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Ecosystem Restoration –
From Research to Implementation

Beate Jessel

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Institute of Architecture (IA)
Environmental Enginneering Institute (IIE)

Laboratory of Landscape Development (LAND)

We deal with the coordination and moderation of different demands on space in terms of sustainable development.

Holistic understanding of landscape: An area perceived as such by humans, whose character is the result of the interaction of natural as well as anthropogenic components.

Inter- and transdisciplinary approaches and working at different scales and planning levels.

Interdisciplinary team of engineers, geographers, architects, economist

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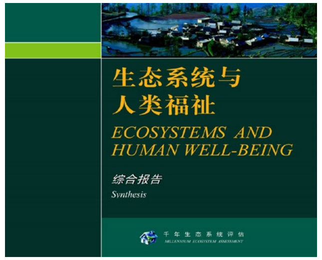
Ecosystem Restoration – A broad field of action emerged



MES (Millenium Ecosystem Assessment, 2005):

- pointed to the existing and accelerating degradation of ecosystems
- brought the term "Ecosystem Services" to attention = The benefits that humans obtain from nature

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

UN Decade on Ecosystem Restoration (2021-2030)

aims to

- focus global action on ecosystem restoration
- prevent, halt and reverse the degradation of ecosystems on all continents and in all oceans.

European Commission

European Commission

18 August 2024: EU Nature restoration law entered into force:

- at least **20% of the EU's degraded ecosystems to be restored** by 2030
- improve river connectivity: **at least 25.000 km of rivers** in the EU to be restored by 2030.

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Ecosystem Restoration – A broad field of action emerged

Fields of Action:

- Water bodies and floodplains
- Peatlands, wetlands
- Forests
- Marine ecosystems and coastlines
- Agroecosystems, farmlands
- Grasslands, scrublands and savannahs
- Mountain ecosystems
- Urban Ecosystems

According to UN-Decade on Ecosystem Restoration 2021

Ecosystem Restoration – A broad field of action emerged

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According to UN-Decade on Ecosystem Restoration 2021

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I. Restoration of floodplains

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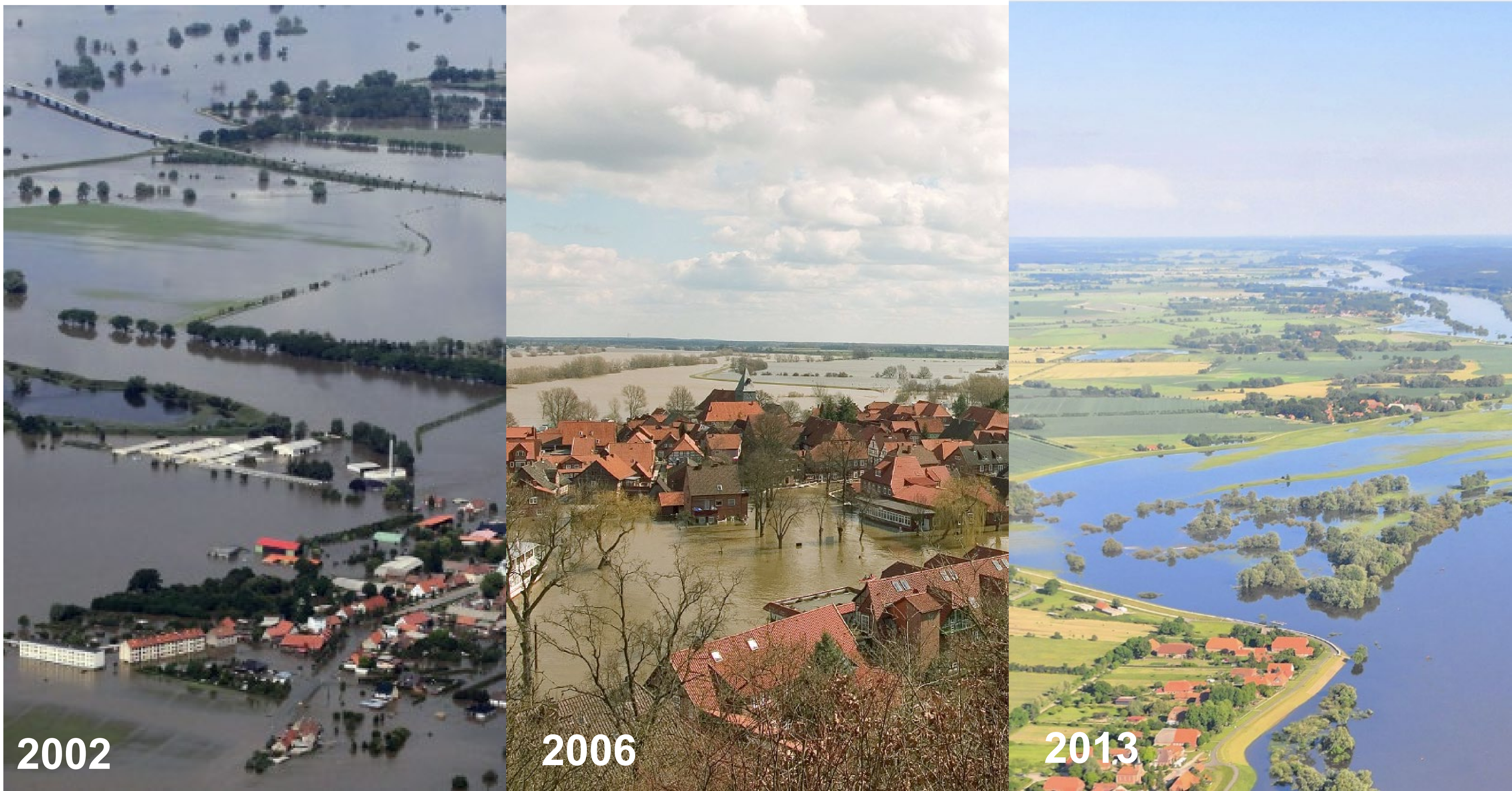
The loss of floodplains exacerbates severe flooding events

Elbe river: Several severe (“100-year”) flooding events since 2000



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Intact floodplains provide numerous ecosystem services

Groundwater recharge

Biodiversity

Cultural Identity

Manifold additional ecosystem services + bennefits of floodplains

Recreation and tourism

Carbon sequestration

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Restoration of Floodplains

How can awareness be raised at the political level for the need to restore floodplains?

How can priorities for restoration projects be identified?

- ➢ Preparation of an evidence-based nationwide overview of the state of German floodplains

How can the benefits of individual restoration projects be demonstrated?

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Preparing a Status Report on Floodplains in Germany

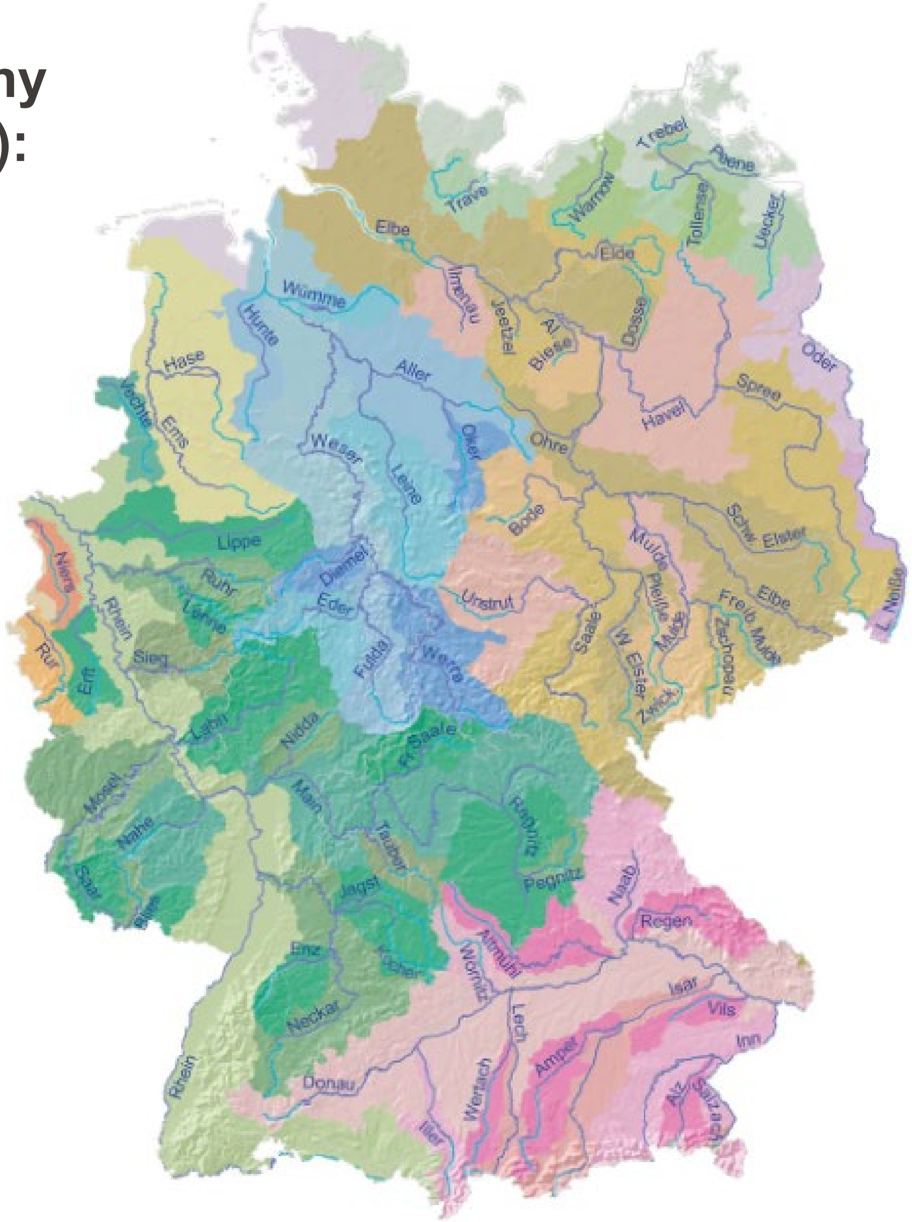
Surveyed rivers and their floodplains in Germany (BfN & BMU 2021, first survey dating from 2009):

