A Servant of Many Masters - When Restoration Has to Meet Many Expectations: Management and Monitoring in a Floodplain Restoration Project along a Danube Stretch in Bavaria (Germany)

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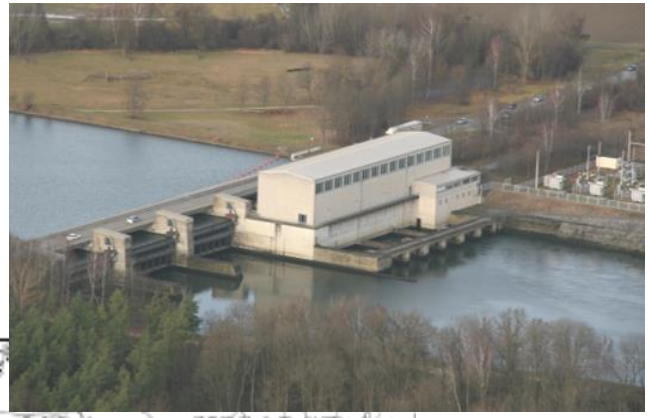
Head of Floodplain Institute Neuburg/Danube

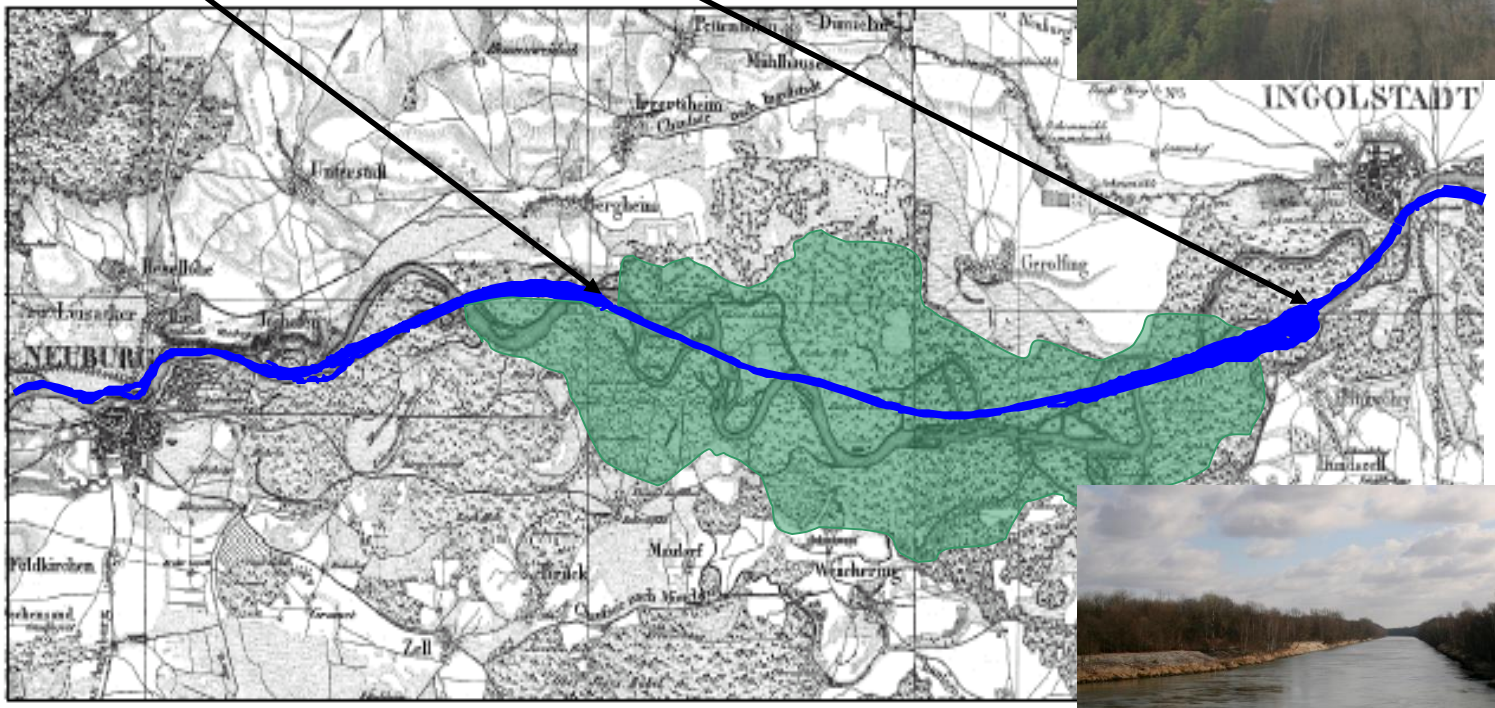
Presentation Outline

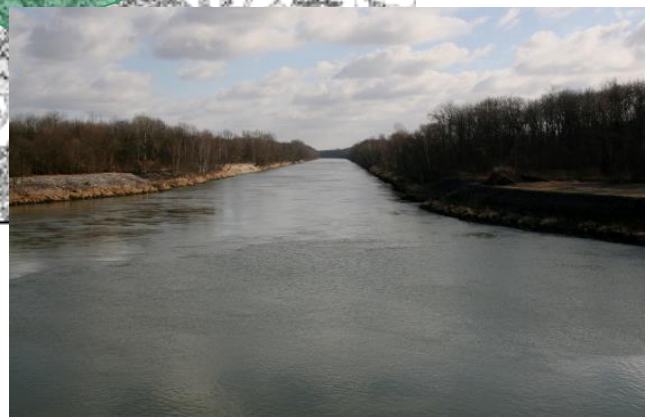
- ‘Dynamization of the Danube Floodplain’
- Introduction of the restoration project Monitoring design
- Efficiency control of ecosystem functions and general results
- Short description of the project RESI
- Short description of the EU Interreg project DanubeFloodplain

Historical Background

Since 1971: hydro power stations of Bergheim and Ingolstadt







Since 1830: embankment and straightening

Inventory of Disturbance

- Change of groundwater dynamics due to lack of natural floods – drying of the floodplain
- No typically hydrological and morphological features like active meanders and sand or gravel banks
- Danger of extinction of floodplain specific species
- No softwood riparian forests with e.g. *Populus nigra, Salix alba or Alnus incana*, and even change of the hardwood forests to only remnants of the original composition
- No possibility for migrating fish and other species to pass damming structures
  (criteria of European Water Framework Directive!)

General Objectives of Restoration

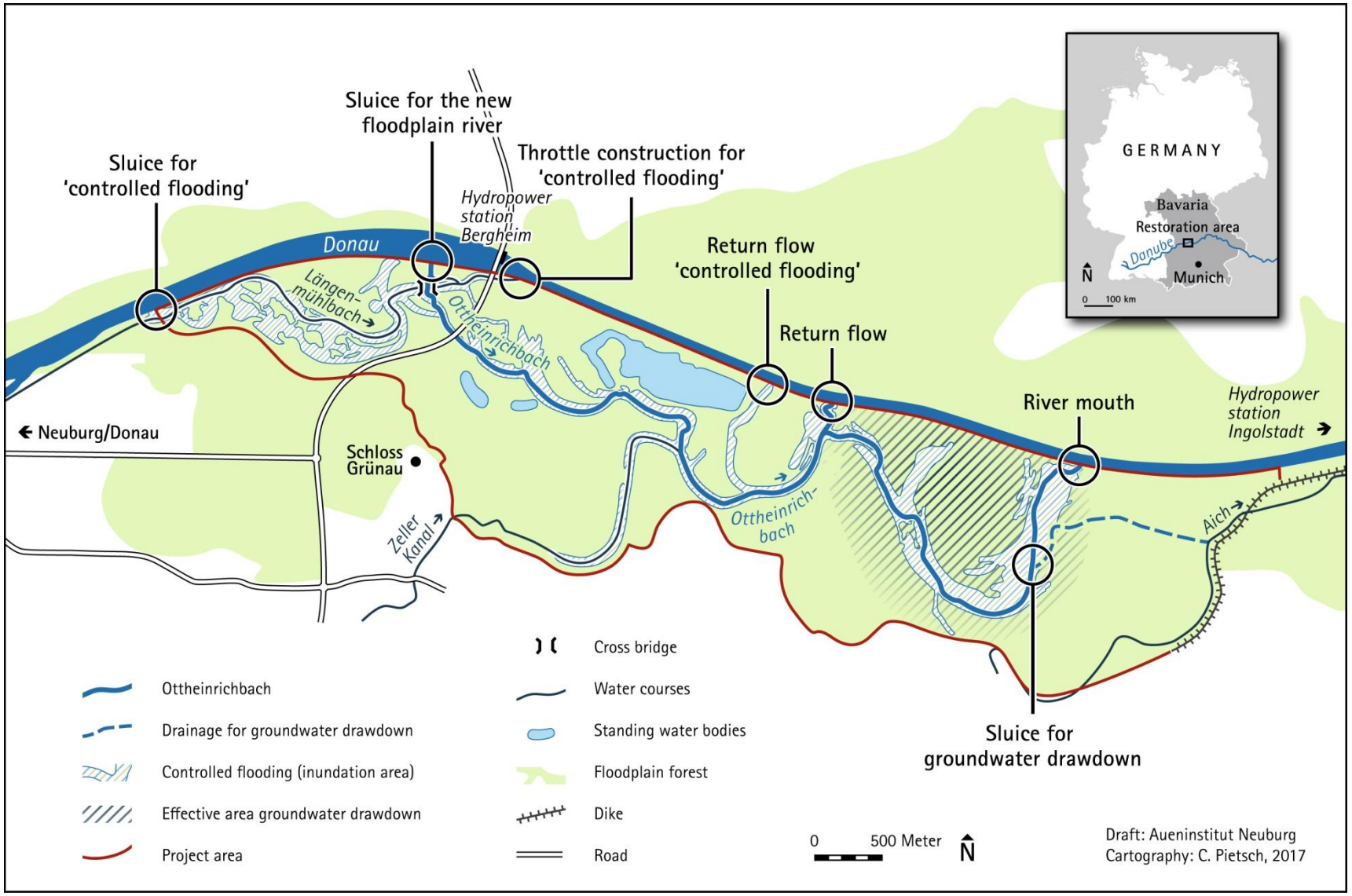
1. **Connectivity – longitudinal and lateral!**
2. **Dynamics – typical floods and droughts on the floodplain!**

   All this in a dammed-up environment with hydro-power stations and managed forests stands.

