-	0.0	0.0
Hh-2 Arable land	0.0	0.0	52.7	2.7	38.4	9.4	0.0	0.0	-	-	0.0	0.0
Hh-3 Built up/paved land	0.0	0.0	100.0	1.4	100.0	29.2	0.0	0.0	-	-	0.0	0.0
Hf-3 High-water-free production forest	0.0	0.0	0.0	0.0	100.0	19.8	57.2	12.8	-	-	100.0	8.5
Ws Side channel	0.0	0.0	72.3	18.1	15.6	2.4	75.8	52.2	25.8	11.7	0.0	0.0
Sb Beach, Bank, Bar	5.1	0.7	80.4	10.5	0.0	0.0	22.9	12.8	28.6	13.5	0.0	0.0
Wf Floodplain channel	25.0	0.7	56.1	35.9	42.0	42.0	75.8	52.2	49.2	21.4	27.3	8.5
Wl Lake	0.0	0.0	60.6	24.2	42.0	42.0	75.8	52.2	54.8	15.0	0.0	0.0
Mh Herbaceous marsh	7.3	1.4	42.1	17.5	43.2	32.6	41.8	24.6	100.0	2.6	0.0	0.0
Fg Moist grassland	25.0	2.8	68.4	22.6	23.8	9.4	34.6	11.8	-	-	0.0	0.0
B2.3 Softwood alluvial forest	0.0	0.0	0.0	0.0	42.4	22.2	36.4	12.8	-	-	100.0	8.5
B3.3 Hardwood alluvial forest	0.0	0.0	0.0	0.0	32.9	22.2	79.2	36.4	-	-	100.0	8.5

- : not assessable.

The saturation index of 100 for the ecotope type *High-water-free production forest* shows that it is possible for at least some ecotopes and for some taxonomic groups to reach full saturation. In this case, however, it does not concern a very important ecotope type for reptiles and amphibians (low TEI constant). These examples show that in assessing the political and legal value of ecotope types, both the ecotope saturation indices (TES) and the ecotope importance score (ATEI) should be taken into consideration.

3.3.3 Scenario analysis

In this paragraph the results of scenario analysis for Rijnwaarden floodplain, the Common Meuse area and the Vynen/Rees floodplain are presented and briefly discussed.

Rijnwaarden floodplain
Two scenarios aim at low influences of river dynamics in the floodplain (scenario 1 and 2), the other two (3 and 4) aim at high influences of river dynamics in the floodplain. The results (see table 3.5) show that in comparison to the reference scenario, the potentials for higher plants and insects selected for BIO-SAFE in all scenarios strongly increase. As far as potentials for fish

species are concerned, the scenarios do not differ noticeably. For reptiles, amphibians and mammal species, all scenarios, but especially those aimed at low influence of river dynamics, offer good opportunities. As far as birds are concerned, it is remarkable that especially the high dynamics scenarios result in considerably lower potentials as compared to the low dynamics scenarios.

Table 3.5. Evaluation of reconstruction plans for the Rijnwaarden floodplain.

	ADS		LD16		LD18		HD16		HD18	
	TFI	ATFI	TFI	ATFI	TFI	ATFI	TFI	ATFI	TFI	ATFI
HP	355	71	636	128	654	114	1014	189	980	190
BI	2227	1240	3032	1726	3245	1754	2397	1263	2385	1310
HF	4993	2191	6652	2671	7046	2909	6368	3009	6144	2910
MA	3998	2082	4838	2406	5130	2562	4020	1972	4049	1998
FI	1256	546	1395	596	1622	695	1308	535	1487	568
BU	346	0	1308	0	993	0	674	0	649	0
DD	767	122	2361	241	2094	262	1251	98	1345	79
Total	**13941**	**6252**	**20223**	**7769**	**20783**	**8295**	**17032**	**7065**	**17038**	**7055**

TFI: Taxonomic group Floodplain Importance score, potentials per taxon for each scenario
ATFI: Actual Taxonomic group Floodplain Importance, potentials per taxon for each scenario based on species actually present
HP: Higher Plants, BI: Birds, HF: Reptiles and Amphibians, MA: Mammals, FI: Fish, BU: Butterflies, DD: Dragon- and Damselflies.
ADS: Autonomous Development Scenario; LD16: Low Dynamics Scenario for a 16,000 $m^3 s^{-1}$ design discharge at Lobith; LD18: Low Dynamics Scenario for a 18,000 $m^3 s^{-1}$ design discharge at Lobith; HD16: High Dynamics Scenario for a 16,000 $m^3 s^{-1}$ design discharge at Lobith; HD18: High Dynamics Scenario for a 18,000 $m^3 s^{-1}$ design discharge at Lobith.