Floodplains of 79 rivers

with catchments > 1000 qkm

total length of 10.297 km

4,5 % of Germany‘s area



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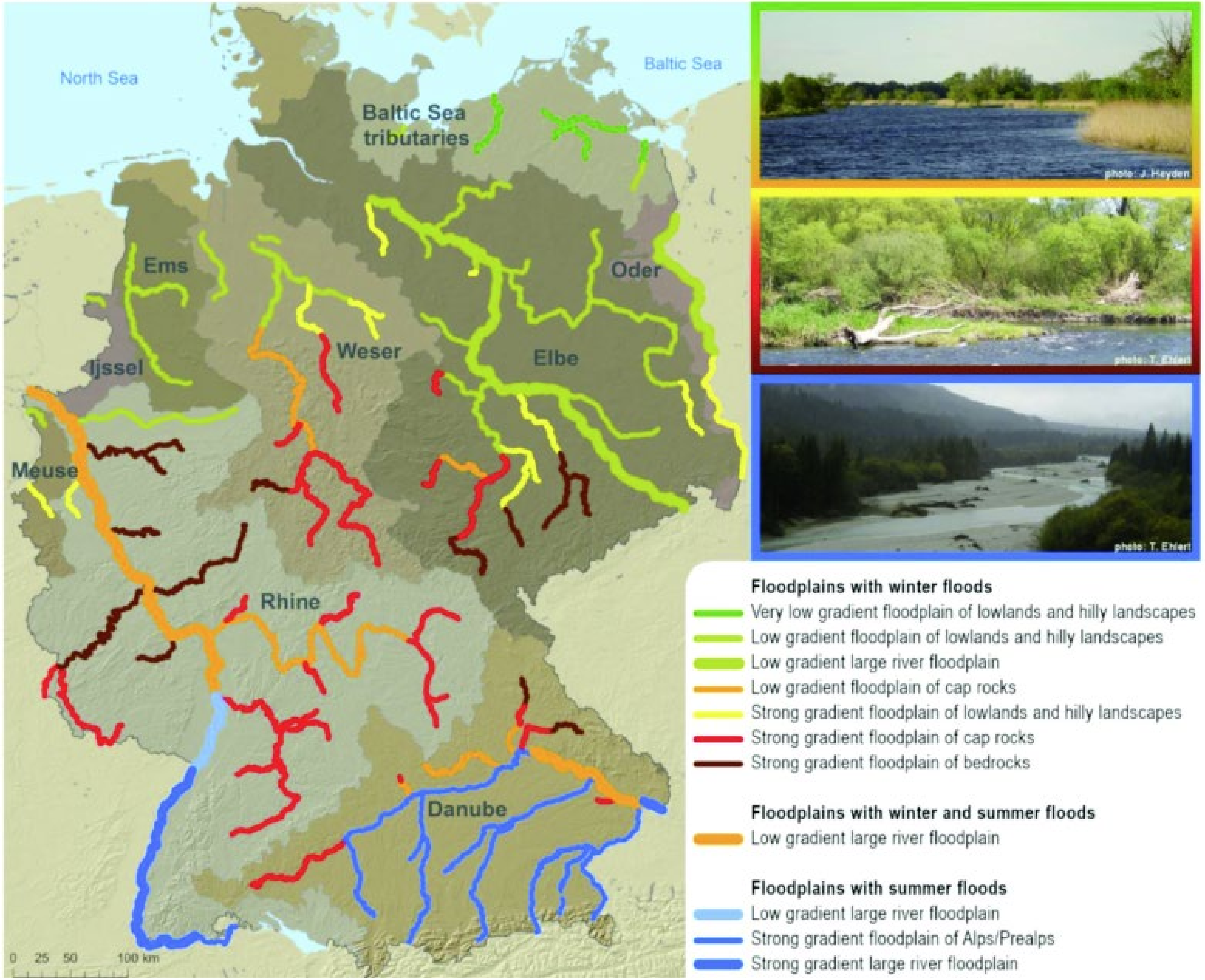
Preparing a Status Report on Floodplains in Germany

I. Identification

Elaborate a typology of German river basins and floodplains

(according to Koenzen 2005)

Data sources: [32,33], basic spatial data © GeoBasis-DE/ BKG (2014), hillshade derived from European Digital Elevation Model (EU-DEM), version 1.1, © European Union, Copernicus Land Monitoring Service 2016, European Environment Agency (EEA)



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Preparing a Status Report on Floodplains in Germany

I. Identification

Delineation of the floodplains

Steps to determine the boundaries of the sub-units:

1. Take the river area from the Digital Land Cover Model.
2. Determine the active floodplain on the basis of flood probability data (medium pro bability, “100-year flood”).
3. Determine the boundaries of the morphological floodplain by a semi-automated calculation based on a detailed digital terrain model and flood areas of rare floods (low probability).

River‘s morphological floodplain can be subdivided in:

Active floodplain: Areas still inundated during floods

Former floodplain: Areas cut off from the river‘s flooding regime

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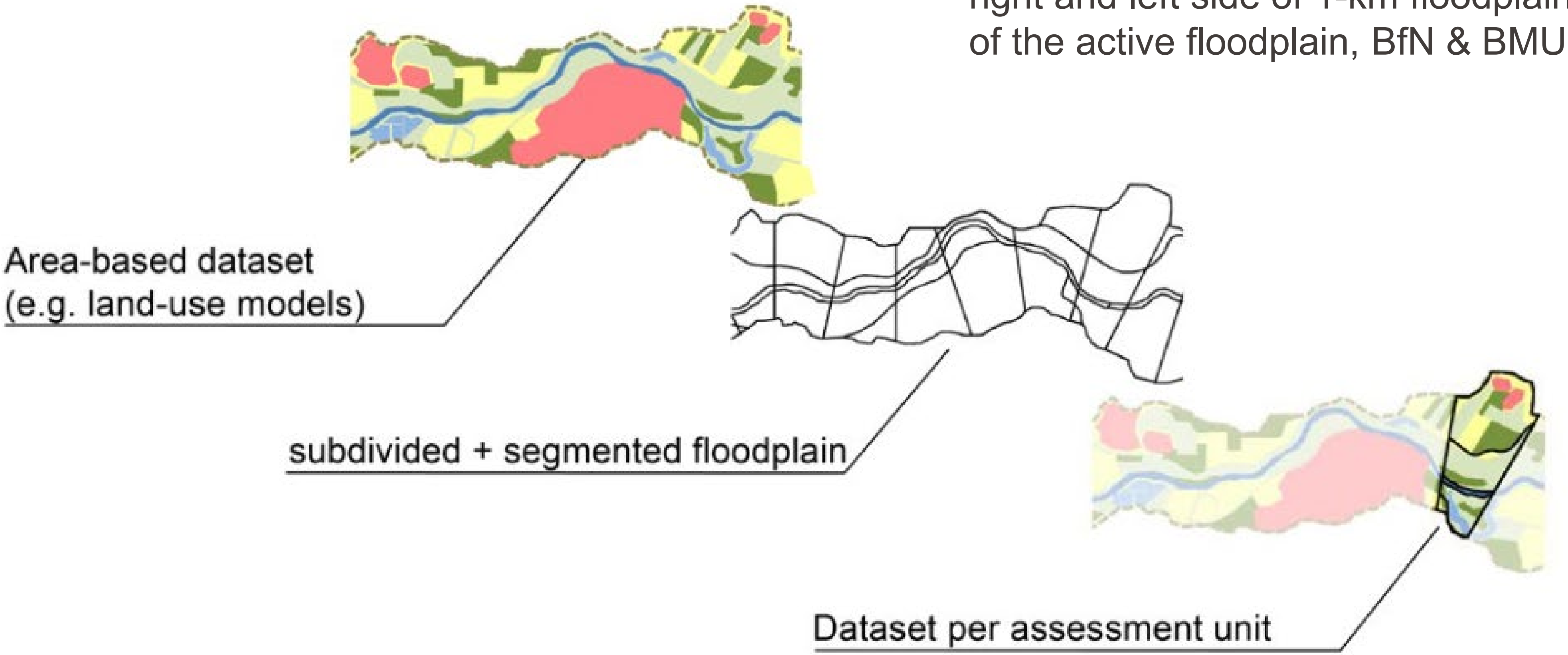
Preparing a Status Report on Floodplains in Germany

II. Analysis

Floodplain Status Assessment

Merging and assigning area-based data to the assessment categories (functional units, right and left side of 1-km floodplain sections of the active floodplain, BfN & BMU 2021)

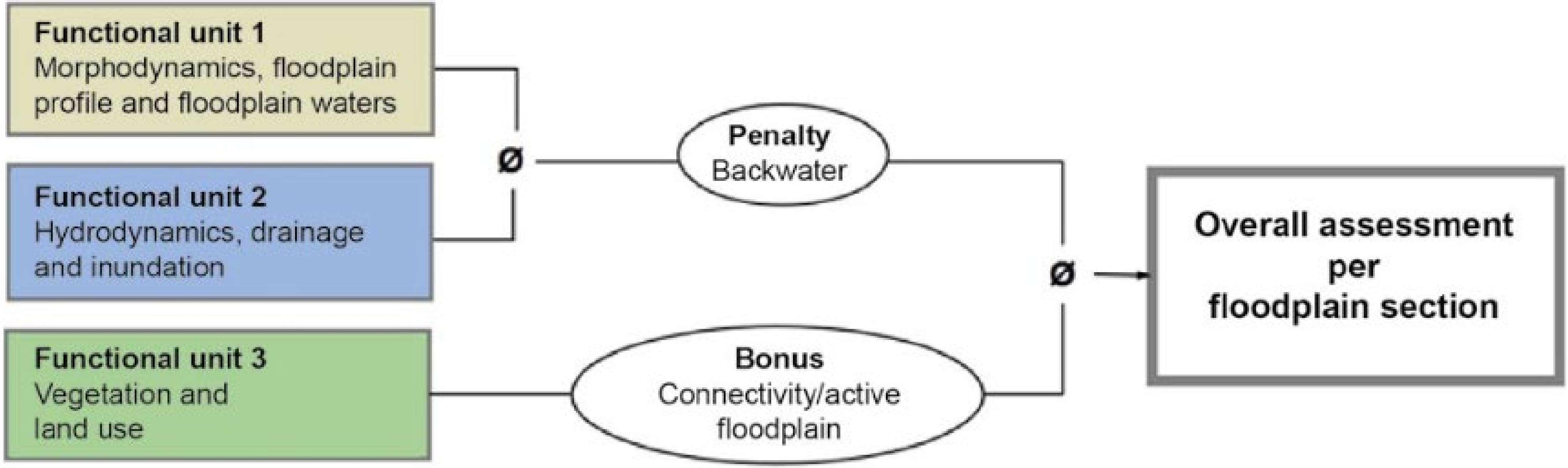


Preparing a Status Report on Floodplains in Germany

II. Analysis

Floodplain Status Assessment

Calculating the status of the functional units by combining the following criteria (BfN & BMU 2021):



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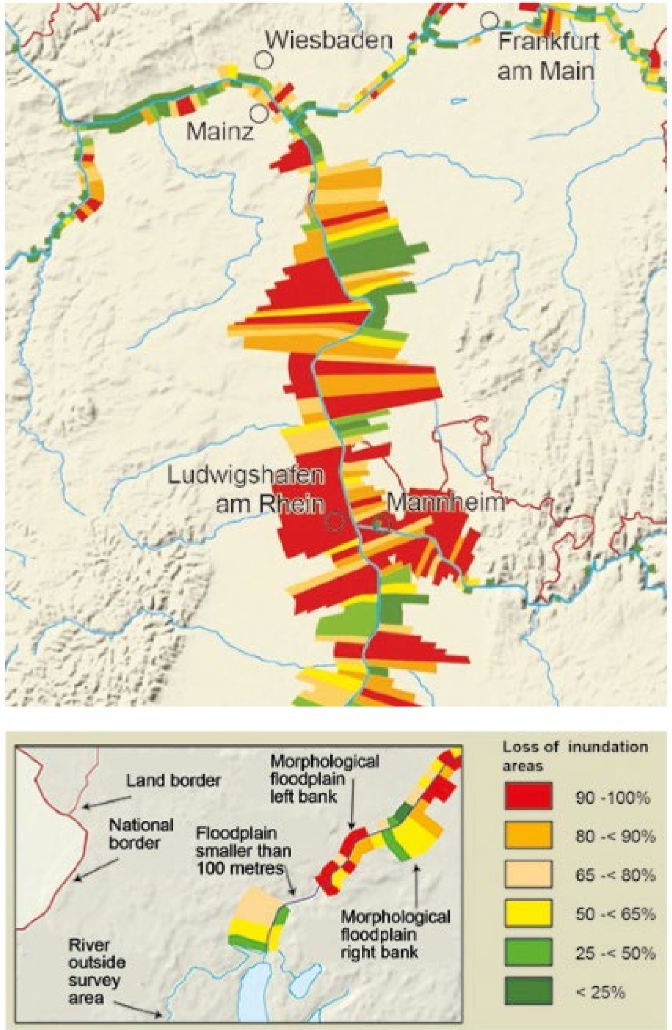
Preparing a Status Report on Floodplains in Germany