General Hypothesis

- Hydrological processes are the key for more dynamics /water and sediment)and the precondition for typical floodplain fauna and flora

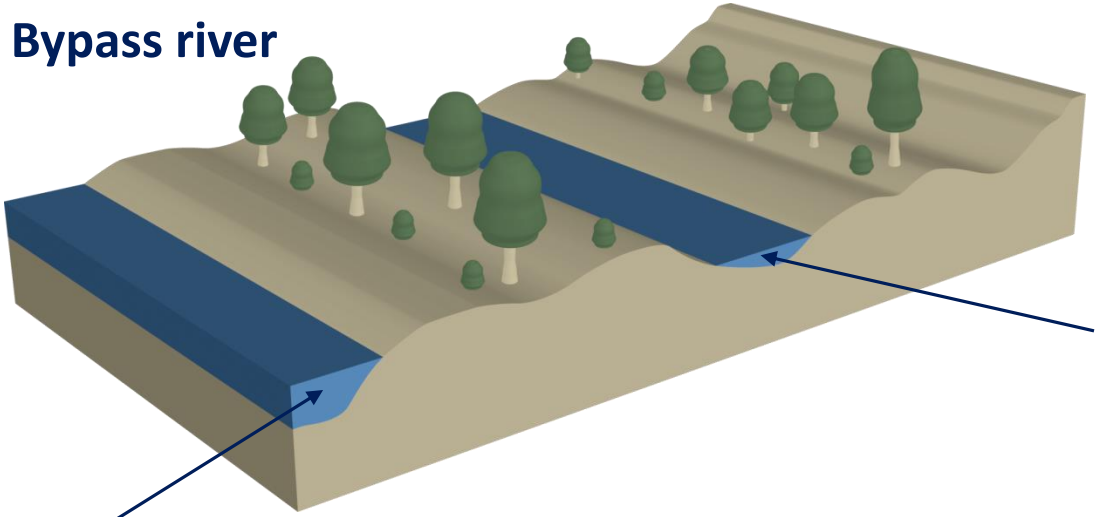
Project Area – a Short Stretch of the Upper Danube



Details of the Project

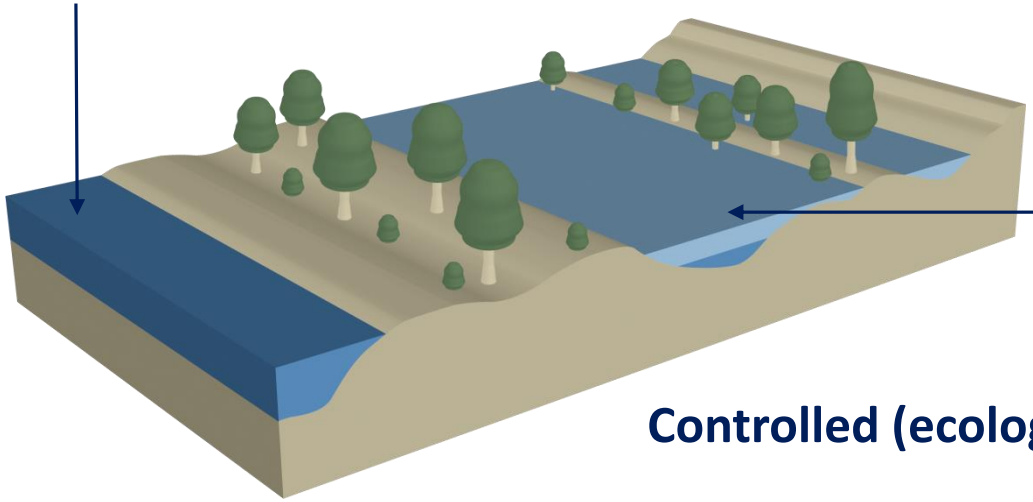
MQ = Mean discharge
Q = Discharge

Bypass river



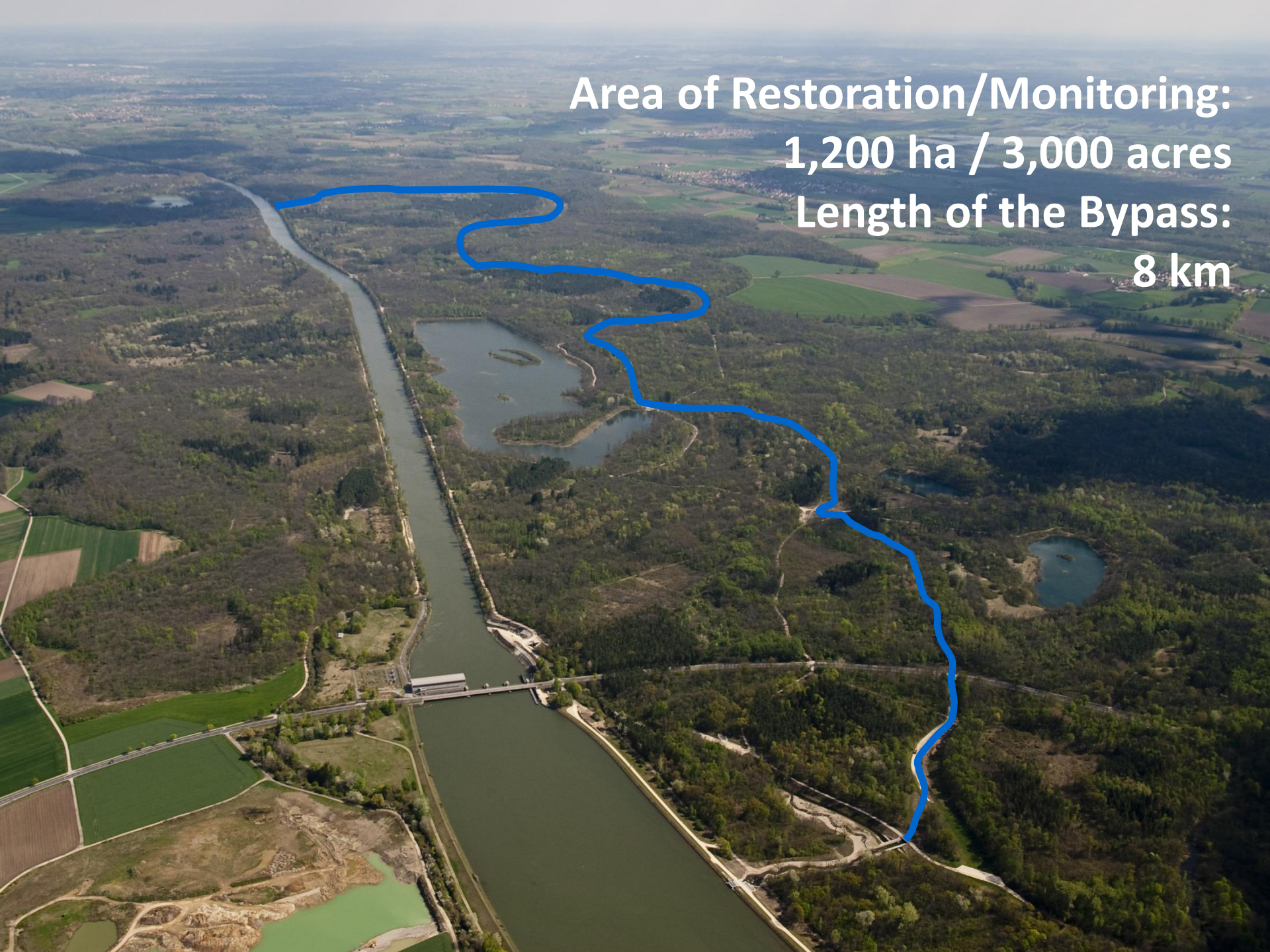
$Q \leq 5\ m^3/s$, length about 8 km

Danube, $MQ = 300\ m^3/s$



$Q \leq 30\ m^3/s$, 2-5 times/year

Controlled (ecological) flooding


Area of Restoration/Monitoring:
1,200 ha / 3,000 acres
Length of the Bypass:
8 km