Vynen/Rees floodplain

Results show that the scenario calculated for a decrease in water levels has negative impacts on all species groups in the area except birds. The overall value of the -50 cm scenario is 5500. Compared to 6232 for the reference scenario this is a drop of 12 %. The overall value of the +50 cm scenario is 6613, this is an increase of value by 6 %. Large differences between the scenarios can be seen for butterflies and reptiles and amphibians.

Table 3.6. Assessment of impacts of changes in mean water levels of the Rhine for the Vynen/Rees floodplain.

	Reference scenario	Scenario 1 + 50 cm	Scenario 2 - 50 cm
	TFI	TFI	TFI
HP	206	235	189
BI	662	692	663
HF	1866	2018	1268
MA	1939	1938	1927
FI	478	555	422
BU	960	1031	922
DD	121	144	108
Total	**6231**	**6613**	**5500**

TFI: Taxonomic group Floodplain Importance score, potentials per taxon for each scenario
HP: Higher Plants, BI: Birds, HF: Reptiles and Amphibians, MA: Mammals, FI: Fish, BU: Butterflies, DD: Dragon- and Damselflies.

Common Meuse area

The three scenarios for development of the Common Meuse area according to different types of reconstruction and management can be ranked, using the TFI indices, as follows:

1. Sustainability scenario (10877)
2. Nature development scenario (9515)
3. Nature conservation scenario (8752)

Table 3.7. Results of the scenario analysis for the Common Meuse area.

	Autonomous Development	Nature conservation	Nature development	Sustainability
	TFI	TFI	TFI	TFI
HP	760	738	401	279
BI	631	666	912	1005
HF	26	22	573	1139
MA	2614	2762	3195	3764
FI	256	271	382	201
BU	1966	1894	1079	822
DD	2280	2399	2973	3666
Total	**8532**	**8752**	**9515**	**10877**

TFI: Taxonomic group Floodplain Importance score, potentials per taxon for each scenario
HP: Higher Plants, BI: Birds, HF: Reptiles and Amphibians, MA: Mammals, FI: Fish, BU: Butterflies, DD: Dragon- and Damselflies.

3.3.4 Trend analysis

Rijnwaarden floodplain
Analysis of the prospective trend as given in figure 3.3 shows that the overall potential slowly increases and stabilises after 15 years. For plants and butterflies, it can be seen that potentials drop sharply after a small rise in the first 5 years. Potentials for dragon- and damselflies first drop and than rise slightly after the first 5 years.

Gameren floodplain
In tables 3.8 and 3.9 and figure 3.4, trends are given for the Gameren floodplain. Trends for all species groups (using ecotope data and TFI) and also (1997-2000) trends for plants and fish (using ecotope data and ATFI) are given in table 3.8. The retrospective trend using species data shows that values for plants decreased slightly, fish biodiversity increased during this period of time (see table 3.9). On the whole the value of the floodplain increased by 5 % during this period. A decrease of potential value was calculated for plants, birds and reptiles and amphibians. The trends for plants and fish show the same pattern in all figures: ecotope trend calculations confirm calculation on the basis of species data, which is a validation of the BIO-SAFE trend analysis technique.

Figure 3.3. Analysis of a prospective trend for the Rijnwaarden floodplain.