II. Analysis

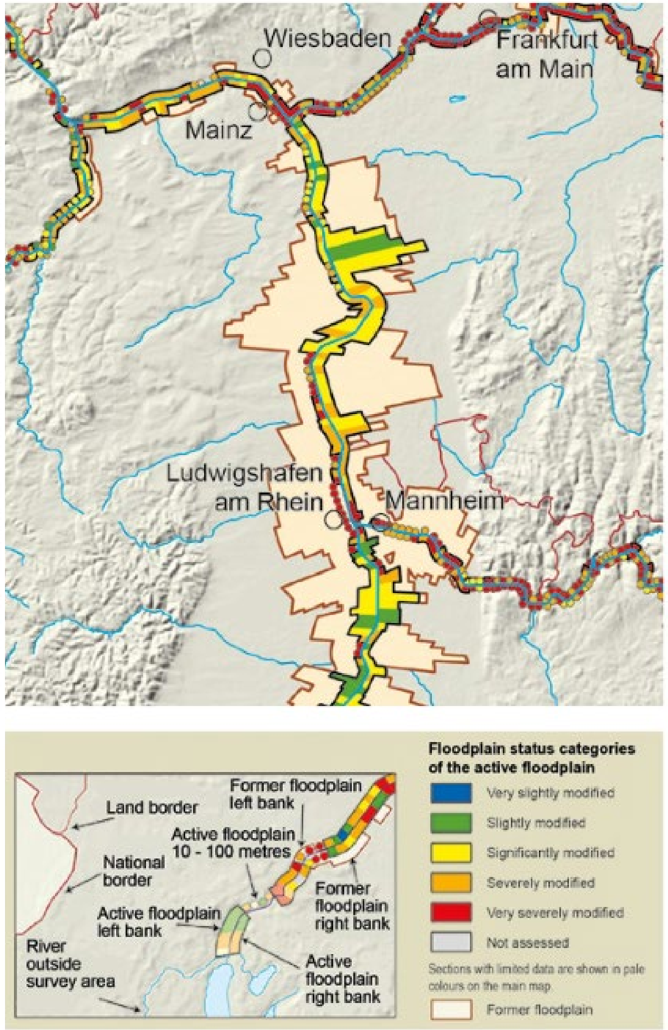
Floodplain Status Assessment

Category		Characteristics
1	Very slightly modified	▶ Floodplains not disconnected or only very slightly disconnected from flooding due to river engineering and/or flood protection measures ▶ Rivers usually with a very low degree of engineering, rarely with standard profile, with very high potential for inundation ▶ Mainly no land use or very low-intensity land use, mostly forest, wetlands and occasionally grassland
2	Slightly modified	▶ Floodplains disconnected to a small degree from floods by river engineering and/or flood protection measures ▶ Rivers with varying degrees of engineering, partly with standard profile, but generally with high potential for inundation ▶ Mainly low-intensity land use, mostly forest, wetlands and grassland
3	Signif-icantly modified	▶ Floodplains partially disconnected from flooding by river engineering and/or flood protection measures ▶ Rivers usually engineered, but with potential for inundation ▶ Variable land use intensities
4	Severely modified	▶ Floodplains largely disconnected from flooding by river engineering and/or flood protection measures ▶ Rivers generally engineered, partially impounded ▶ Intensive land use, mainly intensive agriculture and settlements
5	Very severely modified	▶ Floodplains disconnected from flooding by river engineering and/or flood protection measures ▶ Rivers generally heavily engineered, often impounded ▶ High intensity land use, mostly with higher proportions of settled land

Resulting floodplain status categories (BfN & BMU 2021)



Section of map „Loss of inundation areas“



Section of map „Floodplain status“

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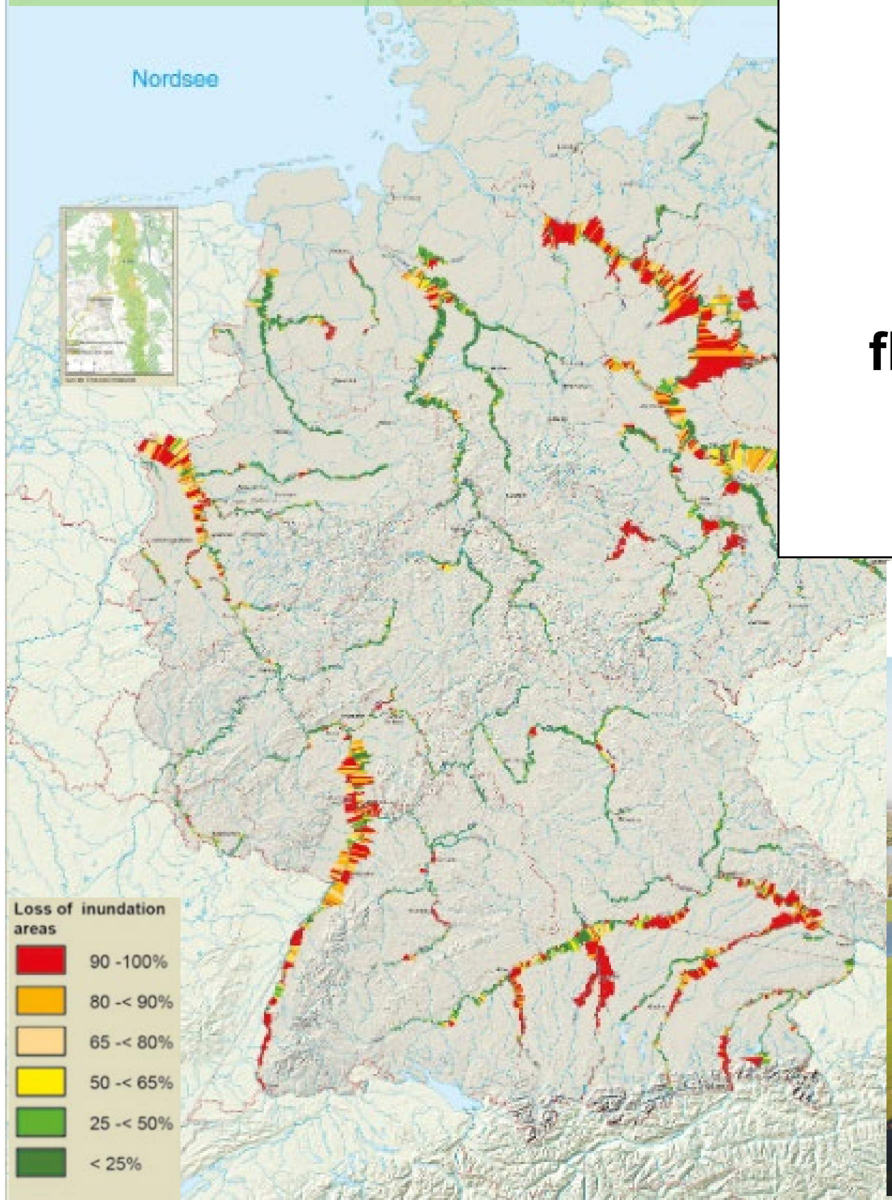
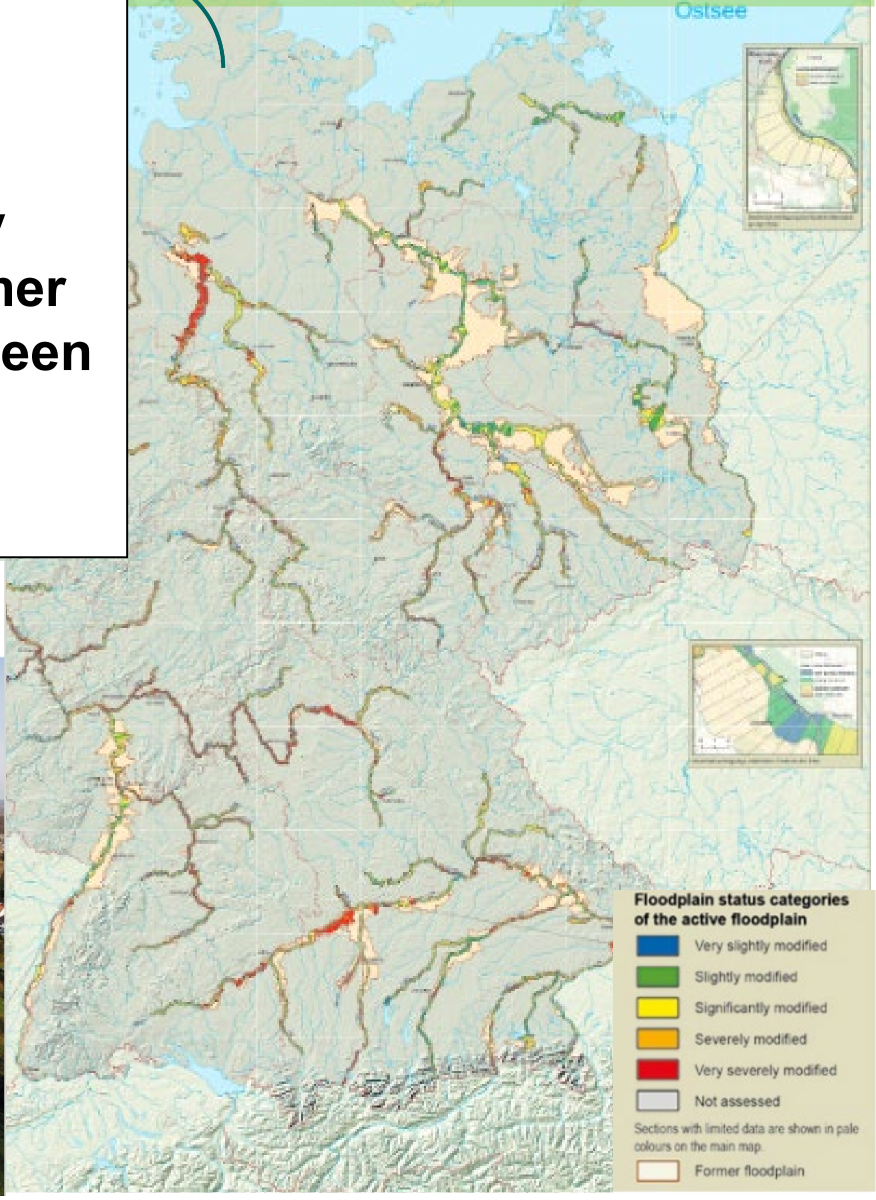
Nation-wide overview of the status of floodplains

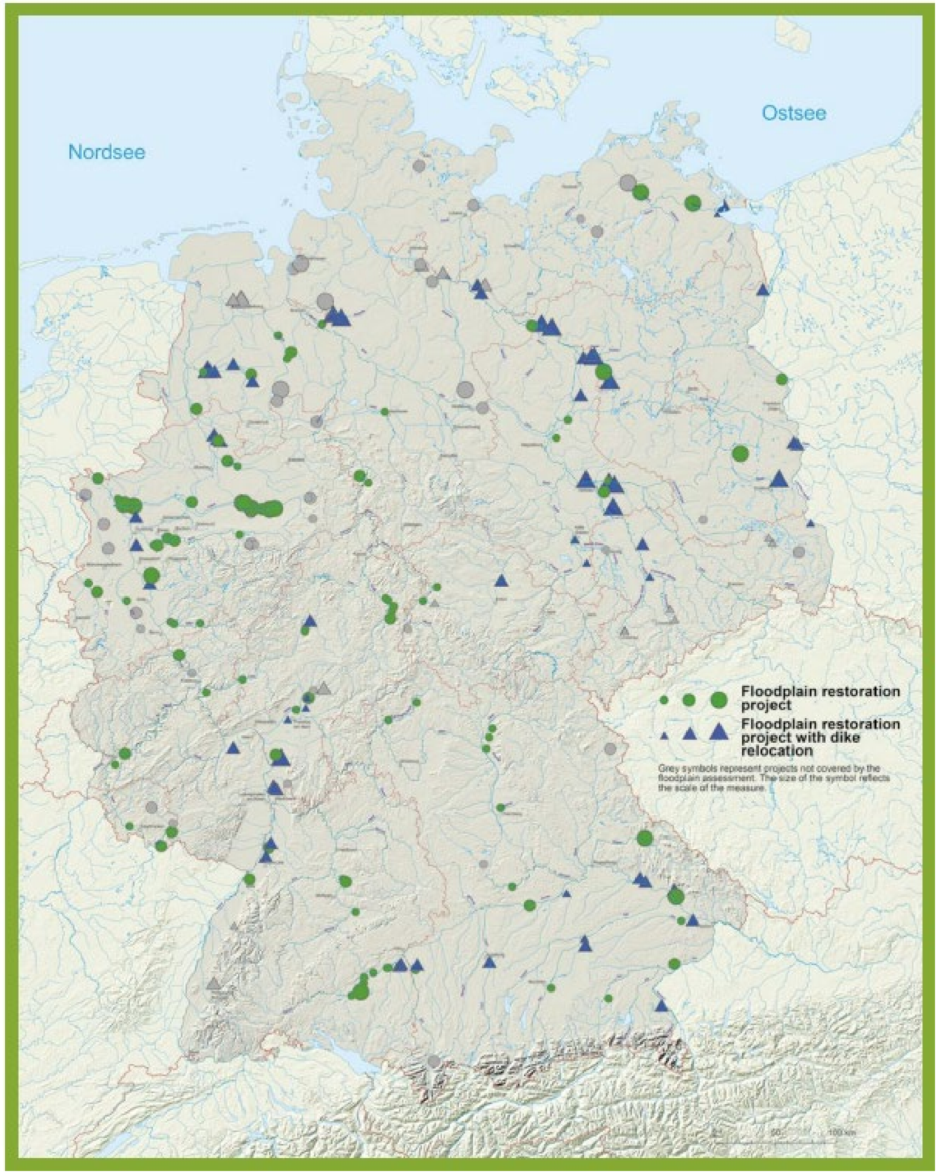
Loss of inundation areas | **Ecological state of floodplains**