Starting the Bypass in June 2010 – Some Impressions

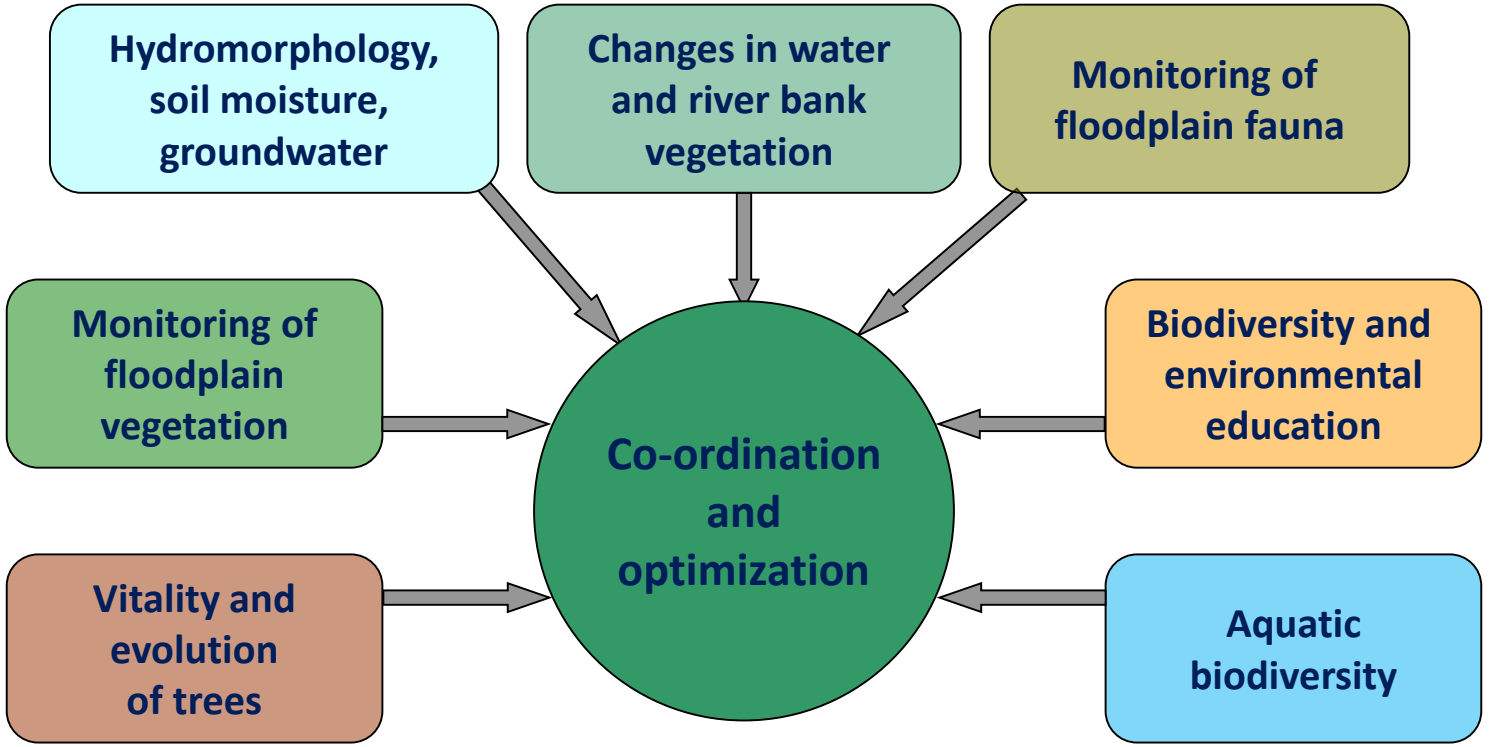
Maximum discharge: 5 m^3/s or 175 ft^3/s

Opening of the Sluice Gates for Ecological Flooding

Maximum discharge: 25 m^3/s (combined with the bypass ca. 30 m^3/s)
Maximum discharge: 880 ft^3/s (combined with the bypass ca. 1,050 ft^3/s)

Monitoring design of MONDAU

Study Group ‘Monitoring of Hydro-ecological Processes’



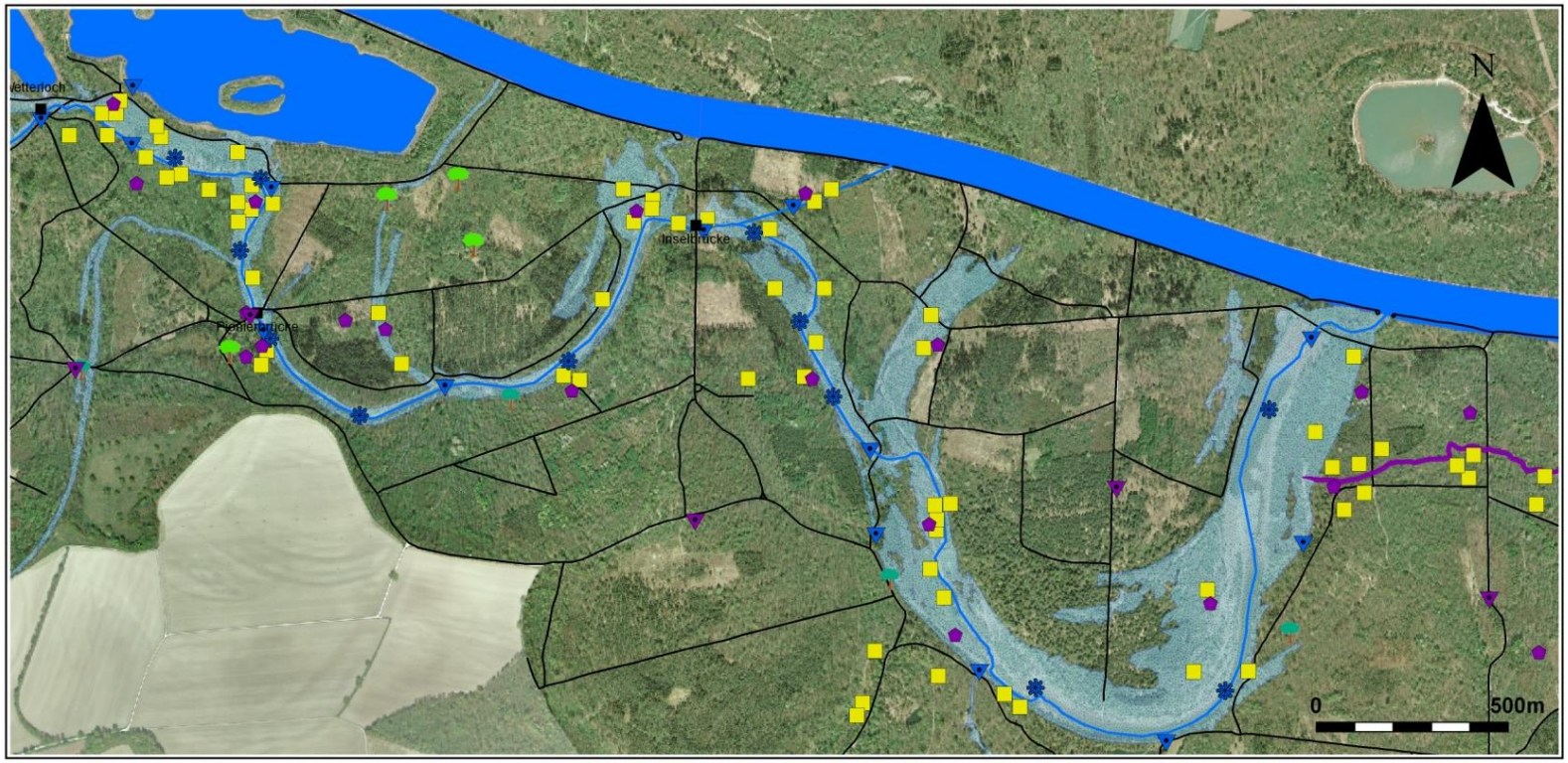
Monitoring design of MONDAU

Important abiotic and biotic parameters / species groups in focus:

- Discharge and groundwater level
- Erosion and aggradation
- Arthropods and birds
- Bats
- Fish
- Macroinvertebrates
- Macrophytes and river bank vegetation
- Vegetation in general
- Vitality of tree species
- …

Monitoring design of MONDAU

Partial plan of gauges and monitoring plots etc. – eastern project area



Location of gauging stations for soil moisture (⬟ 31),
runoff (▼ 15) and groundwater (▼ 22) as well as about vegetation permanent plots (■ 120)
and vegetation transects (✹ 25) (digits valid for entire project area)