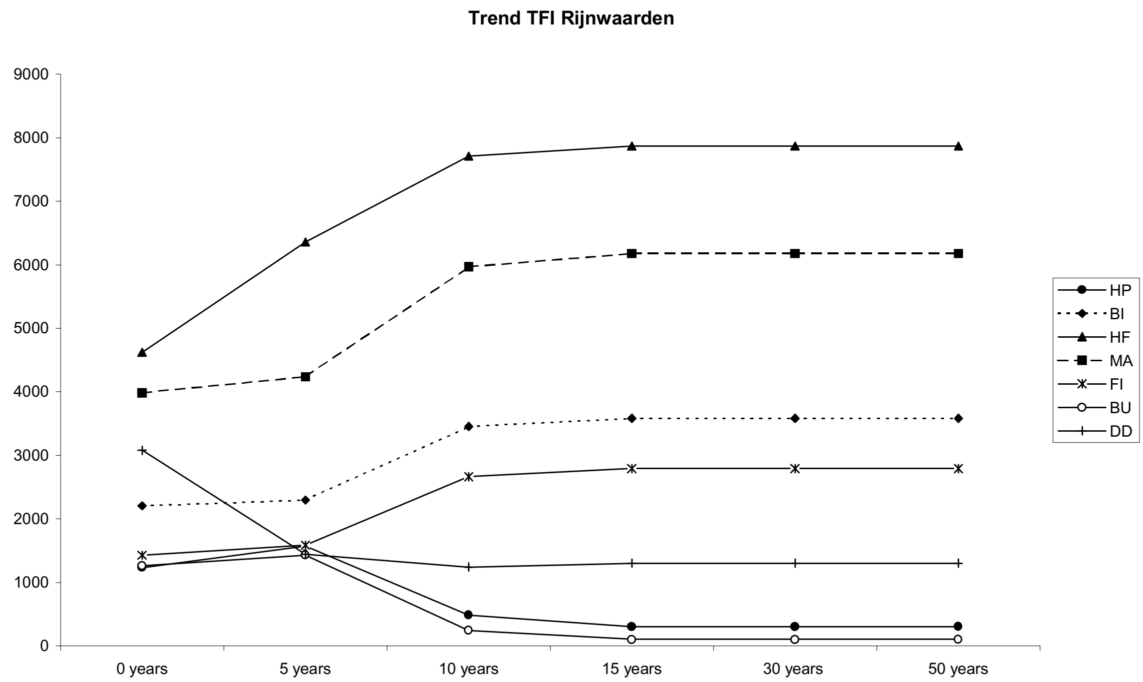


Table 3.8. Analysis of a retrospective trend for the Gameren floodplain on the basis of ecotope and species data.

	1997		2000	
	TFI	ATFI	TFI	ATFI
HP	600	61	488	30
BI	2419	0	1463	0
HF	3223	0	2789	0
MA	3578	0	4069	0
FI	1253	346	1652	425
BU	621	0	726	0
DD	2125	0	3272	0
Total	**13819**	**407**	**14458**	**455**

TFI: Taxonomic group Floodplain Importance score, potentials per taxon for each scenario
ATFI: Actual Taxonomic group Floodplain Importance, potentials per taxon for each scenario based on species actually present
HP: Higher Plants, BI: Birds, HF: Reptiles and Amphibians, MA: Mammals, FI: Fish, BU: Butterflies, DD: Dragon- and Damselflies.

Table 3.9. Analysis of a retrospective trend for the Gameren floodplain on the basis of species data only.

	1998	1999	2000
HP	6.4	-	4.3
FI		9.1	14.4

HP: Higher Plants, FI: Fish.