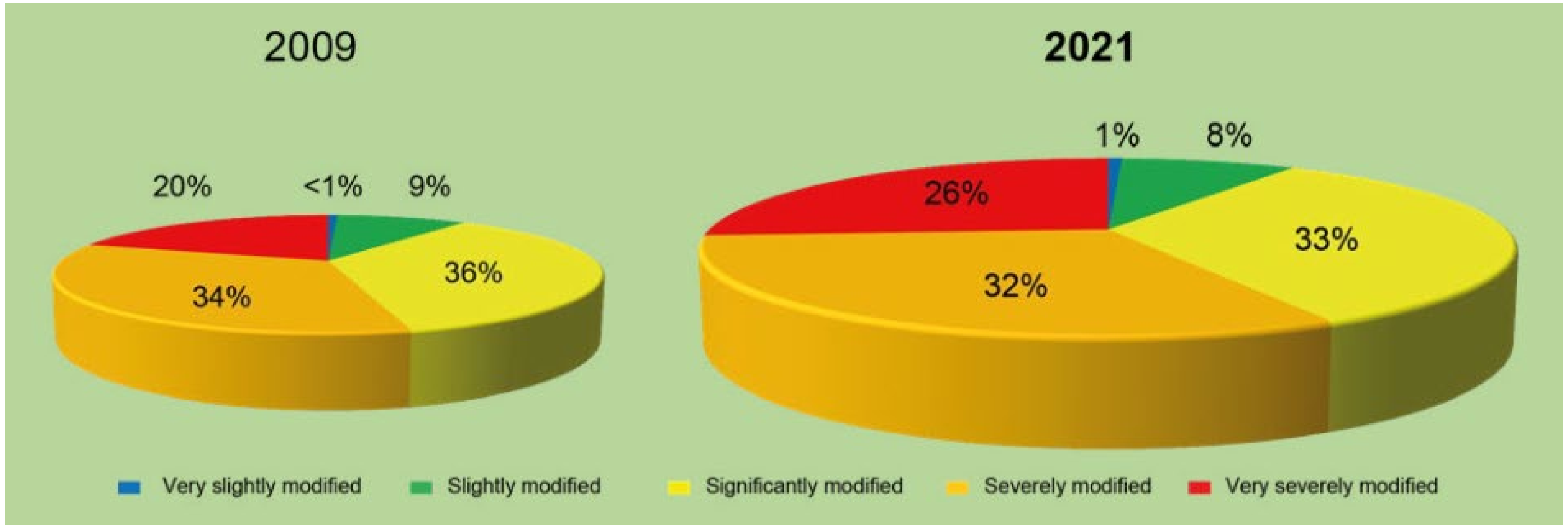


All over Germany two-thirds of former floodplains have been lost



Nation-wide overview of the status of floodplains





Despite of many floodpain restoration projects on rivers in Germany over the last years…

…no significant change in the status of the river floodplains in Germany over the last 12 years

…still **only 9 % of the foodplains are „slightly“ oder „very slightly modified“**, but one third are „significantly modified“

(BfN & BMU 2021)

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Nation-wide overview of the status of floodplains

Despite of many floodpain restoration projects on rivers in Germany over the last years…

…the overall status of floodplains did even slightly deteriorate from 2009 to 2021.

Excavated water body

Landfill site

Arable land and intensively used grassland in the floodplain

Intensive agriculture and quarry ponds

Buildings in the floodplain

Various forms of land use that contribute to a negative state of floodplains

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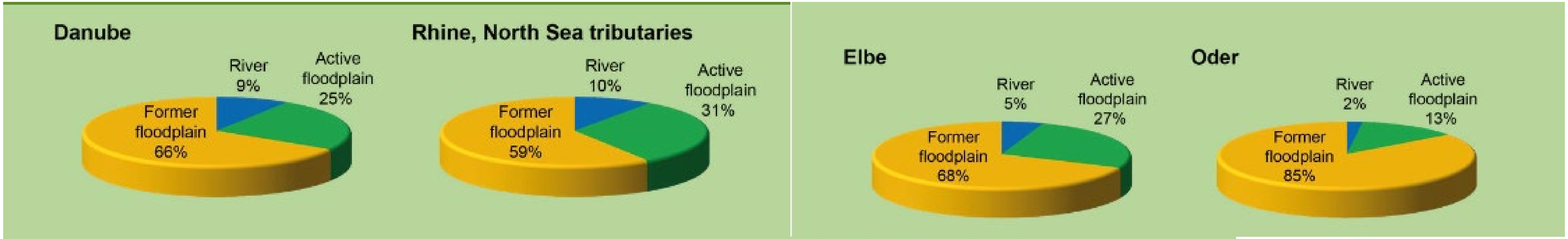
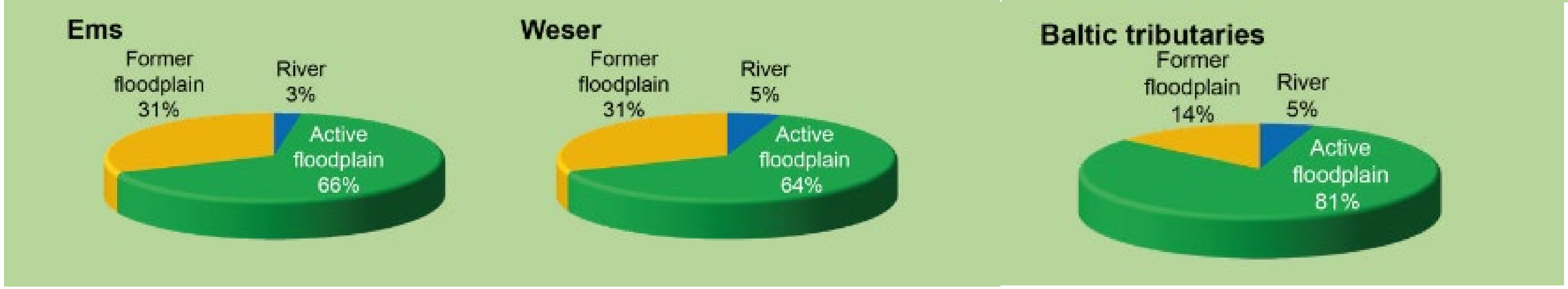
Nation-wide overview of the status of floodplains





Proportions of remaining active floodplain areas (green) within the seven river basins (BfN & BMU 2021)

However, there are significant regional differences between the river basin districts, and thus different needs for action….

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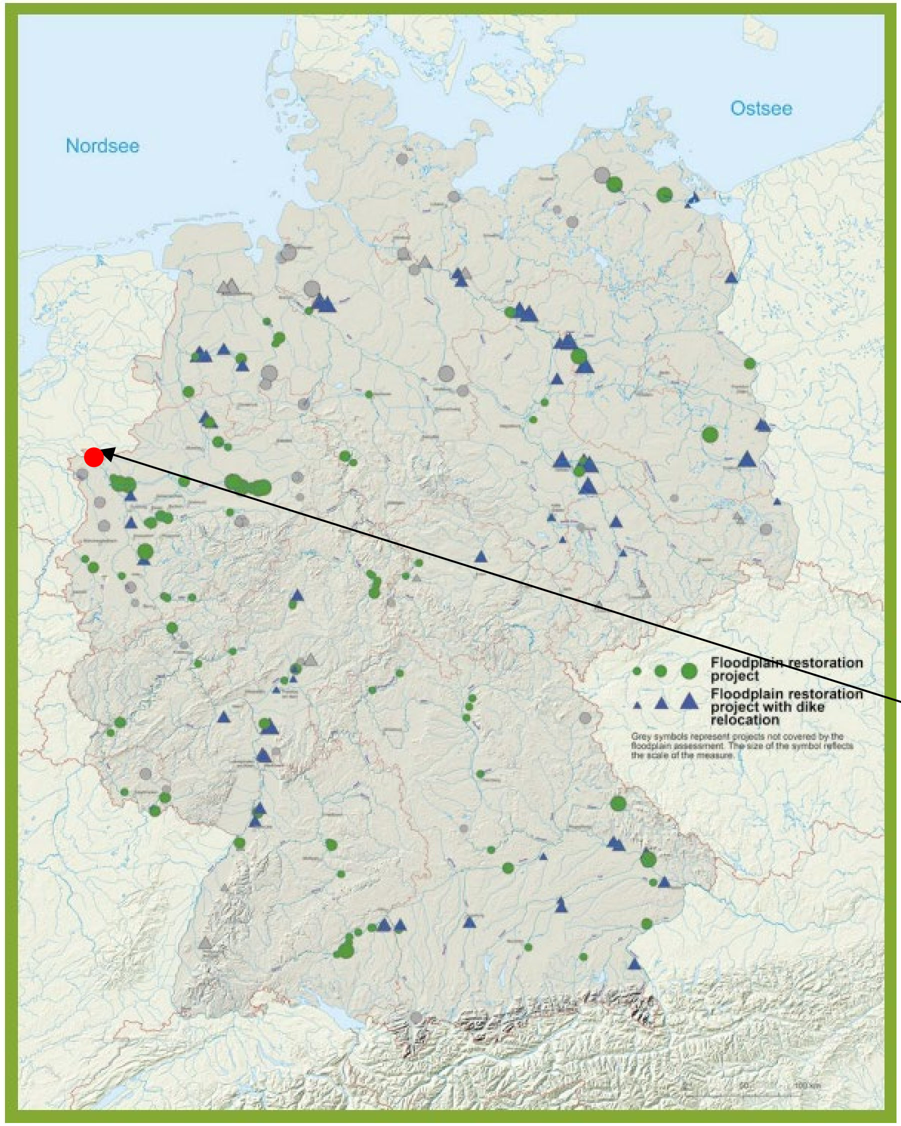
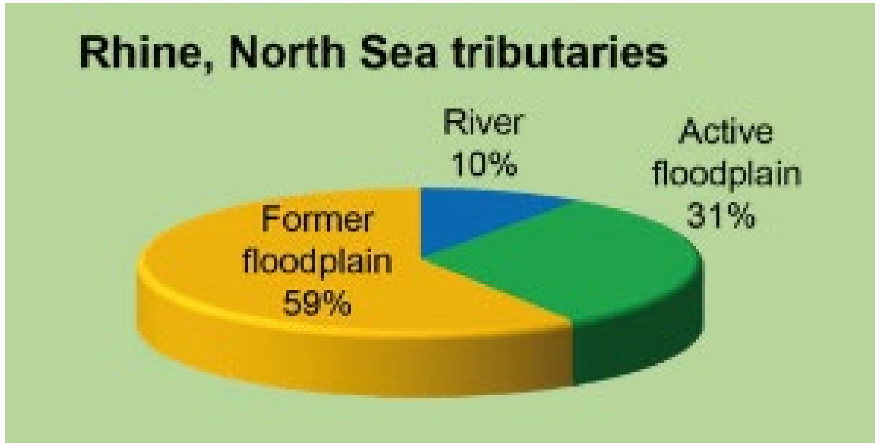
Status of Floodplains in Germany

III. Implementation





Proportions of remaining active floodplain areas (green) within the Rhine +North Sea tributaries basin (BfN & BMU 2021)

Restoration Project „Mouth of the Lippe

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Status of Floodplains in Germany

III. Implementation

Restoration Project „Mouth of the Lippe

The mouth of the Lippe: white lines: floodplain delineation with 1-km floodplain sections

The Lippe before the measures were implemented (left) and immediately after the measures were implemented (right)

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Status of Floodplains in Germany