Monitoring – Examples

Monitoring – Examples

Monitoring – Examples

Monitoring – Development over Time

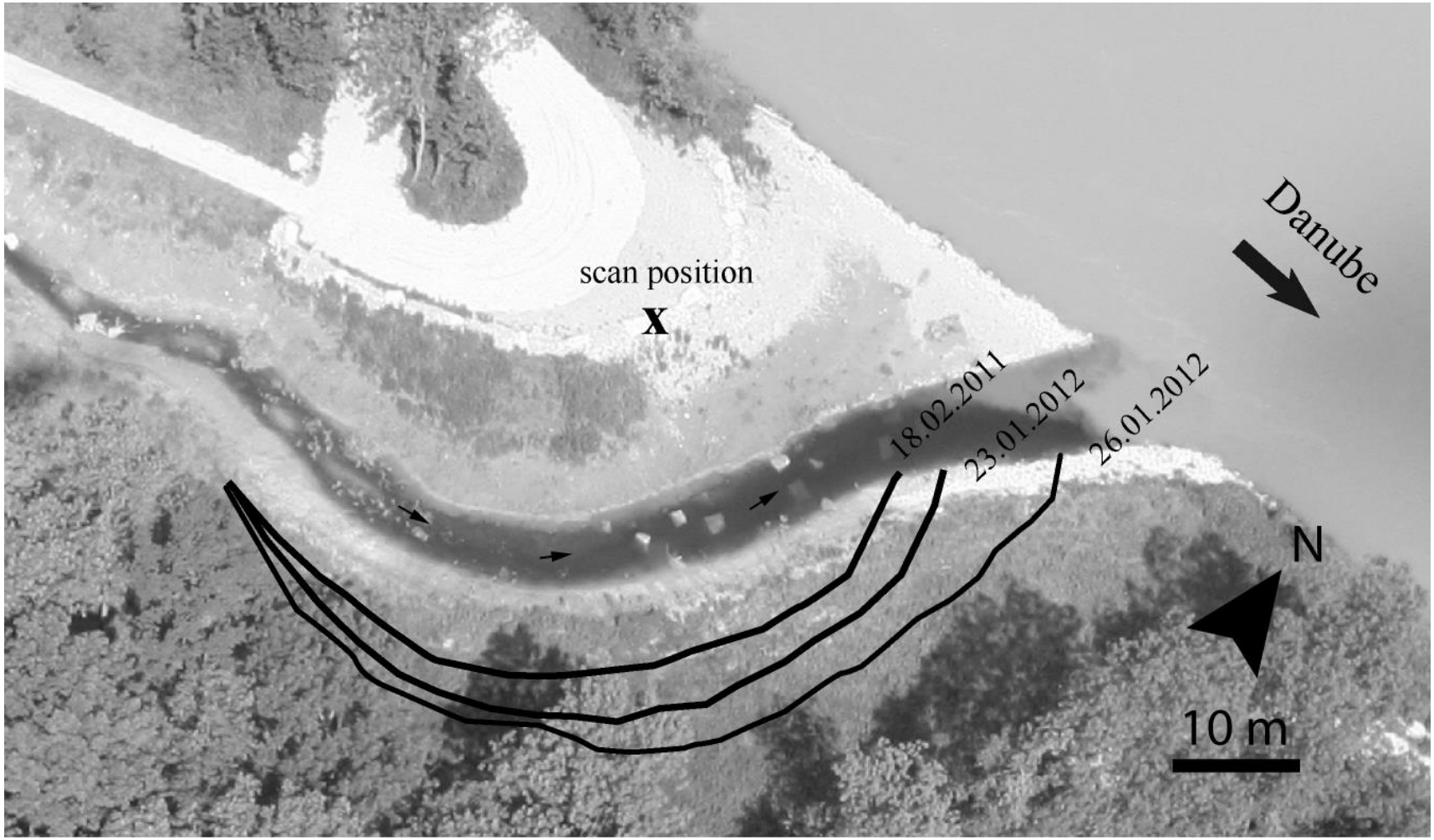
Heavy Erosion at Several Places

10.06.2010

Photos were taken from nearly the same position!

27.01.2012

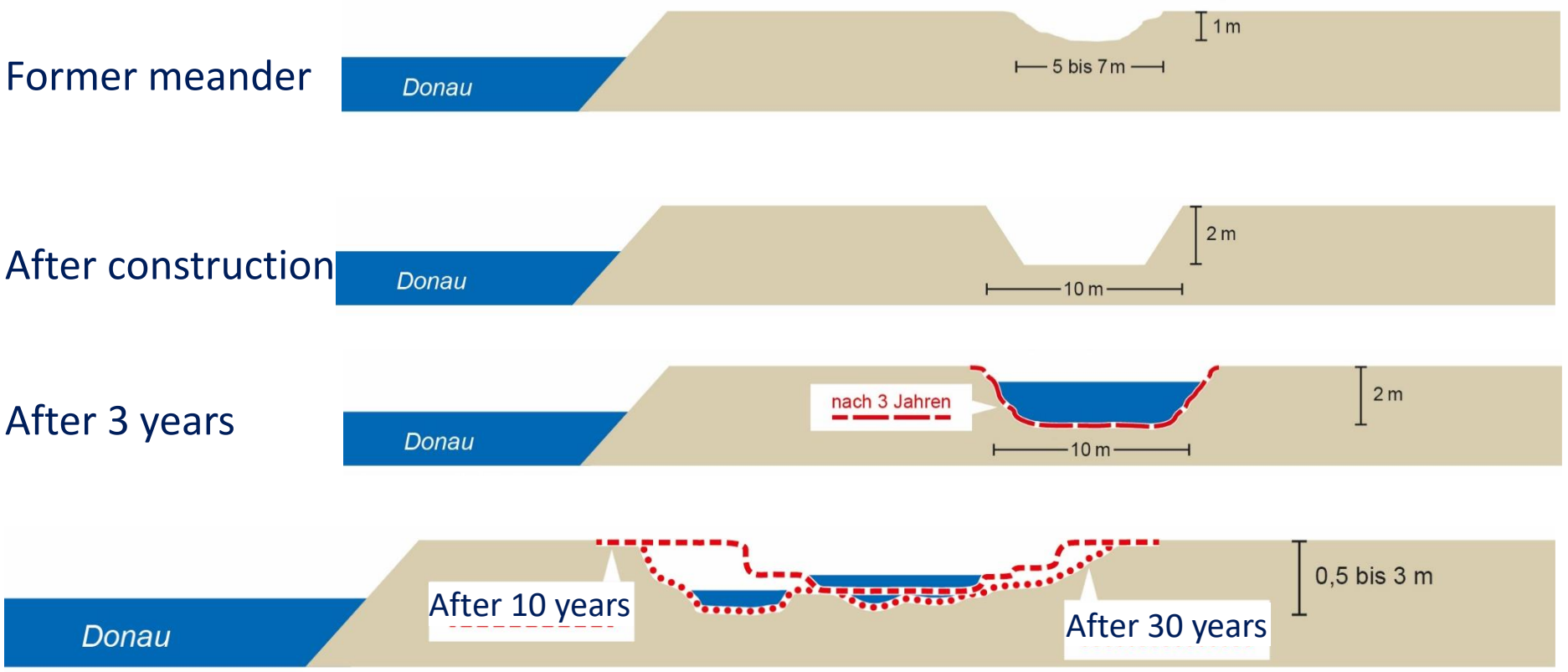
Results from Terrestrial Laser Scanning



18 m of river bank erosion in less than two years!

But also Aggradation!

Hydro-morphological Dynamics – Secondary Floodplain



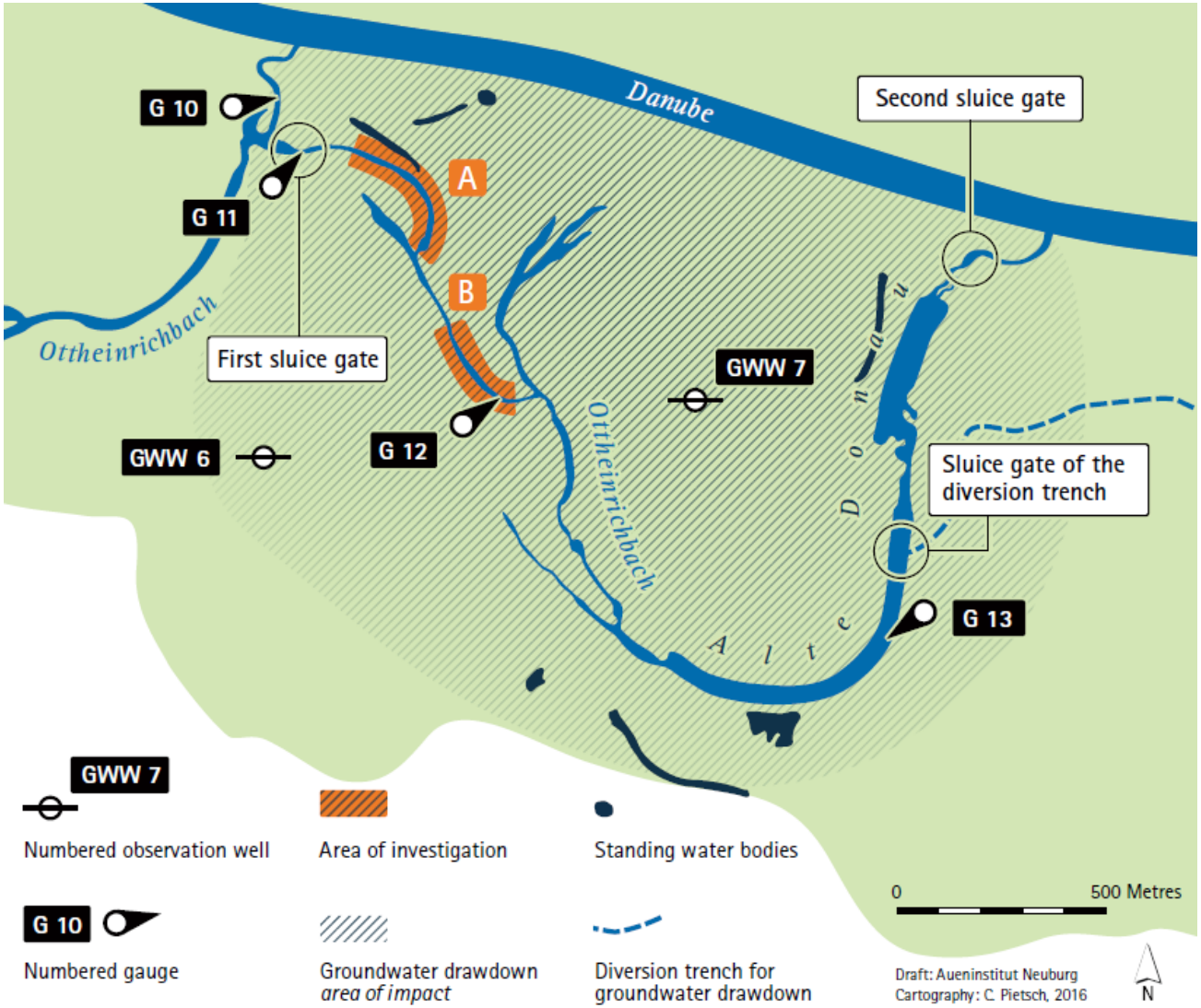
There is no dynamization of the original Danube floodplain, the floodplain of the bypass river, however, is developing near-naturally.