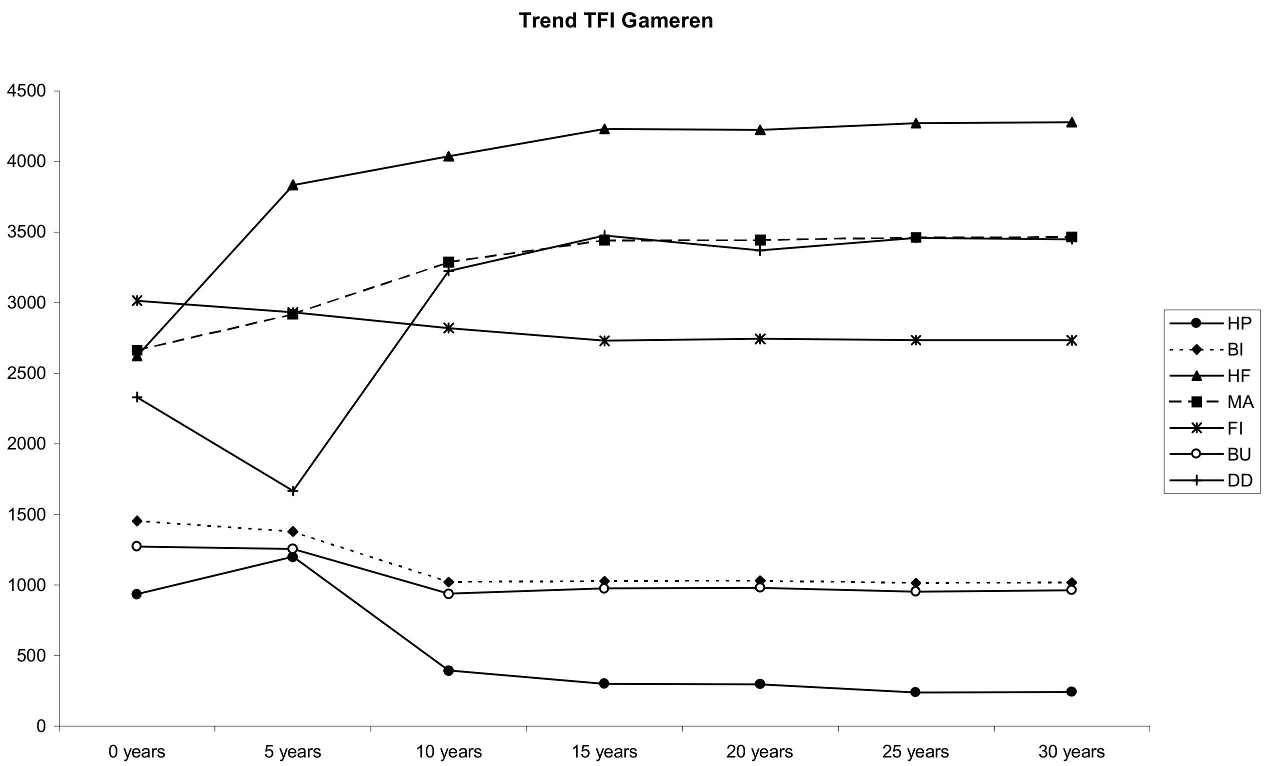


Figure 3.4. Analysis of a prospective trend for the Gameren floodplain.

TFI: Taxonomic group Floodplain Importance score, potentials per taxon for each scenario
HP: Higher Plants, BI: Birds, HF: Reptiles and Amphibians, MA: Mammals, FI: Fish, BU: Butterflies, DD: Dragon- and Damselflies

The prospective trend, representing developments of the Gameren floodplain for the next 30 years are given in figure 3.4. The patterns differ greatly between the species groups. On the whole, maximum values are reached after 15 years. For plants and birds there is a strong negative trend, for fish the trend is only slightly negative. Values of the floodplain for butterflies are decreasing after 5 years. For mammals, reptiles and amphibians the trend is positive. Values for mammals are showing a positive trend over the whole time period.

4 Discussion

4.1 Components of BIO-SAFE

Database
The species selection incorporated into the BIO-SAFE model represents the species that have a certain status in policy and legislation and are to be accounted for when taking measures in floodplains that alter actual and potential biotic and abiotic conditions. River characteristic species have adapted their life cycles and survival strategies to the (dynamic) character of river systems. Because the species in the model are for a large part dependent on riverine habitats in floodplains, they are the species that suffer the worst from negative impacts and benefit the most from positive effects of floodplain reconstruction.

Ecotope typology
The BIO-SAFE ecotope typology was developed in close co-operation with the RIZA (the Netherlands), the Institute of Nature Conservation (Belgium), the Federal Institute of Hydrology (Germany) and the University of Rouen (France). The Institute of Nature Conservation designed a typology for INTERMEUSE that was almost identical already prior to attuning. This is a reason to believe that the typology is reproducible and has a broad basis. The BIO-SAFE ecotope typology comprises five different levels of spatial scale, which offers the opportunity for up and down scaling of model output and enables BIO-SAFE users to work with input data on various levels of scale. The core of the typology is formed by river specific typologies that are applicable in a transnational context.

Valuation criteria
The choice of valuation criteria for species in the BIO-SAFE model was validated by interviews with experts from four riparian countries. Results of the questionnaire show that the distribution of weights to the policy instruments for species conservation are very similar in all four countries. Because policy makers as well as scientists were included in the questionnaire, this equity of valuation criteria is a very relevant remark for policy based valuation in general. However, for Belgium, France and Germany the response of experts consulted was relatively low (see table 2.3) and deserves attention during further research.