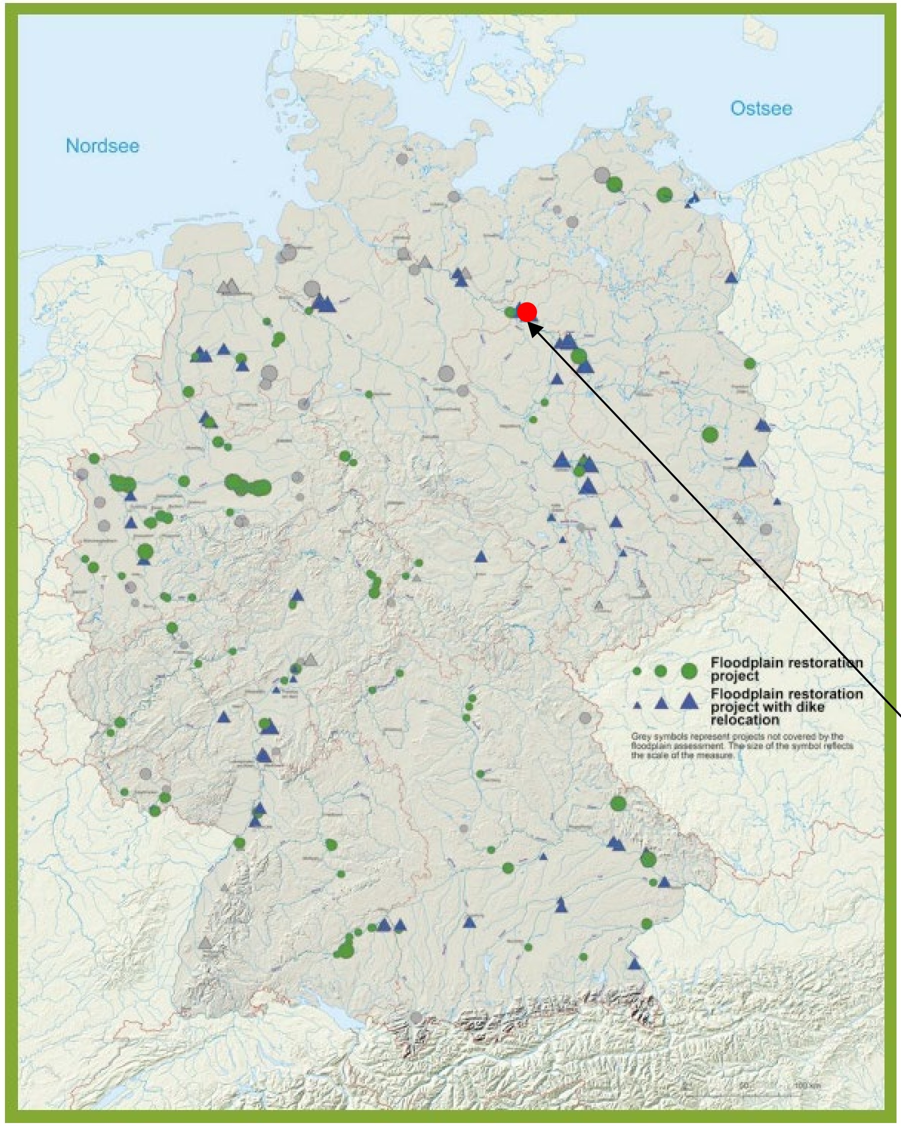
III. Implementation

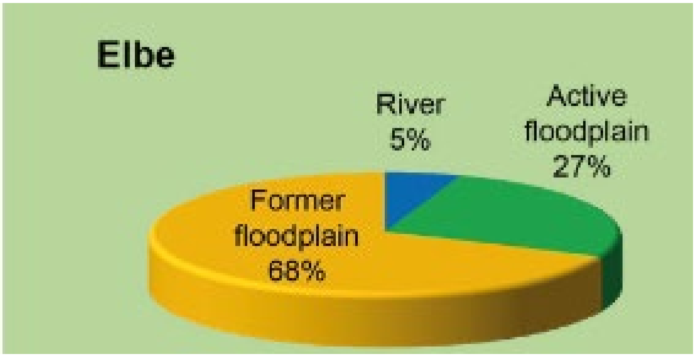
Restoration Project „Mouth of the Lippe“

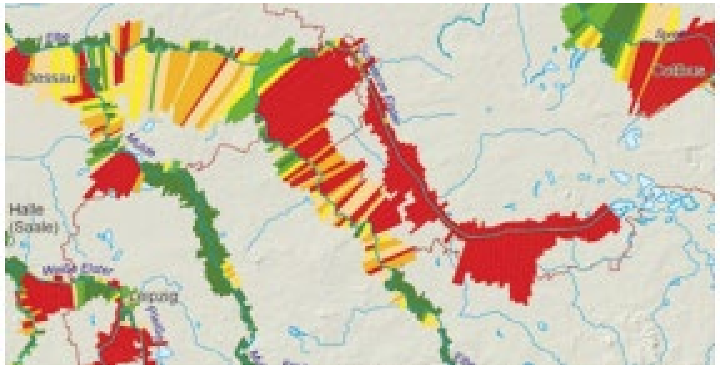
The engineered mouth of the Lippe before it was redesigned (left) and following its restoration (right) (BfN & BMU 2021).

Status of Floodplains in Germany

III. Implementation







Proportions of remaining active floodplain areas (green, above) within the Elbe rivertributaries basin and loss of inundation areas at the Middle Elbe (BfN & BMU 2021)

Restoration Project „Lenzener Elbtalaue“

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Status of Floodplains in Germany

III. Implementation

Restoration Project „Lenzener Elbtalaue“

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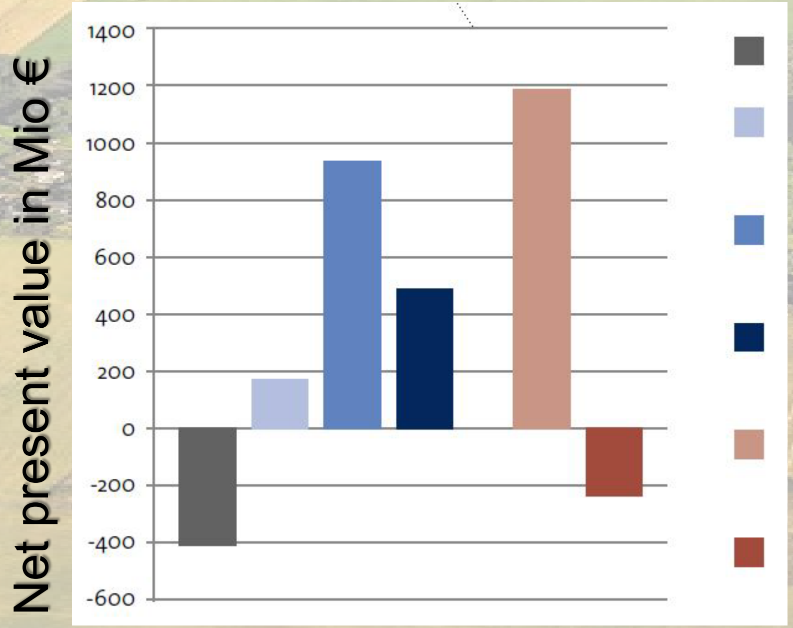
Status of Floodplains in Germany

III. Implementation

Restoration Project „Lenzener Elbtalaue“

Making aware the related benefits



- Investment costs
- Benefit (avoided flood damages)
- Benefit (willingness to pay for biodiversity)
- Benefit (increased nutrient retention)
- Total (broad) multifunctional perspective
- Total (traditional) flood protection perspective

Source: TEEB DE (2014), based on Grossmann et al. 2010)

Photo: NABU Germany

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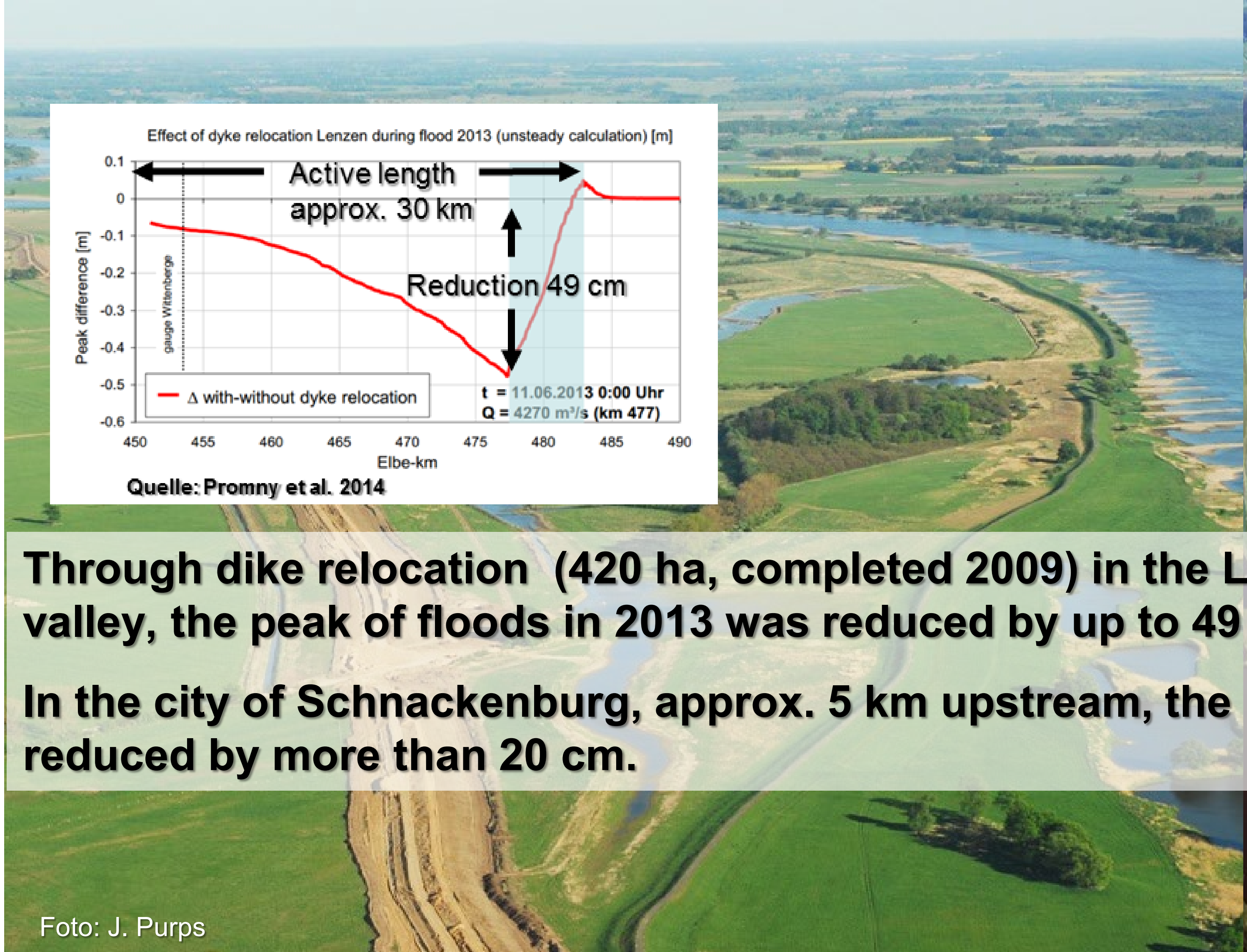
Status of Floodplains in Germany

III. Implementation

Restoration Project „Lenzener Elbtalaue"



Through dike relocation (420 ha, completed 2009) in the Lenzener Elbe valley, the peak of floods in 2013 was reduced by up to 49 cm.

In the city of Schnackenburg, approx. 5 km upstream, the peak was reduced by more than 20 cm.