Restoration of Fluctuating Water Zones in Floodplains by Temporary Groundwater Drawdown and Low Flow

What are we looking for?

- Muddy streambanks as a result of fluctuating water zones
- Willow and cottonwood seedling recruitment by hydrochory

Areas of Investigation



Species under observation

Oenanthe aquatica (among others) – Water dropwort

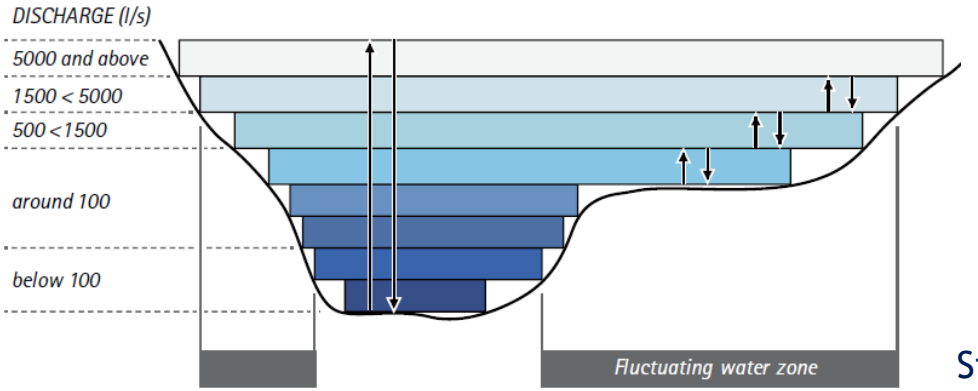
(Red list species in Germany)

Sapling

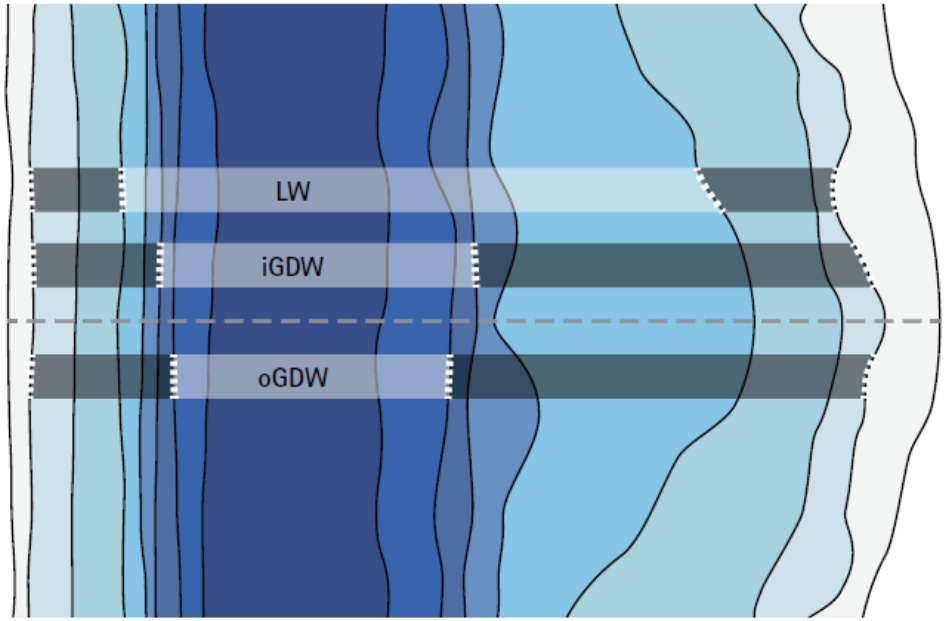
Adolescent

Adult

Research Design – ‘Playing’ with the Low Flow



Side view

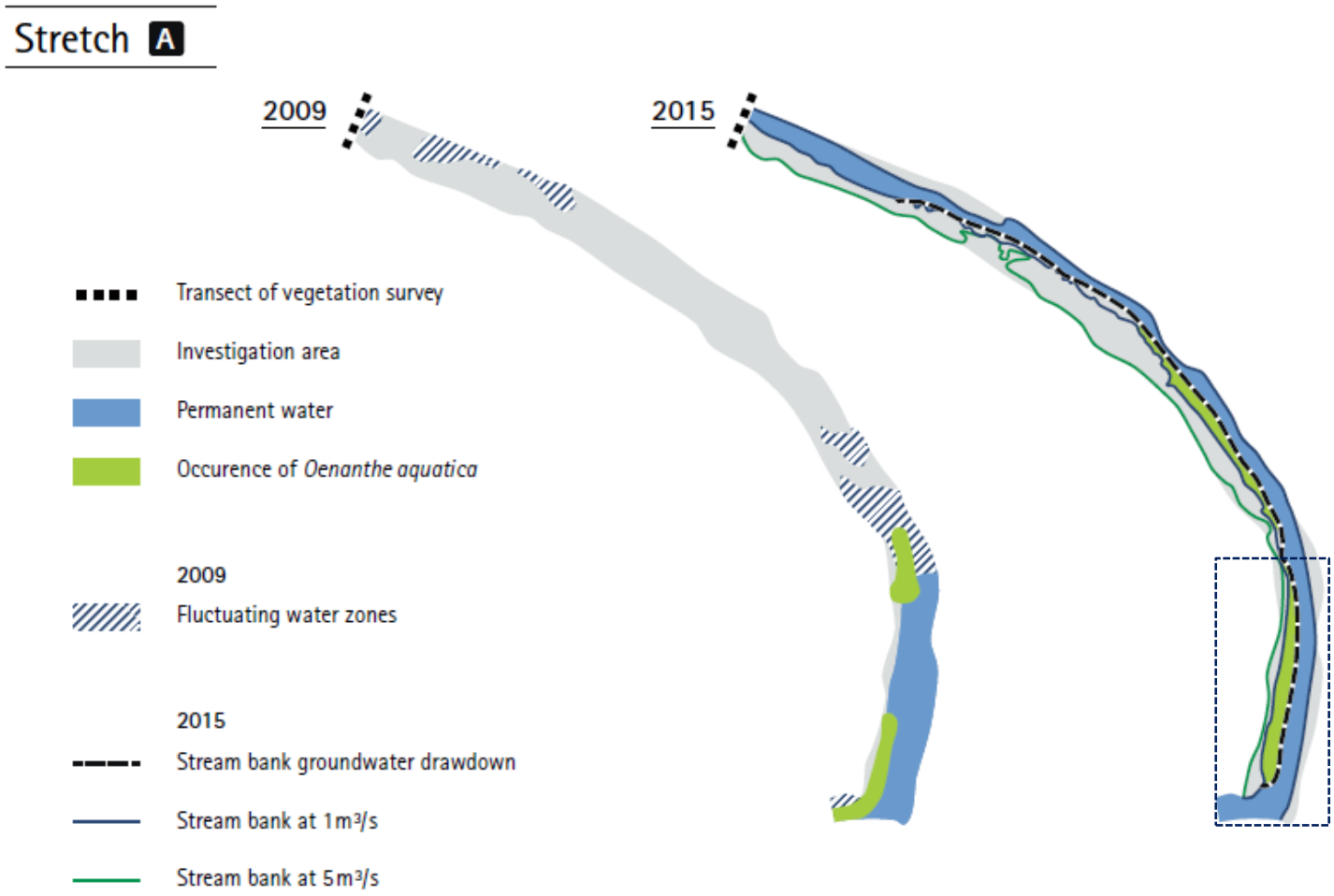


Plan view

Extent of fluctuating water zones under different measures

oGDW = original groundwater drawdown
iGDW = improved groundwater drawdown, with an e-flow of about 100 l/s
LW = natural low flow

Restoration of Fluctuating Water Zones in Floodplains by Temporary Groundwater Drawdown – Findings



Restoration of Fluctuating Water Zones in Floodplains by Temporary Groundwater Drawdown

Numerical Results

	Total		Stretch A		Stretch B	
	2009	2015	2009	2015	2009	2015
Fluctuating water zones [m^2]	1.675	618	747	533	928	85
Area with *Oenanthe aquatica* [m^2]	627	511	288	426	339	85
Number of individuals	79	193	27	82	52	111
Density [individuals/m^2]	0.13	0.38	0.09	0.19	0.15	1.31

Decrease

Increase

Management Options

- Floodplains are very resilient ecosystems and can therefore be restored by only restoring the water dynamics.
- To enhance rivers with muddy streambanks, low water conditions must be created for several weeks during summertime.
- Groundwater drawdown as a restoration measure works only on streams with shallow banks.
- An additional restoration measure could be the shaping of such streambanks.
- There is a management clash: Fish need more water, softwood seed less water, at least for a certain time in the year.
- If you care for aquatic species, an option could be to increase the mean water level (if possible) to raise the system in general.
- **Be patient – it takes some time!**

A Muddy, but Important Picture

Credits:

