Fluvial ecosystem services in the Rhine delta distributaries between 1995 and 2035

Menno Straatsma[a,b], Maarten Kleinhans[a]

[a]Utrecht University, Faculty of Geosciences, Department of Physical Geograpy, [b] corresponding author m.w.straatsma@uu.nl

Universiteit Utrecht

Faculty of Geosciences
Research group
River and delta morphodynamics

Introduction

Mapping of fluvial ecosystem services (ES) and documenting their change over time provides important information for decision making in river management. ES can be extracted partly from spectral aerial imagery, such as available from Google Earth, by linking observable features to ES through inferred fluvial processes, and natural ecosystem functions (Large and Gilvear, 2014). However, additional interpreted data is available from spatial databases, and existing hydrodynamic model parameterizations.

Objective

We aimed at the development of a GIS routine (1) to extract ecosystem services from existing spatial and hydrodynamic model data based on historic time series of the fluvial part of the Rhine Delta (1997 and 2012), and (2) to automate positioning and parameterization of landscaping measures to determine projections of ecosystem services for posiible landscapes in the year 2035.

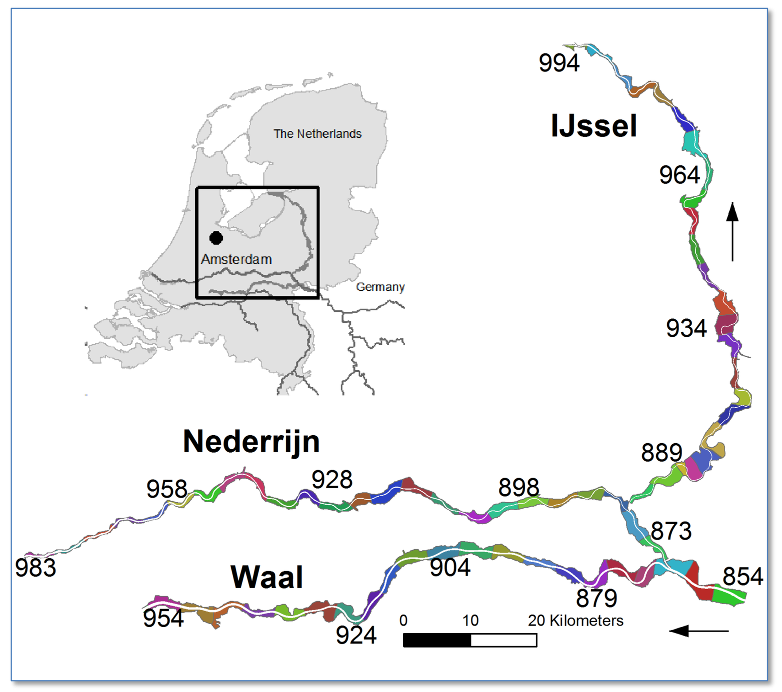

Figure 1. Study area of the Rhine River distributaries covering the fluvial part of the Rhine delta. The numbers represent the river kilometer. The colors represent the river sections over which the ecosystem services were computed (Fig. 3).

Methods

We computed 16 river attributes (Fig. 3) that were subsequently aggregated into eight ES. ES scores were computed for provisioning ES (fisheries, agriculture, timber, water supply), regulating ES (flood mitigation, carbon sequestration, water quality), and supporting ES (biodiversity). Historic ES were derived for the years 1997 and 2012 based on ecotope maps combined with a water levels and flow velocities derived from a calibrated 2D hydrodynamic model (WAQUA). ES for 2035 were based on scenarios of landscaping measures: lowering floodplain roughness and side channel creation. Suitable locations for the measures were determined automatically using map algebra, scripted in PCRaster-Python, with existing spatial data as input.