Foto: J. Purps

Foto: K. Nabel

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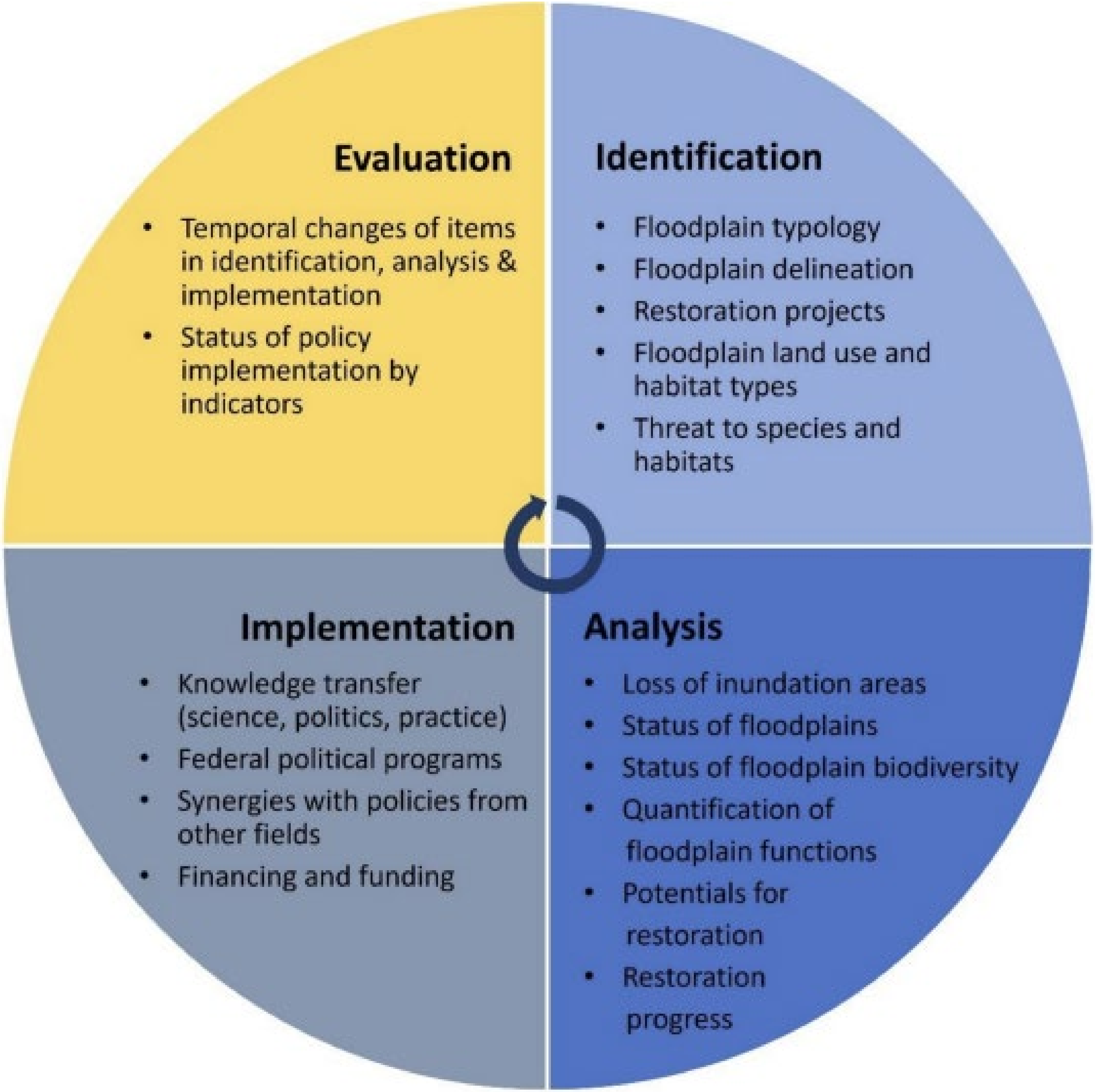
Elements of a comprehensive floodplain management



Heyden & Natho 2022
https://doi.org/10.3390/su141710610

II. Restoration of Peatlands and carbon-rich soils

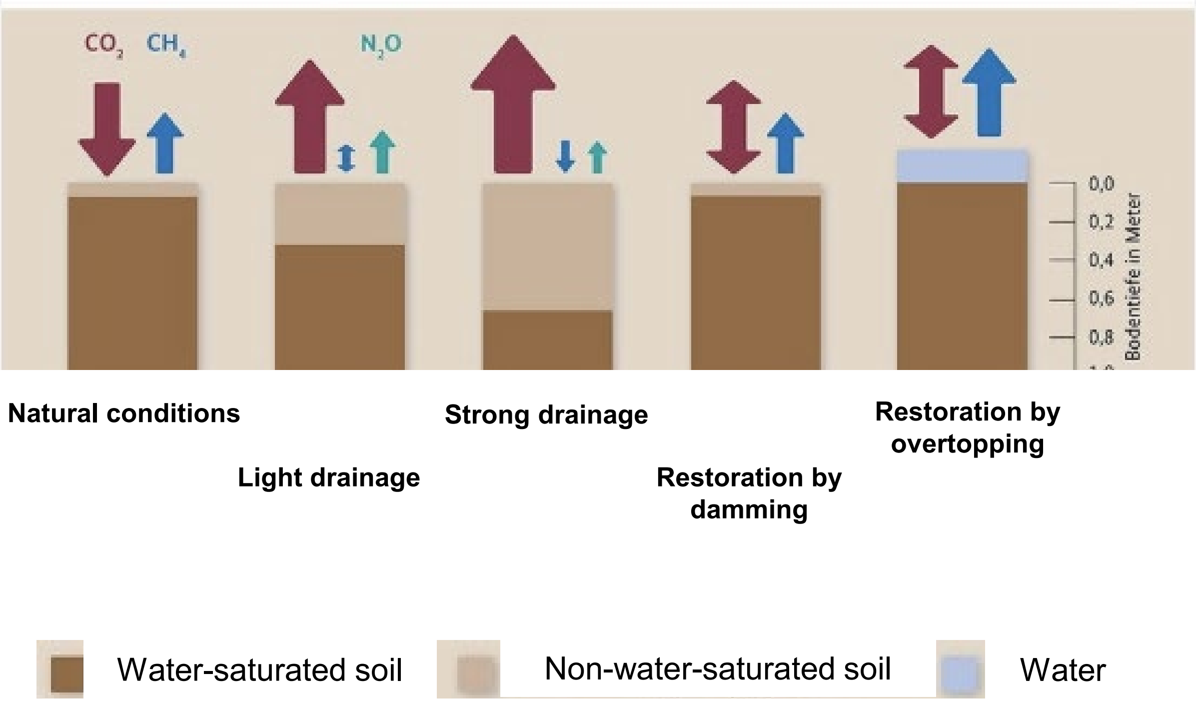
Multiple Ecosystem Services provided by intact peatlands

Function	Description
Sink	Deposition and recycling of nutrients
Disposal	Carbon sequestration
Regulation	Keeping cultural landscapes open; site- and culture-specific biodiversity; ground-water retention
Conservation	Regional responsibility for plant communities; key species
Production	Fodder, food, biomass, raw materials
Information	Landscape beauty, recreation, aesthetics and cognition, research

Foto: © Karin Ullrich

- **Although they cover only 3-4% of the earth's surface, peatlands store about a third of the world's soil CO_2.**

Drained peatlands contribute to climate change



Drösler et al 2020

- Intact peatlands continuously sequester CO_2 in the soil,
  while drained peatlands release large amounts of CO_2 into the atmosphere, accelerating climate change.
- Over 90% of Germany's and Switzerland's peatlands have been drained and disappeared in the last 200 years.
  > Result: Large CO_2-emissions
  (in Germany contributing about 7.5 % of the country's total greenhouse gas emissions).
- Drainage of peatlands also means the loss of other services, such as of the native flora and fauna and the balancing effect on the landscape's water balance.
- Rewetting peatlands: the decomposition of peat is stopped and the release of CO_2 is reduced.
- However, rewetting drained peatlands may result in initially high methane (CH_4) emissions, which is often seen as a counter-argument against rewetting.

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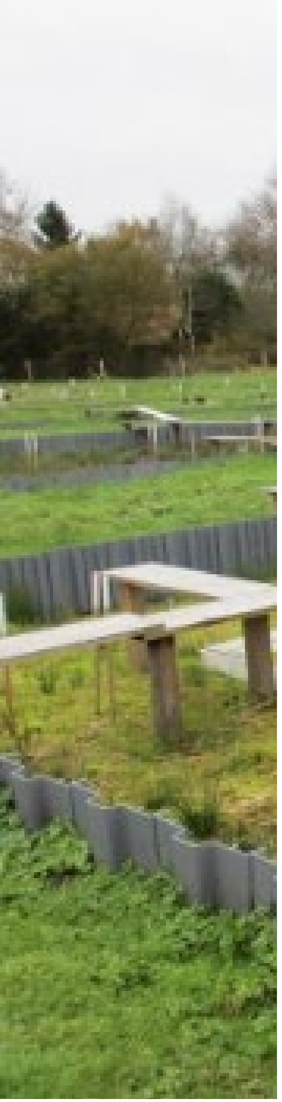
Restoration of peatlands and carbon-rich soils



Which restoration method is best in the long term for maintaining a functional and near-natural raised bog?

How can incentives be created to foster peatland restoration?

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The OptiMoor Project

Is it possible to restore a living raised bog on areas that have been used for agriculture for decades to centuries?

Long-term goal: develop and disseminate guidelines for the restoration of raised bog sites that were previously used for agriculture.

Project consists of two sub-projects:
implementation part 2016–2019
accompanying scientific part 2016–2021

Rewetted bog in the Diepholzer Moor lowlands © N. Jantz

Carried out by:

Universität Rostock Traditio et Innovatio

Europäisches Fachzentrum MOOR und KLIMA

Funded by:

BfN Bundesamt für Naturschutz

Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit

NBank

EUROPÄISCHE UNION
Europäischer Fonds für regionale Entwicklung

EUROPA FÜR NIEDERSACHSEN

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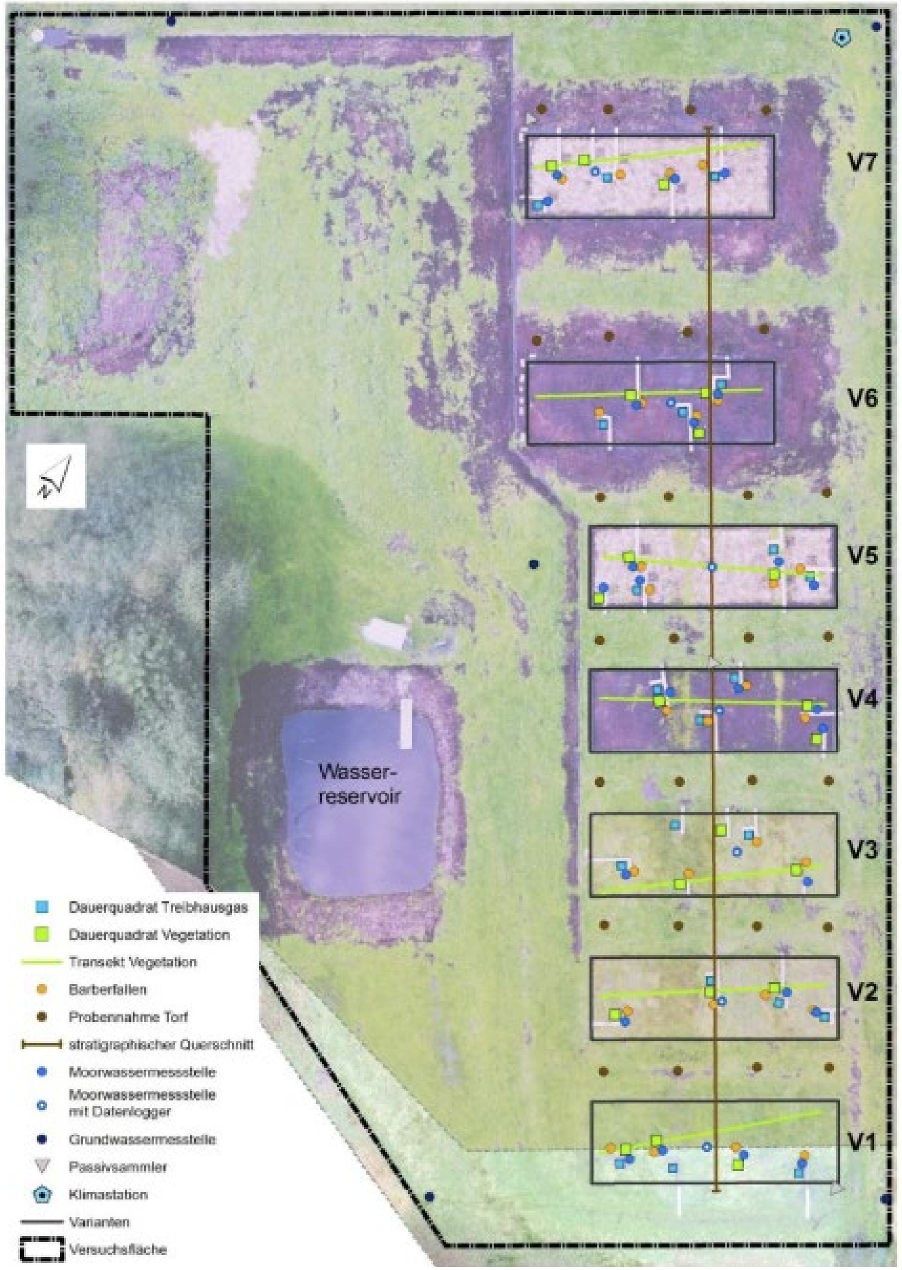
The OptiMoor Project
Test design – seven variants are analysed