The two lines of valuation of policy status (Red Lists and international legislative instruments) are complementary. For instance, if a species is protected by the Habitats Directive, this means there is an international agreement regarding the conservation of this species. It does not always mean the species is actually rare, endangered or shows a negative trend concerning population size and/or area of distribution in the country of concern. Therefore the fact that a species is also on the Red List, or not, provides extra information that should be included in the assessment.

4.2 Application of BIO-SAFE

Input and output of BIO-SAFE
BIO-SAFE uses data on species and ecotopes present. For scenario analysis, also surface areas of the ecotopes must be known. BIO-SAFE is capable of using data on various levels of spatial scale and biological organisation. Species presence data does not need to be precise regarding the exact place within the floodplain or the numbers of individuals. BIO-SAFE is relatively scale independent and allows aggregation of information, while information on species groups or ecotopes is retained. Of course, the quality of the input data determines the output quality. BIO-SAFE uses the national and international policy and legislation status and the habitat demands of around 200 species for each country specifically.

General ecotope valuation
In general, valuation of ecotopes shows that a diversity of ecotopes is important for sustaining a diversity of species groups. Furthermore, there is the fact that different ecotopes are important for different taxonomic groups (e.g. floodplain waters are very valuable for amphibians, but not for butterflies). Therefore a well-balanced reconstruction scenario as concerns biodiversity for a particular floodplain requires designs aimed at ecotope diversity. Assessment of the overall value of a floodplain or ecotope, in general or in a specific case, leads a to large loss of information when only the aggregated values are used. A sound assessment must therefore be carried on the level of species groups.

Valuation of actual situations
Results concerning valuation of a number of floodplains using BIO-SAFE shows that the model enables the user to see for which species group an area already is important. Also the link with area potential can be made. From valuation of ecotopes on the basis of data on species presence in various areas, it becomes clear that there are large differences within floodplains regarding the biodiversity values of different ecotopes and species groups. Several ecotopes have very high biodiversity values and should be regarded as conservation priority ecotopes in early stages of the planning process. This prevents problems with legislation that can lead to obstruction of the implementation of flood defence measures.

Scenario analysis
Application of BIO-SAFE to various scenarios in the Netherlands, Belgium and Germany demonstrated that there can be large differences between different reconstruction scenarios regarding impacts on biodiversity. Most reconstruction designs assessed show an increase of biodiversity, but also strong negative effects were calculated. Using BIO-SAFE it is possible to rank scenarios according to their value for species of Red Lists and different international agreements. The differences can be traced back to impacts on different taxonomic groups. Increase of the potentials for one group of politically and legally relevant species can involve a decrease of the potentials of another group. Floodplain reconstruction designs can be potentially valuable, because new habitats are created, but at the same time disastrous for flora and fauna in the actual situation. BIO-SAFE can help in making these reconstruction dilemmas manifest.

Trend analysis
Application of BIO-SAFE to trend data shows that this type of analysis enables the user to gain insight into the patterns of biodiversity in time. This can be used retrospectively to assess the success of management or restoration measures, or to determine a suitable reference situation. Assessing prospective trends can help planning future management or reconstruction measures and can determine what the consequences of hydraulic and morphological developments are for characteristic species with policy and legislation relevance.

4.3 Limitations of BIO-SAFE

BIO-SAFE gives only the value of actual and potential situations from a nature conservation policy perspective, but gives no information on ecosystem functioning. The predictive power of BIO-SAFE is limited to the use of species - ecotope relationships for an estimate of the effects of changes of ecotope presence and surface area. There is no prediction of which species will be present in the future. Prediction of ecotopes is not possible using BIO-SAFE. For this information the model must rely on other models (hydraulic models, succession models or ‘ecotope generators’). Floodplain attributes like habitat configuration, soil and water quality, groundwater characteristics and surroundings are, at least explicitly, kept out of the model. This was necessary because the information required is not available for all species.

4.4 Surplus values of BIO-SAFE

The model is very easily adapted to new insights or other (river) ecosystem types as concerns the database, the typology and the set of valuation criteria as well as the distribution of weights between these criteria. Assessments are possible on the basis of available data on species and/or ecotopes that are usually available. BIO-SAFE yields information from a broad and integrated perspective i.e., the use of flora and fauna species in coherence with ecotopes on multiple levels of scale where the quantification of values is based on policy and legislation. It contributes to consistency between flood risk reduction activities and nature conservation policies. A BIO-SAFE assessment can be done very location specific, by choosing the appropriate scale, valuation strategy and set of species groups. BIO-SAFE provides the opportunity to aggregate biodiversity values of different species groups, and to upscale model output to levels of scale or abstraction suitable for the desired field of application.