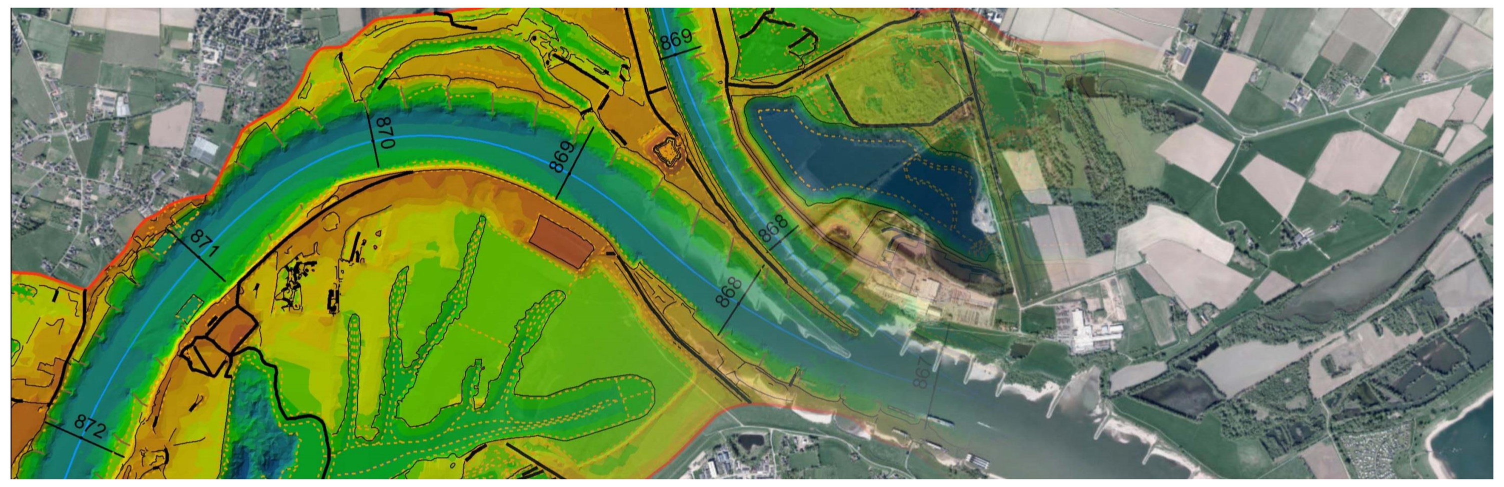

Figure 2. Pannerden bifurcation point: Geospatial data greatly enhance the interpretability of the image compared to spectral data alone.

Results

Due to the river restoration projects carried out between 1997 and 2012 the ES increased in all three distributaries (Figs. 3 and 4), with the largest increase found in the Nederrijn River (15%). For the future, many scenarios are possible. Application of floodplain smoothing and side channel measures in all floodplains will lower the ES up to 20%, indicating that careful planning is required. The scenarios did not greatly affect the overall ecosystem scores as many parameters remain unchanged.

Discussion and conclusion

We conclude that the automated methods provide fast insights in the historic and possible future developments of fluvial ES. While useful for the decision making and natural capital mapping between different rivers, additional process-based information would be required for a management tool. Please leave a note on your wishes or ideas.

I'd like my ecosystem served as:

Type and quality of the data, required input, detail of the process, ...