	Plot name	Management measures
V1	IG	Three-cut regime with an N-fertilization equivalent of 150 kg/ha mimicking the previous land use
V2	OS	Rewetting at original surface and free succession
V3	OS+mowing	Rewetting at original surface with regular (two-cut) biomass harvesting
V4	TSR30	Rewetting after topsoil removal of on average 30 cm and free succession
V5	TSR30 + Sphagnum	Rewetting after topsoil removal of on average 30 cm and introduction of *Sphagnum* spp. fragments covered with a straw layer
V6	TSR60	Rewetting after topsoil removal of on average 60 cm and free succession
V7	TSR60 + Sphagnum	Rewetting after topsoil removal of on average 60 cm and introduction of *Sphagnum* spp. fragments covered with a straw layer



Huth et al. 2020

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Test design – different data to be collected

Greenhouse gases
Measurements of the carbon dioxide, methane and nitrous oxide exchange carried out with the help of gas collection hoods.

Nutrients
The initial hydrological conditions on the area were recorded by taking samples of the groundwater (1 m below the mineral subsoil) and the bog water (0.2 m above the mineral subsoil). During the project regular examination of samples of the bog and groundwater in order to track the development of the water chemistry and nutrient situation.

Stratigraphy/Soil conditions
Peat drillings to determine the humus content and the bulk density of the peat, as well as for further nutrient analyses. After uncovering the peat, examine the material to see if germinable seeds and spores are present and to determine which species they belong to.

Flora and Fauna
Vegetation analysis at regular intervals; trap analysis to determine the input of diaspores (to predict which plant species could be established) and to determine the diversity of some animals groups that live on the ground (insects and spiders).

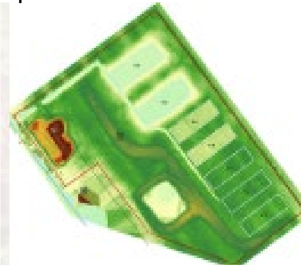
Remote Sensing
Creation of a detailed digital terrain model (to map changes in the terrain and to accurately estimate the amount of peat removed)

Water management
Regulation of the water level using pumps and sheet piling.


Greenhouse gas measurement with the hood method © A. Bartel


Detection of spiders using pitfall traps © N. Jantz


Inserting peat moss (*Sphagnunm* ssp.)


The elevation model shows changes in the relief© Hofer & Pautz GbR


Re-pumping when the water level drops. The water meter measures the amount of water supplied. © A.Bartel

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The OptiMoor Project
Results

Approach	Year	CO_2-C g/m²	Harvest-C g/m²	CH_4-C g/m²	N_2O-N g/m²	Topsoil-C kg/m²
IG	Year 1	185.1 ± 16.4	445.5 ± 18.7	27 ± 13.6	0.3 ± 0.1	0
OS		123 ± 11.4	0	90.8 ± 16.6	0.2 ± 0.1	0
OS+mow.		406.9 ± 13.9	300.6 ± 15.6	111.8 ± 36.2	0.1 ± 0.2	0
TSR30		−39.3 ± 5.8	0	2.5 ± 0.3	−0.1 ± 0.1	17.49 ± 0.95
TSR30 + Sphag.		−76.8 ± 5.5	0	2.1 ± 0.3	−0.1 ± 0.1	20.10 ± 1.17
TSR60		35.1 ± 3.6	0	0.3 ± 0.1	0 ± 0.2	37.05 ± 1.57
TSR60 + Sphag.		−154.5 ± 4.8	0	1 ± 0.1	−0.1 ± 0.1	38.87 ± 3.21

Approach	Year	CO_2-C g/m²	Harvest-C g/m²	CH_4-C g/m²	N_2O-N g/m²	Topsoil-C kg/m²
IG	Year 2	1892.8 ± 33	640.6 ± 24.5	−0.1 ± 0.1	0.4 ± 0.2	0
OS		701.8 ± 15	0	48.5 ± 4	0.2 ± 0.1	0
OS+mow.		631.8 ± 17.9	218.6 ± 25.6	103.8 ± 34.4	0.6 ± 0.5	0
TSR30		−14.5 ± 10.3	0	3.9 ± 0.1	−0.2 ± 0.4	0
TSR30 + Sphag.		−84.2 ± 10	0	3.1 ± 0.3	0 ± 0.2	0
TSR60		26 ± 7.4	0	0.7 ± 0.1	0 ± 0.2	0
TSR60 + Sphag.		−92.7 ± 8.9	0	1.2 ± 0	0 ± 0.1	0

Greenhouse gas emissions (in g/m²) of the *status quo* plot ("IG") and the six restoration approaches in year 1 (24 September 2017 to 25 September 2018) and year 2 (25 September 2018 to 25 September 2019) and C export by TSR (Huth et al. 2020).

OS – Rewetting at original surface

TS – Rewetting after topsoil removal

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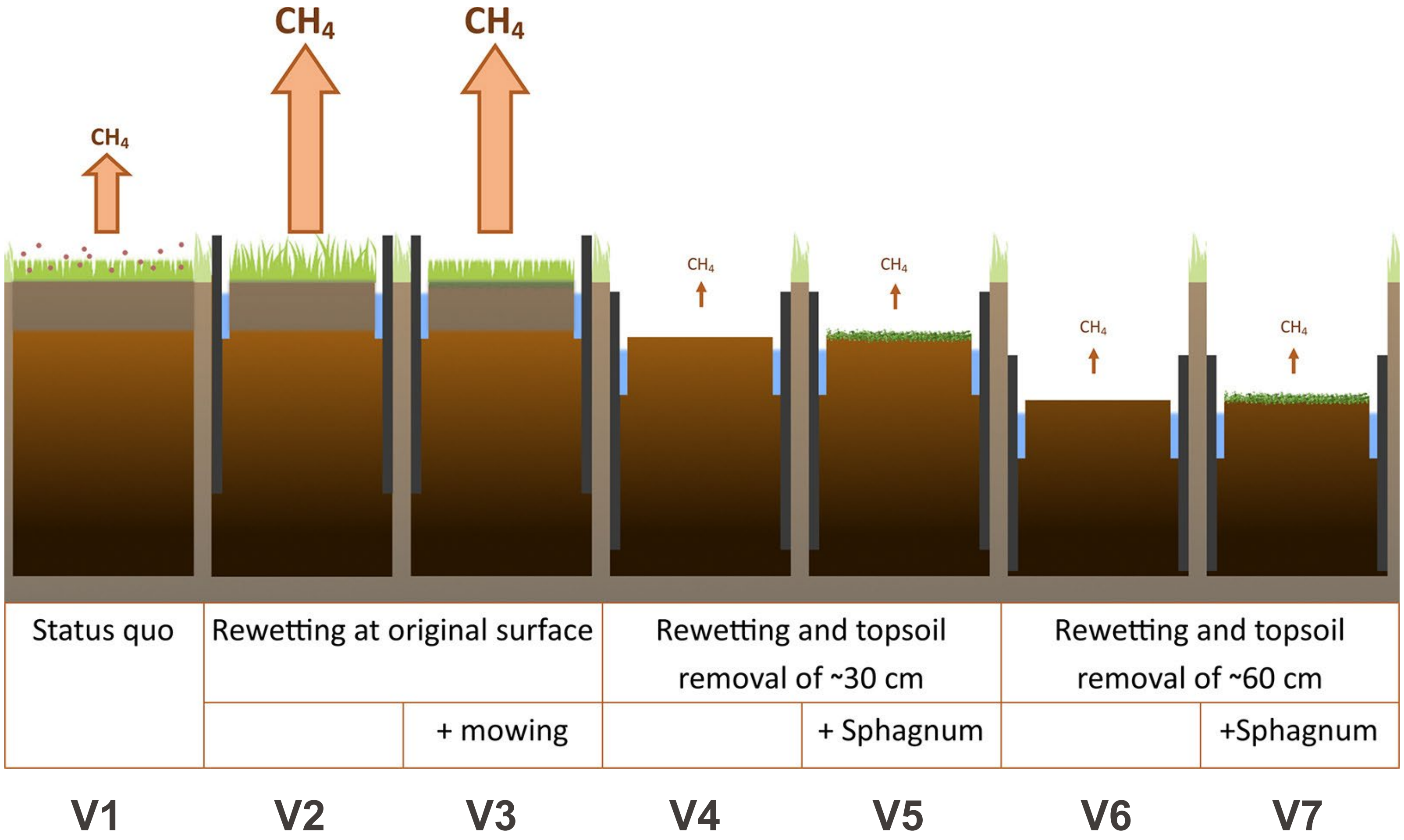
The OptiMoor Project
Results



- Topsoil removal prior rewetting reduces CH_4 emissions by factor 30–400.
- CH_4 production and methanogen abundance are highest in the degraded topsoil.
- Spreading of moss (*Sphagnum* spp.) had only little effect on CH_4 emissions during the first year of establishment.

➢ **Efficiency of removing degraded topsoil to avoid high CH_4 emissions after rewetting was demonstrated**
(Huth et al. 2020)

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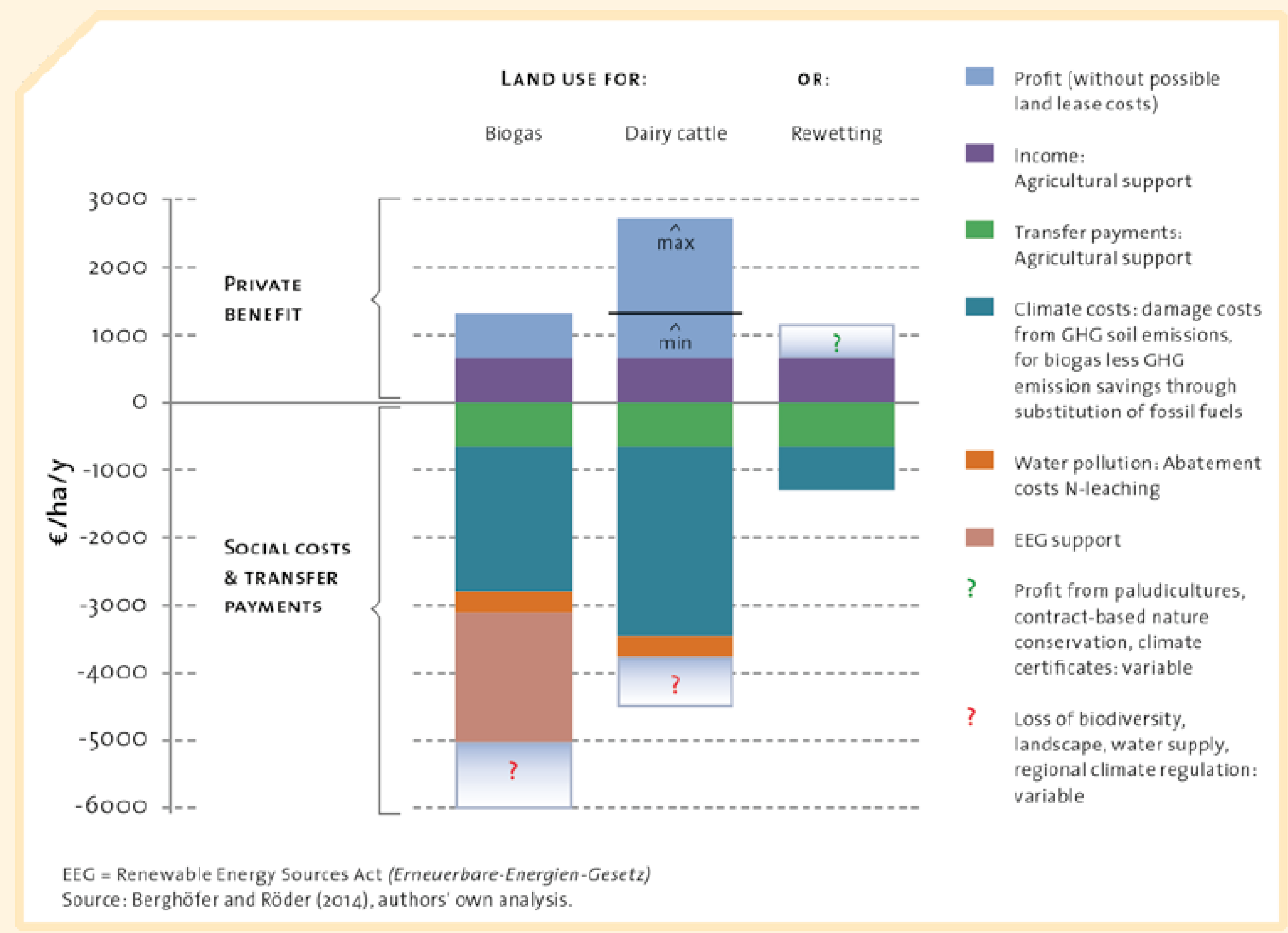
Restoration of peatlands and carbon-rich soils
How can appropriate incentives be established?