State Office for Water Management Ingolstadt, Bavaria/Germany

Federal Agency for Nature Conservation in Germany

For details refer to: *Stammel, B., P. Fischer, M. Gelhaus & B. Cyffka (2016): Restoration of Ecosystem Functions and Efficiency Control: Case Study of the Danube Floodplain between Neuburg and Ingolstadt (Bavaria/Germany). Environmental Earth Sciences (2016) 75:1174.*

Interreg
Danube Transnational Programme
Danube Floodplain

www.interreg-danube.eu/danube-floodplain

The Danube Floodplain Project: Establishing a Win-Win-Situation of Flood Protection and Floodplain Ecology in a Large River Basin

Bernd Cyffka & the Danube Floodplain Project Team

Catholic University Eichstaett-Ingolstadt, Floodplain Institute

Bavaria/Germany

February 8-10, 2022 | Stevenson, USA

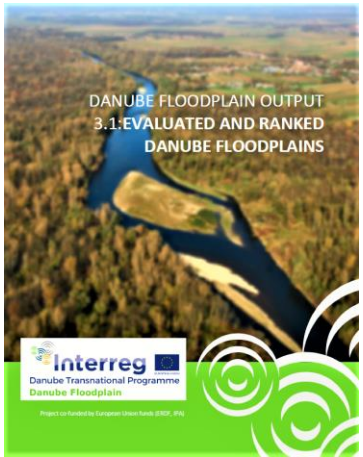
Project co-funded by the European Union (ERDF, IPA funds)

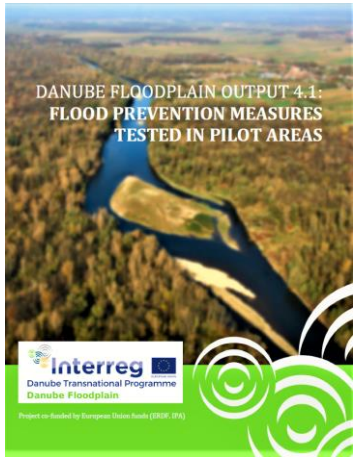
Main questions

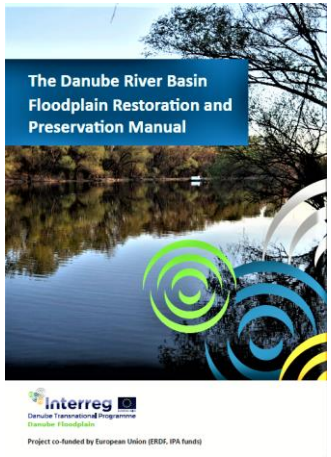
- Is it possible to manage a large river basin (2,850 km river length; 10 riparian countries) to achieve a win-win
- EU legislation vs national legislations
- Capacity building
- Transferability to other basins

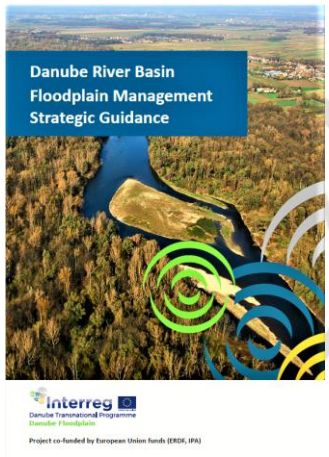
Project Output

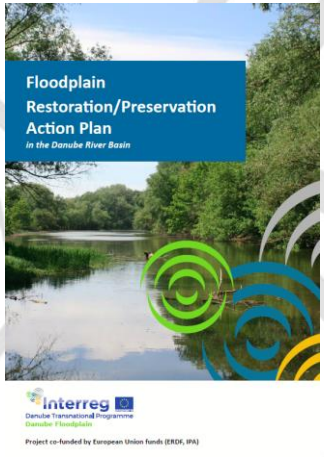
Output	Name
1	Evaluated and ranked Danube floodplains
2	Flood prevention measures tested in pilot areas: Morava (CZ-SK), Krka (SL), Middla Tisza (HU), Begecka Jama (SR) and Bistret (RO)
3	Danube River Basin floodplain restoration and preservation **Manual**
4	Danube River Basin Floodplain Management **Strategic Guidance**
5	Floodplain restoration/preservation **Action Plan**
6	Experts **trained** in floodplain management within a Workshop











The River Ecosystem Service Index RESI

- a new tool for sustainable floodplain management tested along the Upper Danube

Barbara Stammel, Marion Gelhaus, Bernd Cyffka, Christine Fischer, Mathias Scholz, Martin Pusch & RESI-Team

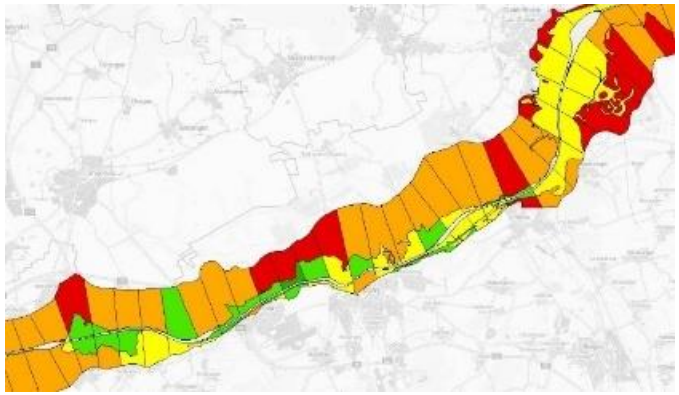
Auen institut Neuburg/Donau
Katholische Universität Eichstätt-Ingolstadt
FONA Nachhaltiges Wassermanagement BMBF
NaWaM Nachhaltiges Wassermanagement ReWaM
GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

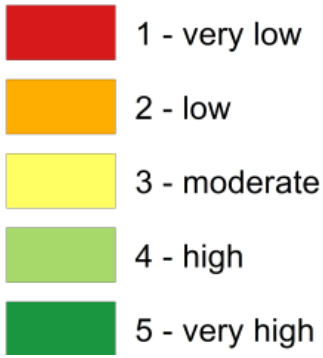
Objectives of the RESI project

- Assessment of river floodplains for management based on ecosystem services (ESS) >>trans-sectoral evaluation
- Synoptic visualization: trade-offs and synergies
- Comparison of different scenarios of contrasting interests; decision support for ecology and society at the regional planning level

Assessment framework of RESI

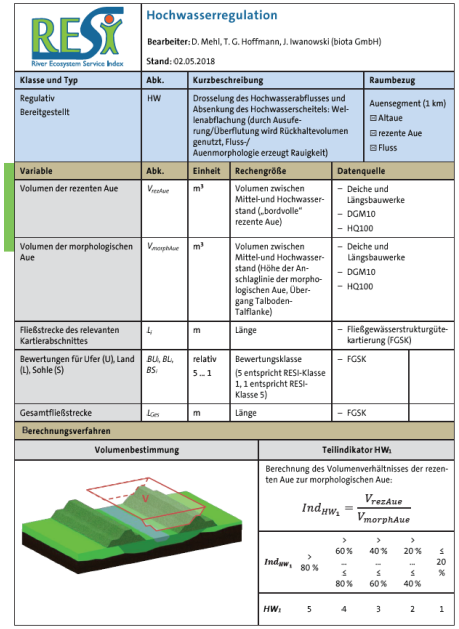
- All relevant ecosystem services of river landscapes in Germany/Central Europe
- Based on existing spatial data
- Evaluation of 1 km-floodplain segments, differentiated into active and former floodplain
- 5-step evaluation





Evaluation methods of the individual ecosystem services

- Development of evaluation methods for 16 ecosystem services: provisioning, regulating and cultural according to CICES
- Tested for 6 river floodplains in Germany: Danube, Rhine, Elbe, Nebel, Lahn, Wupper
- Method description in fact sheets (www.resi-project.info/en)



RESI River Ecosystem Service Index

Hochwasserregulation

Bearbeiter: D. Mehl, T. G. Hoffmann, J. Iwanowski (biota GmbH)

Stand: 02.05.2018

Klasse und Typ	Abk.	Kurzbeschreibung	Raumbezug
Regulativ Bereitgestellt	HW	Drosselung des Hochwasserabflusses und Absenkung des Hochwasserscheitels: Wellenabflachung (durch Ausufe-rung/Überflutung wird Rückhaltevolumen genutzt, Fluss-/ Auenmorphologie erzeugt Rauigkeit)	Auensegment (1 km) ☒ Altaue ☒ rezente Aue ☒ Fluss

Variable	Abk.	Einheit	Rechengröße	Datenquelle
Volumen der rezenten Aue	V_{rezAue}	m³	Volumen zwischen Mittel-und Hochwasser-stand („bordvolle" rezente Aue)	– Deiche und Längsbauwerke – DGM10 – HQ100
Volumen der morphologischen Aue	$V_{morphAue}$	m³	Volumen zwischen Mittel-und Hochwasser-stand (Höhe der An-schlaglinie der morpho-logischen Aue, Über-gang Talboden-Talflanke)	– Deiche und Längsbauwerke – DGM10 – HQ100
Fließstrecke des relevanten Kartierabschnittes	L_i	m	Länge	– Fließgewässerstrukturgüte-kartierung (FGSK)
Bewertungen für Ufer (U), Land (L), Sohle (S)	BU_i, BL_i, BS_i	relativ 5 ... 1	Bewertungsklasse (5 entspricht RESI-Klasse 1, 1 entspricht RESI-Klasse 5)	– FGSK
Gesamtfließstrecke	L_{Ges}	m	Länge	– FGSK

