A new approach for softwood forest restoration by linking ecological and hydraulic modelling

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Introduction:
Softwood floodplain forests are one of the most endangered ecosystems in the world due to regulation and fragmentation of river-floodplain systems. Their restoration, though highly desirable seems problematic since softwood vegetation is thought to intensify flood risk by hydraulic effects. Additionally, natural regeneration of softwood forest vegetation is reduced due to a lack of bare ground as establishment sites for sexual recruitment. Therefore, a concept for the restoration of softwood forests combining ecological and flood protection issues needs to be developed. Our aim is to identify habitats in the recent floodplain of the Elbe River in Germany (Fig. 1), not only biologically suitable for the establishment of softwood forests structured by Black Poplar (*Populus nigra*) and four different Willow species (*Salix alba, S. x rubens, S. triandra, S. viminalis*), but also acceptable considering flood protection.
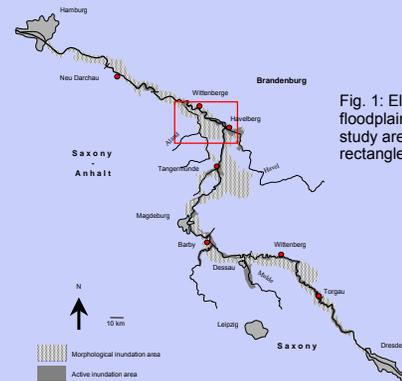

Fig. 1: Elbe River floodplain with the study area (red rectangle)

Morphological inundation area
Active inundation area

Methods: A combination of a vegetation model describing the probability of occurrence of the different softwood forest species in their different life stages (seedling, juvenile & adult) and a mathematical model delineating the hydraulic situation considering different softwood forest structures will lead to the combined model categorizing the study area into suitable, partially suitable (under the aspect of further management measures) and unsuitable sites for the establishment of softwood forest vegetation under flood protection issues.

Identification of biologically suitable sites

Field recordings of presence/absence of species in relation to specific explanatory variables e.g. average groundwater level, water level fluctuations, duration of flooding, type of soil, land use
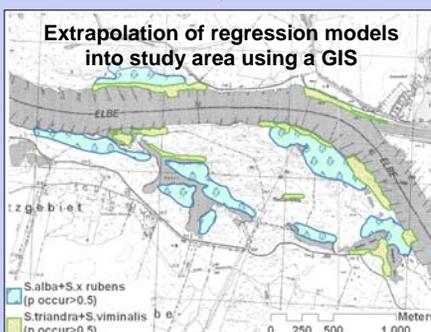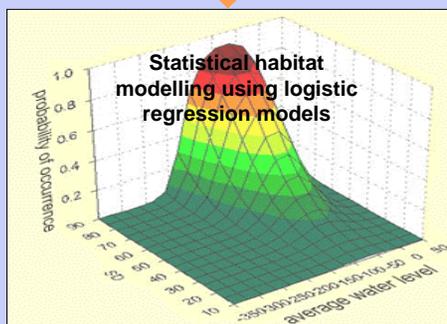
Interdisciplinary exchange of knowledge

Identification of hydraulically suitable sites

Laboratory experiment simulating hydraulic effects of different softwood forest vegetation patterns on surface water levels of the Elbe river using an laboratory flume exhibiting reduced Elbe scales

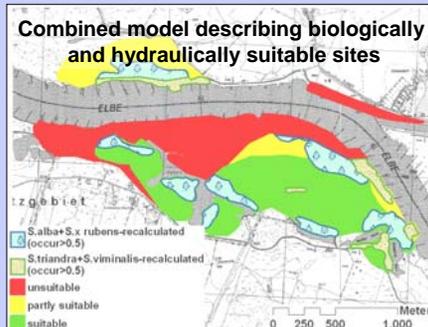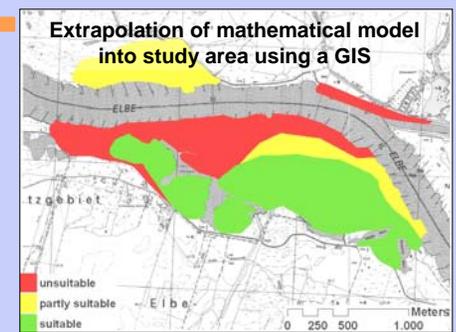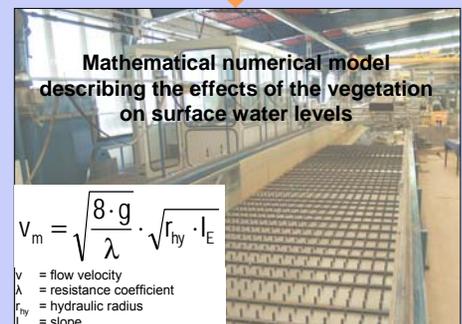**Statistical habitat modelling using logistic regression models**

Data on structure of floodplain forest vegetation
e.g. distance between trees, number of branches, species

Data on hydrological conditions within floodplain

Mathematical numerical model describing the effects of the vegetation on surface water levels

$$v_m = \sqrt{\frac{8 \cdot g}{\lambda}} \cdot \sqrt{r_{hy} \cdot I_E}$$

v = flow velocity
λ = resistance coefficient
r_{hy} = hydraulic radius
I = slope

Extrapolation of regression models into study area using a GIS

S.alba+S.x rubens (p occur>0.5)
S.triandra+S.viminalis (p occur>0.5)

Combination of results of biological and hydraulic modelling

Extrapolation of mathematical model into study area using a GIS

unsuitable
partly suitable
suitable

Combined model describing biologically and hydraulically suitable sites

S.alba+S.x rubens-recalculated (occur>0.5)
S.triandra+S.viminalis-recalculated (occur>0.5)
unsuitable
partly suitable
suitable

Scientific prospects:
- Different scenarios will be applied to test effects like e.g. climate change, river management measures on softwood forest vegetation
- Comparison of results in front of and behind dyke since the construction of dykes lead to strong hydrological alterations

Application of results in nature conservation:
- Results will be used to manage plantings of softwood forest species in the end of the project
- GIS-tool will be developed to allow institutions without expert knowledge the application of results
- Further results concerning genetic investigations will be included in the management plan