TEEB Germany 2015, according to S. Wichmann

Private benefits, social costs and subsidies for land use on drained peatlands in Lower Saxony.

Estimates in €/ha/y for

- Biogas (electricity from energy crops),
- Maize (cultivation for dairy cattle fodder),
- rewetting for nature conservation/ climate change mitigation,with paludiculture if appropriate

➢ **From a societal perspective, rewetting it is the best use of peatlands, as it has a less harmful effect on the climate and water resources and enhances other ecosystem services.**

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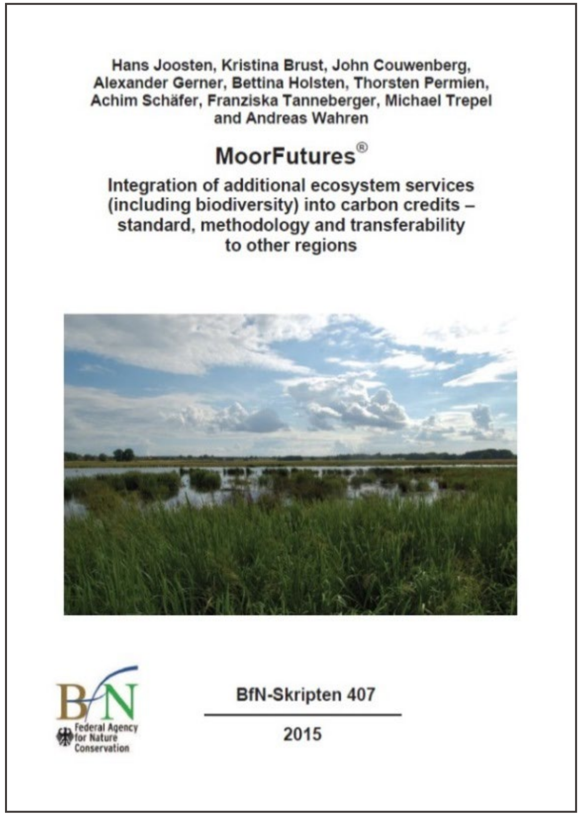
MoorFutures – Establish a Certificate Trading System for restored peatlands

Moor Futures


Hans Joosten, Kristina Brust, John Couwenberg, Alexander Gerner, Bettina Holsten, Thorsten Permien, Achim Schäfer, Franziska Tanneberger, Michael Trepel and Andreas Wahren

MoorFutures®

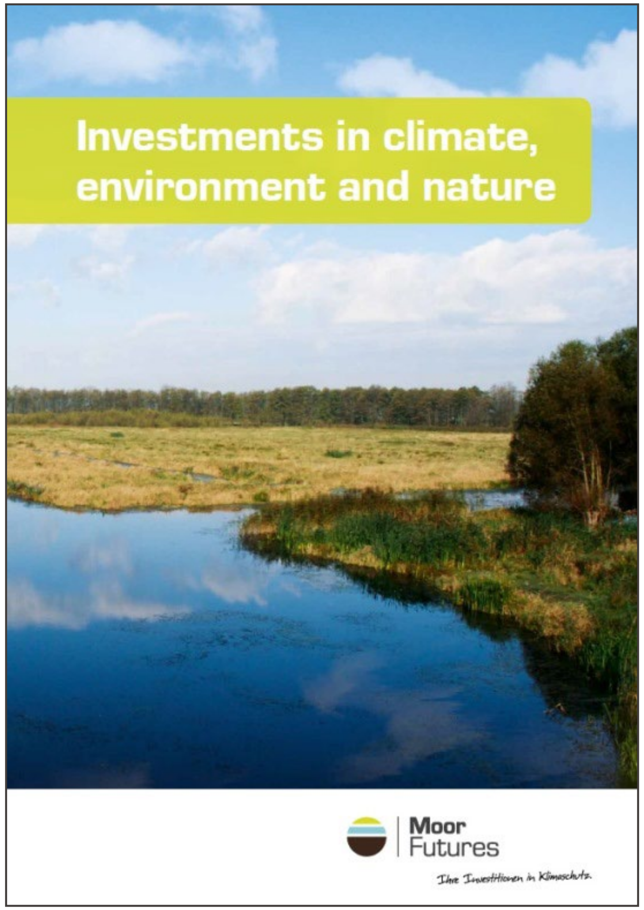
Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions

BfN Federal Agency for Nature Conservation

BfN-Skripten 407

2015

https://www.moorfutures.de/



MoorFutures – Requirements

- Designed for voluntary markets
- Site-specific, science-based + transparent
- Based on certified valuation of reduction of CO_2 emissions
- Take into account additional benefits
- Permanent maintenance has to be guaranteed

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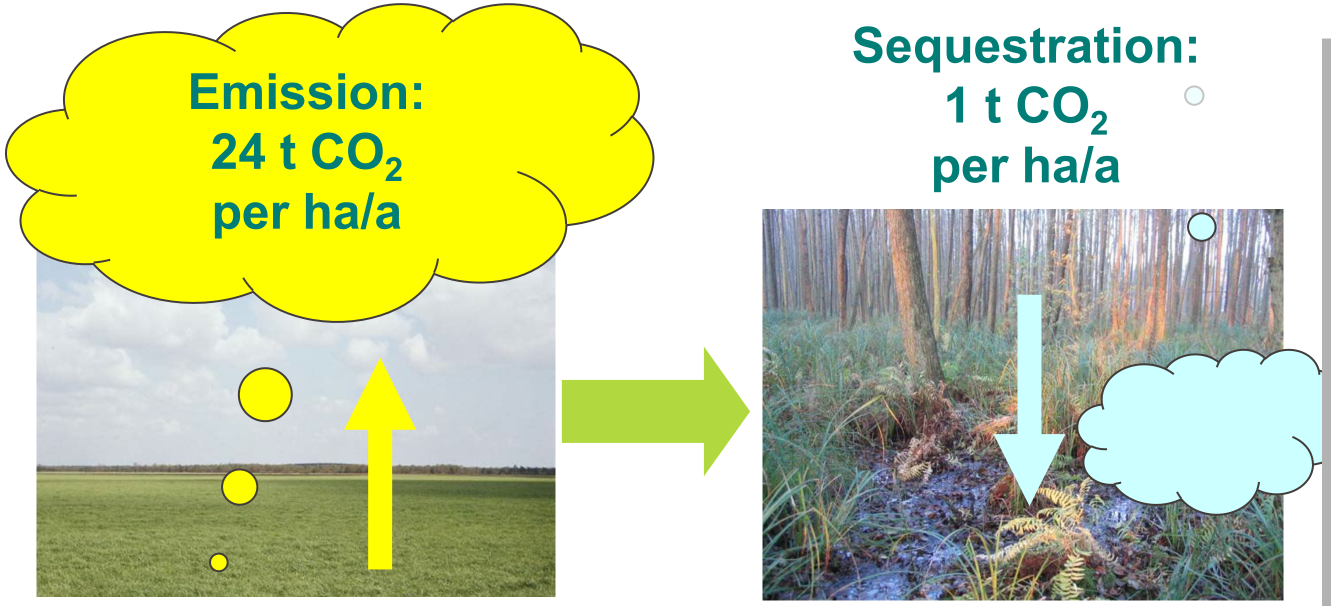
Restoration of peatlands and carbon-rich soils

Making Peatland Restoration a climate investment:

Mitigation of climate gas emissions and carbon sequestration by peatland restoration



intensively used meadows and pastures on peat soil

rewetted grassland with elder afforestation

Value for greenhouse gas mitigation of 30,000 ha peatland restoration in the state „Mecklenburg Vorpommern“: 30 Mio. € per year (avoided damage costs)

ESS = Mitigation of 25 t CO_2 per ha/a

Valued with <u>alternative costs</u> for CO_2 mitigation by wind power (40 € per t CO_2)
Value of ESS = 25 • 40 € = 1000 € per ha/a

Valued with <u>avoided damage costs</u> (70 € per t CO_2):
Value of ESS = 25 • 70 € = 1750 € per ha/a

Mitigation costs per t CO_2:
0 – 4 €

Source: Schäfer 2007, 2009

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Case 2: Peatland restoration -
Moor Futures 2.0 – integration of further ecosystem services

Intact Peatlands are much more than Carbon

MoorFutures 2.0 represent those effects

MoorFutures 2.0 represent:

- Improvement of water quality
- Improvement of groundwater recharge
- Flood reduction
- Cooling of local climate
- Biodiversity typical for peatlands

…by rewetting degraded peatlands

Additional Effects are:

- Identified
- Assessed
- Quantified (e.g. in kg)
- *Monetarized (in €)*
- *Sold (in €)*

Attention:
Price of certificates:
☞ Based on site specific project costs
☞ NOT based on generally estimated values of ecosystem services

➔ Benefits are quantified as much as possible

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MoorFutures – There is a complex method behind it

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Sites in Mecklenburg-Western Pomerania pre-selected for rewetting

ESS	Standard	Premium
Improved water quality	Estimation using the NEST approach (kg N y^{-1})	Modelling with WETTRANS (kg N a^{-1}) and **PRisiko** (kg P y^{-1})
Flood prevention	Modelling of the retention volume (m^3) – as a standard procedure if entry data are available, or else as a premium procedure. Modelling of flood peak reduction as a premium procedure only	
Groundwater enrichment	Modelling of the total available amount of water (m^3) and the water table (cm above/below surface) - as a standard procedure if entry data are available, or else as a premium procedure	
Evaporative cooling	Estimation using the EEST approach (W m^{-2} or kWh ha^{-1} y^{-1})	Modelling with AKWA-M (W m^{-2} or kWh ha^{-1} y^{-1})
Increased mire typical biodiversity	Estimation using the BEST approach	Measuring and evaluation through indicator species models

Site-specific quantification in a standard an a premium approach

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Conclusions

- Ecosystem restoration may provide multiple ecosystem services and synergies, e.g. to mitigation/adaptation to climate change, flood protection, biodiversity and recreation
- Initial Research („Vorlaufforschung“) appropriate to be prepared when political requirements come about
- Local Restoration activities should be embedded into broader surveys
- More large-scale restoration projects needed to provide better effects
- Ecological and socio-economic approaches have to go hand in hand
- Ecosystem restoration should be accompanied by monitoring and reporting

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Thank You!
Questions?

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