Berechnungsverfahren

Volumenbestimmung

Teilindikator HW_1

Berechnung des Volumenverhältnisses der rezenten Aue zur morphologischen Aue:

$$Ind_{HW_1} = \frac{V_{rezAue}}{V_{morphAue}}$$

Ind_{HW_1}	> 80 %	> 60 % ... ≤ 80 %	> 40 % ... ≤ 60 %	> 20 % ... ≤ 40 %	≤ 20 %
HW_1	5	4	3	2	1

Teilindikator HW_2

Berechnung der längengewichteten mittleren Gesamtklassifizierung des Fließgewässers:

$$Ind_{HW_2} = \sum_{i=1}^{n} \frac{L_i}{L_{Ges}} \cdot \left(\frac{BU_i + BL_i + BS_i}{3}\right)$$

Ind_{HW_2}	≤ 1,5	> 1,5 ... ≤ 2,5	> 2,5 ... ≤ 3,5	> 3,5 ... ≤ 4,5	> 4,5
HW_2	5	4	3	2	1

Gesamtindikator

Berechnung des Gesamtindikators ***HW*** als Mittelwert aus den Ergebnissen der Teilindikatoren HW_1 und HW_2:

$$Ind_{HW} = \frac{HW_1 + HW_2}{2}$$

Skalierung ☒ de ☐ lokal	Ind_{HW}	≥ 4,5	< 4,5 ... ≥ 3,5	< 3,5 ... ≥ 2,5	< 2,5 ... ≥ 1,5	< 1,5
RESI		5	4	3	2	1
Qualitative Beurteilung		**Kein** oder nur **sehr geringfügiger** Verlust an rezentem Auenvolumen, **sehr hohe** Wellenabflachung	**Geringer** Verlust an rezentem Auenvolumen, **hohe** Wellenabflachung	**Mäßiger** Verlust an rezentem Auenvolumen, **mäßige** Wellenabflachung	**Hoher** Verlust an rezentem Auenvolumen, **geringe** Wellenabflachung	**Gravierender** Verlust an rezentem Auenvolumen, **keine** oder **sehr geringe** Wellenabflachung

Bedeutung der Indikatoren

Interpretation

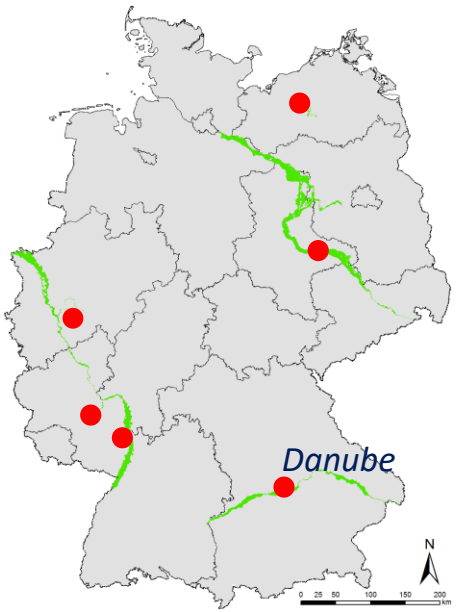
Der Teilindikator HW_1 gibt vereinfachend an, wie stark sich der theoretische Hochwasserrückhalteraum in einem Auenabschnitt im Vergleich zum ursprünglichen Zustand verändert hat und spiegelt damit einen direkten Bezug zur ÖS. Hochwasserregulation wider. Der Teilindikator HW_2 erfasst vereinfachend die Prozesse der Wellenabflachung infolge von Profiländerungen, Rauigkeiten und induzierter Turbulenz in Abhängigkeit der kartierten strukturellen Ausprägung.

Erweiterungsmöglichkeiten

Im Falle der Verfügbarkeit von berechneten Ausuferungsflächen (z. B. aus Hochwassergefahrenkarten) können diese direkt für eine genauere Bestimmung des Retentionsvolumens der Aue genutzt werden.

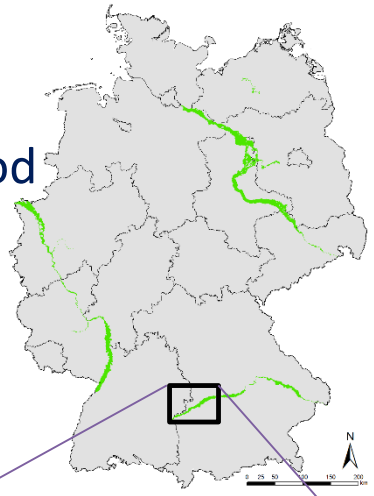
Für etwaige Szenario-Berechnungen, die das Anlegen von Polderflächen vorsehen, kann wie folgt vorgegangen werden:

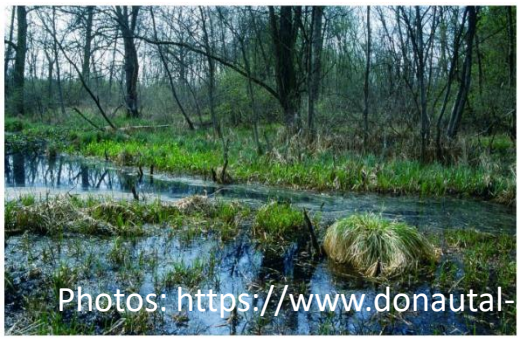
1. Ermittlung der folgenden Variablen: Fläche der rezenten Aue (A_{rezAue} in m²), Fläche der morphologischen Aue ($A_{morphAue}$ in m²), Polderfläche (A_{Polder} in m²), Polderfläche innerhalb der rezenten Aue ($A_{polderAue}$ in m²), Volumen der rezenten Aue (V_{rezAue} in m³), Volumen der morphologischen Aue ($V_{morphAue}$ in m³)
2. Zuordnung der Gewichtung (G_{Polder}) der Polderart in Abhängigkeit der Überflutungshäufigkeit:
   - ungesteuerter Polder HQ_{20} und seltener als HQ_{10} - G_{Polder} = 0,5
   - ungesteuerter Polder häufiger als HQ_{10} - G_{Polder} = 1,5
   - gesteuerter Polder HQ_{20} und seltener als HQ_{10} - G_{Polder} = 2,5
   - gesteuerter Polder häufiger als HQ_{10} - G_{Polder} = 5

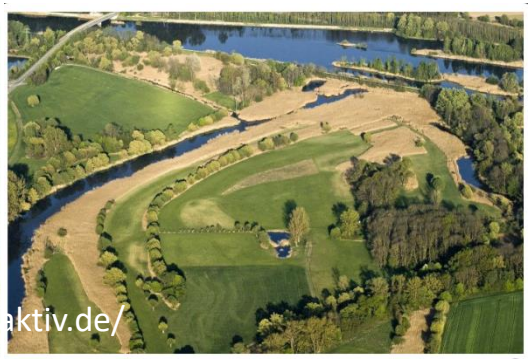


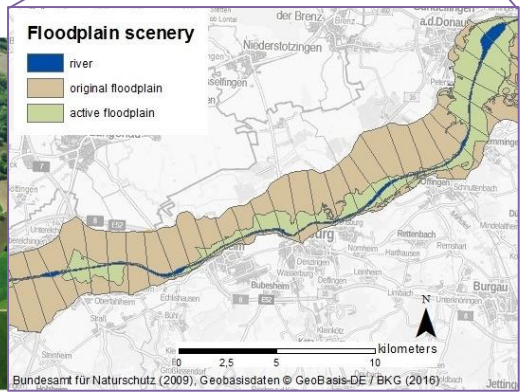
The upper Danube - investigation region and scenarios

- River stretch of 80 km
- Competing interests of flood protection, agriculture, nature conservation, recreation
- Actual need for action and plans: flood protection and nature conservation
- >> effects on 15 ecosystem services
- >> Status quo and scenarios