Multiplied by the surface area of the river section.
With a temporal dimension

On a website

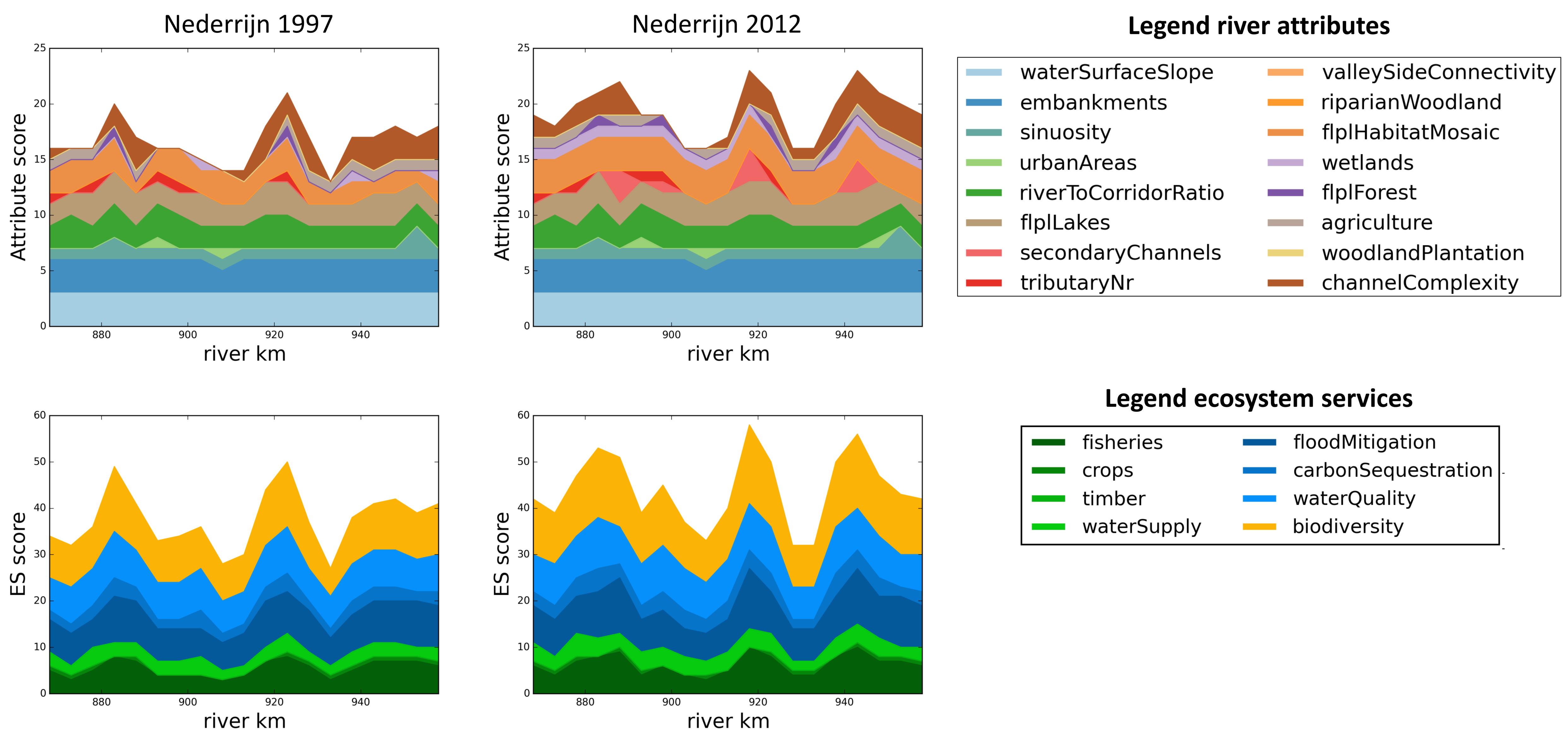

Figure 3. Changes in river attributes (top) and ecosystem services (bottom) score for the Nederrijn River between 1997 (left) and 2012 (right).