Assessment of impacts of landscape reconstruction measures on biodiversity, on the basis of policy based and legal criteria can provide a useful tool during the planning process. Besides assessment of effects of reconstruction measures, BIO-SAFE can also be applied as a model for trend analysis and for analysis of long-term scenarios on different scales. BIO-SAFE is complementary with network analysis on the population level and supplementary to detailed single species models for impact assessment. Assessment and valuation of ecological impacts contributes to integrated problem solving approaches and improves the quality and societal acceptance of policy decisions with respect to flood risk reduction measures. This may result in shorter and cheaper planning procedures. Moreover, thorough evaluation preceding execution of reconstruction measures can prevent sub-optimal results.

BIO-SAFE is a model that can be used as a management tool to optimise mutual attuning of nature conservation policies and other interests in spatial planning and water management. It may contribute to preservation, protection and improvement of the quality of the environment, including the conservation and development of natural habitats of wild flora and fauna, which are essential objectives of general interest pursued by the European Union. Tools like BIO-SAFE are meant to gain insight into an enormous complexity and to organise information in a way as to assist in decision-making. Use of indices and different levels of aggregation make BIO-SAFE suitable for integration in more generic models used for integrated assessment.

5 Conclusions and recommendations

Application of BIO-SAFE

- The results of the application of BIO-SAFE to the various case study areas illustrate that it is possible to make the concept of policy based biodiversity assessment operational for transnational river management. The transnational version of BIO-SAFE developed can be properly used for valuation of actual situations, scenarios for flood defence measures and trends regarding biodiversity developments resulting from flood defence measures.

- Application of BIO-SAFE shows that flood defence measures can lead to an increase of biodiversity values if already very valuable ecotopes are conserved and an increase of diversity of ecotopes is realised. The alternatives for reconstruction aiming at he most natural conditions show the highest potentials for biodiversity. However, it is not possible to formulate generic rules for reconstruction regarding impacts on biodiversity because these impacts are always largely location specific: the actual biodiversity, the hydromorphological conditions in this location, the way in which the measures are taken etc.

Information yielded by BIO-SAFE

- BIO-SAFE is capable of giving information on the basis of relatively rough and scarce information. The model is meant to organise ecologically very complex information in a way as to assist decision making. Because of its policy-based character, the model yields information at the landscape ecological level that is complementary to more established biological diversity indices, detailed habitat models and ecological network analysis (metapopulation models).

- BIO-SAFE gives information regarding the degree to which floodplain designs or actual valuations meet goals set in (international) agreements. BIO-SAFE can be seen as a mirror confronting policy aimed at flood defence with policy aimed at nature conservation. Assessments of actual situations and different scenarios for a (floodplain) with BIO-SAFE, in an early stage of the planning process can help directing the planning process in the stage where this is still possible.

Components of BIO-SAFE

- Landscape ecological classification is an essential component of landscape ecological studies aimed at valuation of areas. It is the starting point for analysis and understanding, requiring definition of units within a complex system. For transboundary rivers, a transnationally harmonised methodology for landscape ecological classification is therefore crucial for the success of river management. The landscape ecological classification system developed in this project may contribute to this harmonisation process.

- The distribution of weights to the policy instruments for species conservation is very similar in al four countries. Because policy makers as well as scientists were included in the questionnaire, this equity is a very relevant remark for policy based valuation in general.

Recommended application of BIO-SAFE

- BIO-SAFE is recommended as a tool for various policy and management purposes such as determining the effectiveness of nature management measures, scenario studies for ex-ante evaluation of physical planning projects and monitoring and ex-posterior evaluation of the progress of such projects. BIO-SAFE can also be used for underpinning spatial planning reports and environmental impact assessments for large scale activities in river basins.

- BIO-SAFE assessments of the actual situation and different scenarios for development or reconstruction of a (floodplain) area give insight into what kinds of measures will meet a lot of resistance from legislation. BIO-SAFE helps translating obligations regarding species to detection and delineation of most valuable ecotopes in the area, which allows a fine tuning of the design. This may result in shorter and cheaper planning procedures. Moreover, thorough evaluation preceding execution of reconstruction measures can prevent sub-optimal results.