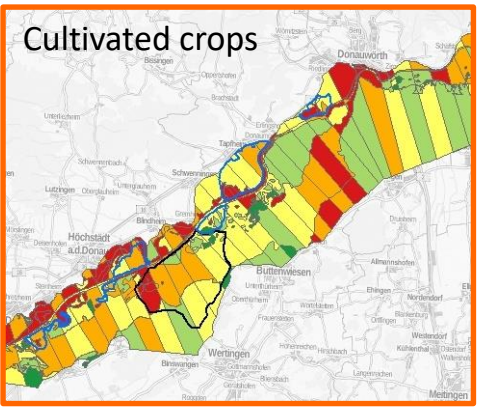


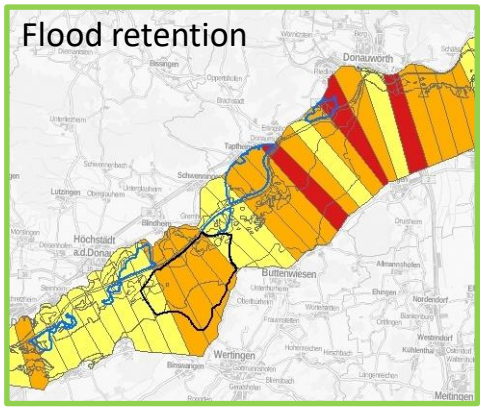


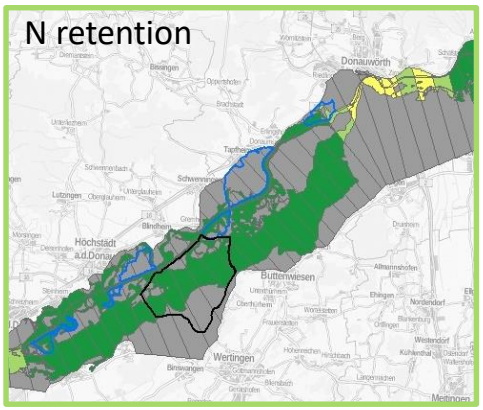


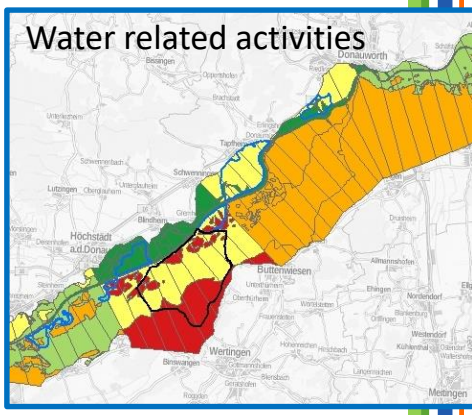
Photos: https://www.donautal-aktiv.de/

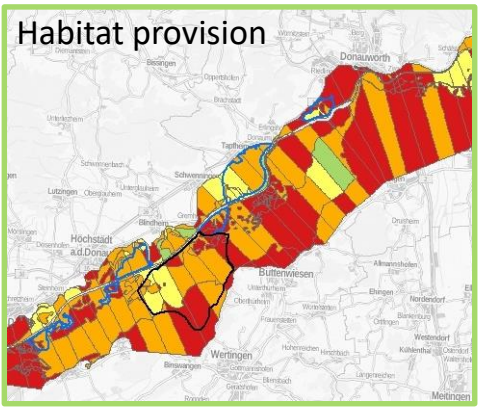
Results – Status quo

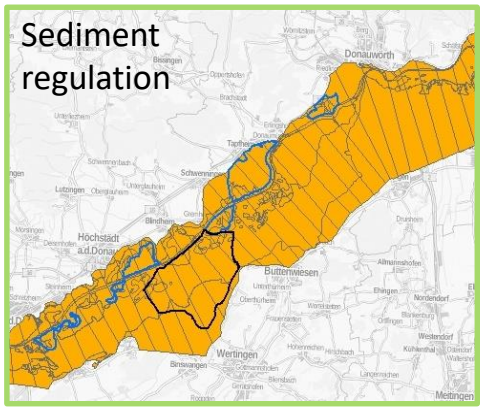


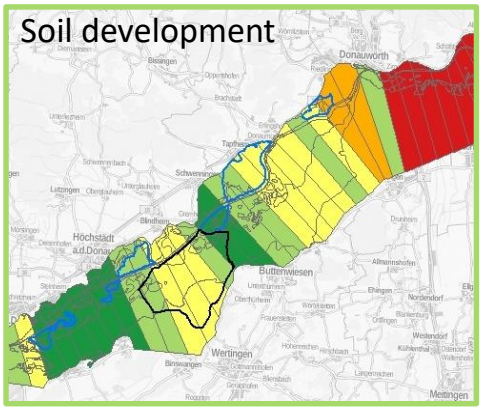


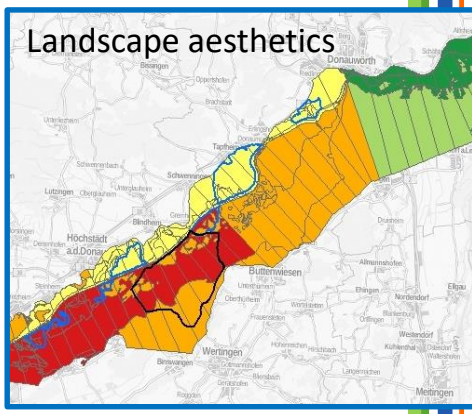






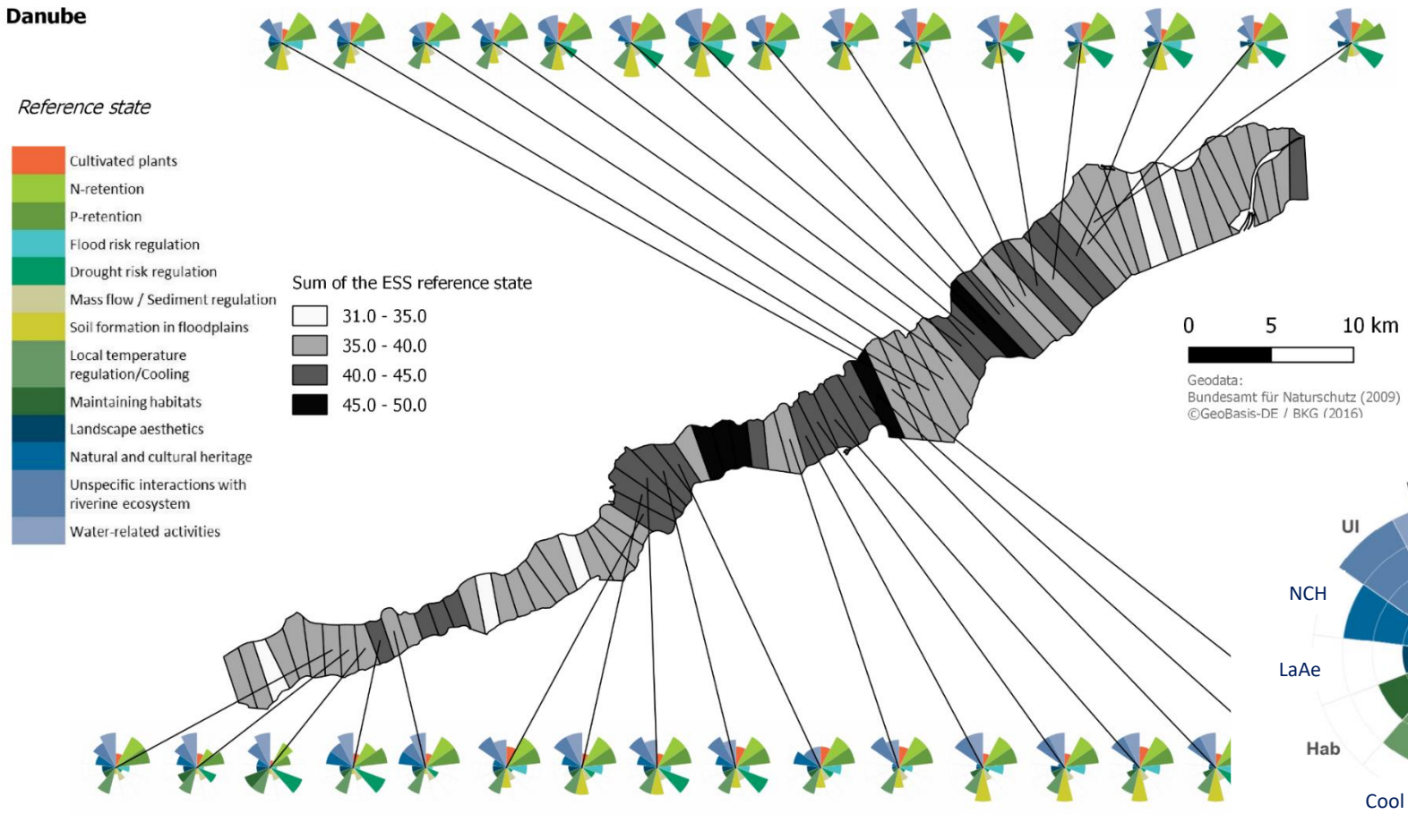


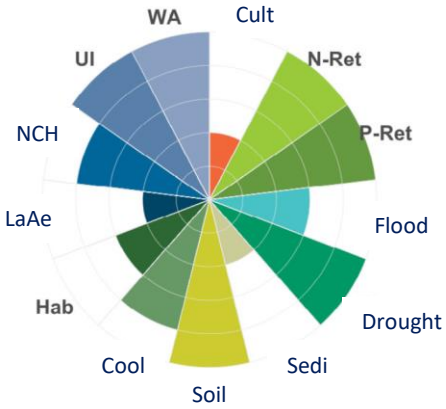




- 1 - very low
- 2 - low
- 3 - moderate
- 4 - high
- 5 - very high

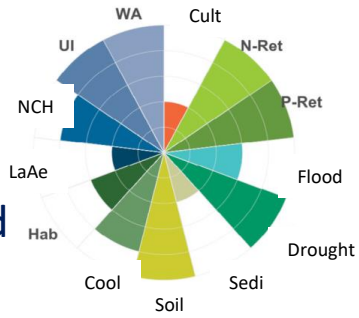
Synthesis – Status quo





Conclusions

- **RESI is a tool of joint and consistent assessment for river/floodplain management**
  - based on ecosystem services
  - using publicly available data
  - designed modularly
- **Results for the investigation region Upper Danube**
  - spatial differences for the actual situation can be identified
  - ecolgically orientated flood control measures (Scenario 1): various synergies with other ESS (N/P retention, habitat provision)
  - exclusive flood control measures (Scenario 2): trade-offs with nature conservation and agriculture
- **Opportunity**
  - to select less ESS, but maintain inter-sectorality
  - to weight ESS differently (specific and unspecific for floodplains)
  - to visualize the differences of scenarios comprehensively (e.g. public participation), but on a conceptual level
- **Challenges**
  - The methods and levels for the different ESS need to be harmonized
  - Sensitivity for small scale measures needs to be adjusted.
  - RESI needs to be applied in other regions with other available data and other ESS



Thank you for your attention!

For details refer to: *Stammel, B. et al. (2021): Assessing land use and flood management impacts on ecosystem services in a river landscape (Upper Danube, Germany), River Res Applic.;37:209–220.*

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