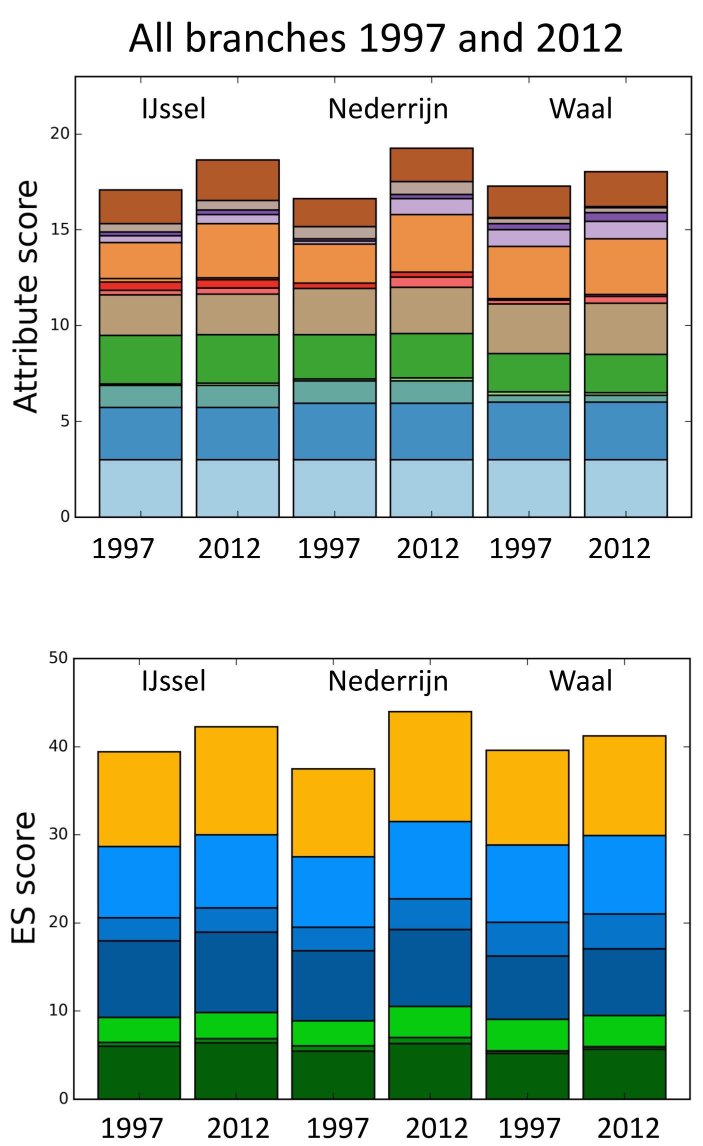

Figure 4. Aggregated scores for all delta distributaries

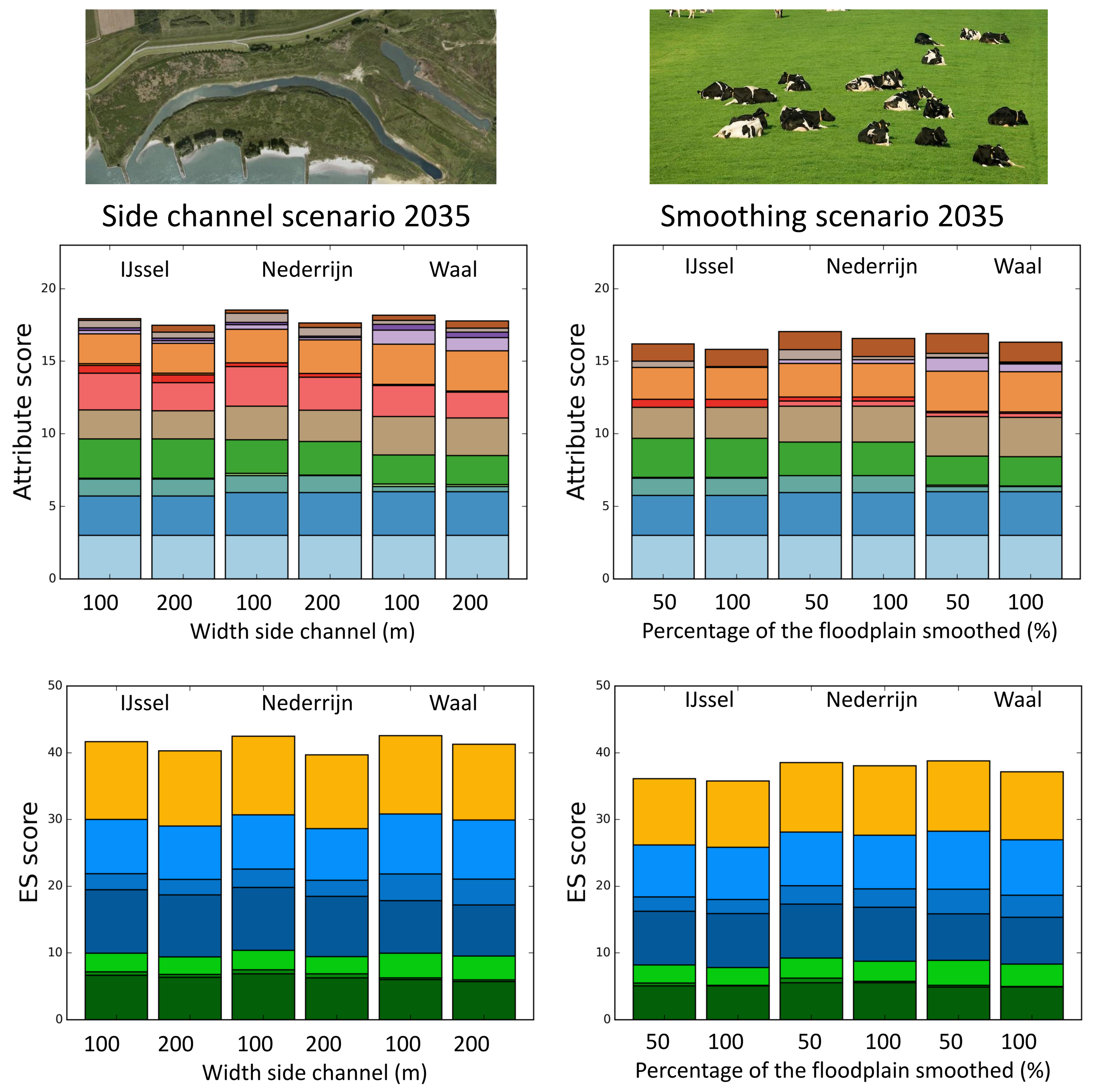

Figure 5. Projection of river attributes and ecosystem scores for all branches: 100 and 200 m wide side channels (left), or smoothing over 50 or 100% (right)

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