Biodiversity assessment

- Floodplain reconstruction measures can have positive as well as negative impacts on flora and fauna. A large number of species is valued for:
  - Their importance for ecosystem (function) integrity.
  - The moral and legal obligations concerning their conservation.

  Biodiversity assessments should include both when studying ecosystems for policy reasons.

Floodplain reconstruction

- In order to achieve optimal results regarding the attuning of conservation and development of biodiversity values on the one hand and flood defence measures on the other, it is recommended to aim at a balance between creating space in the horizontal (width) and vertical (depth) dimension. Uniform solutions must be avoided, a diversity of influence of river dynamics in floodplains should be aimed at. Lowering floodplains are best coupled with measures that enlarge the flooding area, resulting in floodplains where dry as well as wet ecotopes are represented, ideally along with an intact gradient from wet to dry.

- It is strongly recommended that when a (floodplain) area is the subject of reconstruction measures or management shifts that will alter biotic and/or abiotic conditions, a sound survey is carried out concerning at least the species groups for which Red lists and/or (inter)national legislation exists.

- The definition of reference images and target images for floodplains that are the subject of reconstruction measures are recommended as an essential part of the planning process. Any valuation of ecosystems requires a clearly described reference situation that serves as evaluation basis. Any assessment of reconstruction measures requires clearly described targets that have evaluative power. This should include the conservation of (ecologically) valuable actually present ecotopes in the reconstruction design. Reference images and target images for floodplain development should be defined on high as well as low spatial scales.

- BIO-SAFE should be incorporated into a DSS for river management and adapted to other river basins in order to increase its range of applicability.

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Glossary

BIO-SAFE:	Spreadsheet Application for Evaluation of BIOdiversity
CORINE:	Co-Ordination of Information of the Environment
ICPM:	International Commission for Protection of the Meuse
ICPR:	International Commission for Protection of the Rhine
IRMA:	Interreg Rhine Meuse Activities
PSU:	Phyto-Sociological Units
RES:	River Ecotope System
AFI:	Actual Floodplain Importance score, total potential for each scenario based on species actually present
ATEI:	Actual Taxonomic group Ecotope Importance score, actual importance for each ecotope per taxon (0-100)
ATFI:	Actual Taxonomic group Floodplain Importance score, potentials per taxon for each scenario based on species actually present
BS:	Biodiversity Saturation index, degree of realisation of biodiversity potential of the area (0-100)
FI:	Floodplain Importance score, total potential for each scenario
TBS:	Taxonomic group Biodiversity Saturation index, degree of realisation of biodiversity potential of the area per taxon (0-100)
TEI:	Taxonomic group Ecotope Importance constant, importance of each ecotope per taxon (0-100)
TES:	Taxonomic group Ecotope Saturation index, degree of realisation of biodiversity potential of each ecotope per taxon (0-100)
TFI:	Taxonomic group Floodplain Importance score, potentials per taxon for each scenario
Biodiversity:	The variability among living organisms including ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.
Ecotope:	Spatial ecological unit of which the composition and development are determined by their abiotic, biotic and anthropogenous factors.
Flood Risk:	The product of the chance of flooding and the damage done by flooding.
Habitat:	The place where an organism lives. In this report: the set of riverine ecotopes that a species can use for the various components of it's life cycle.
Nature conservation instruments:	Policy instruments and legislative frameworks that can/must be used to underpin activities aimed at conservation of nature. In this report: Red Lists of the Netherlands, Germany, France and Belgium, regional protection of plants in France, the EU Habitats Directive, the EU Birds Directive, the Bonn Convention and the Bern Convention.
Red List:	Data book compiled according to IUCN criteria, giving an overview of species that have disappeared, show declining population sizes and/or are rare and are therefore considered threatened or vulnerable.
Scenario:	Hypothetical description of alternative images of the future and of causally related processes, events and actions which lead to these images of the future, where a final situation is sketched from a starting situation (usually the present situation).
Species policy status:	In this study: the status of a species according to national Red Lists, Convention of Bonn, Convention of Bern, EU Birds Directive, EU Habitats Directive and in some cases Regional policy documents.
Taxon(omic group):	A species group on a certain biological level, in this report: mammals, birds, reptiles, amphibians, fish, butterflies, dragonflies, damselflies and the higher plants.
Transnational:	Applicable in more than one riparian country.