# Impact of agricultural land-use intensity on stream ecosystems (Project: OperaSOS)

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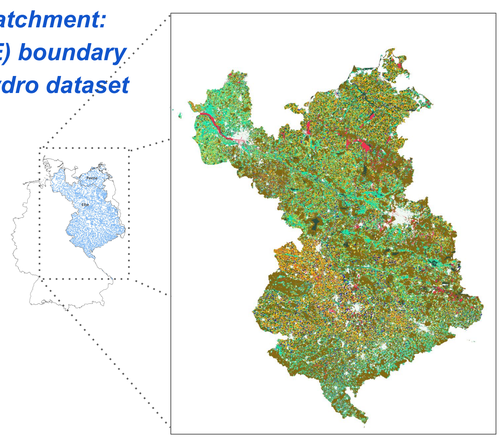
## *Background*

- OperaSOS: Operationalizing the 'Safe Operating Space' concept for a functional management of freshwater ecosystems under global change
- We develop **agricultural land-use intensity index** and quantify responses of **ecosystem structure** and **functions** along the entire agricultural gradient in river catchments across Germany
- The project combines ***fieldwork with data analysis*** in a theory-driven approach to facilitate adaptive land use management of streams and rivers

## *Land-Use Intensity index for Stream ecosystems (LUIS)*

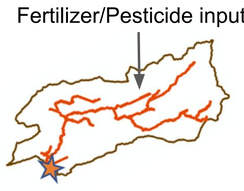
***Test catchment: Elbe (DE) boundary in EU Hydro dataset***



Winter Wheat, Winter Rye, Winter Barley, Spring Barley, Maize, Legumes, Rapeseed, Potatoes, Sugar Beets, Vines, Grassland, Urban Area, Waters, Other Vegetation, Forest, Other crops

Land-use map modified after Preidl et al 2020 (Remote sensing of environment)[2]

Fertilizer/Pesticide input



### *LUIS components*

Nutrient (N, P) inputs from fertilizers ✖ Surface connectivity

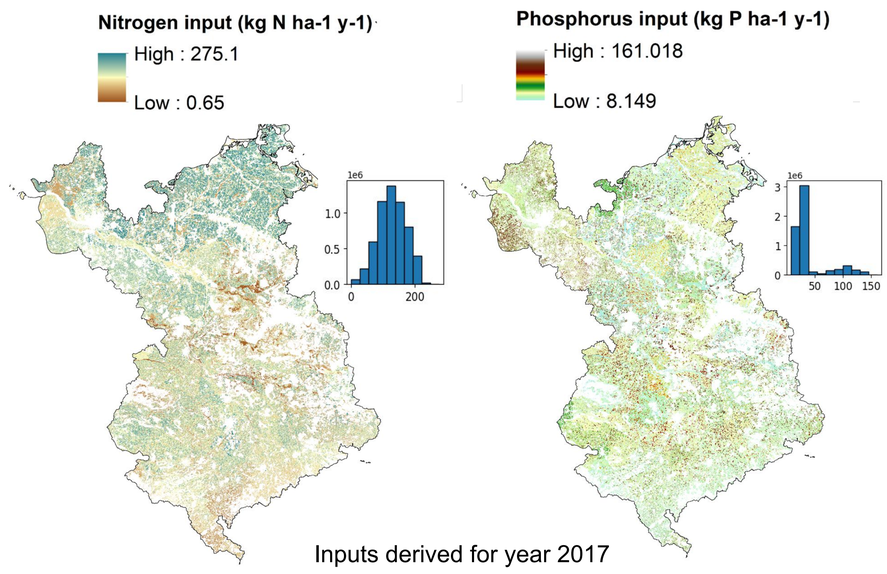
Pesticide inputs

## *Nutrient inputs derived based on Fertilizer Ordinance recommendations*

**N input** =

N requirement value for each crop
*(recommendation from Fertilizer Ordinance tables)*
± Yield difference
*(Landkreis/state level annual average yields)*
- Amount of N available in the soil
*(Based on geographical location (for each state), previous crop type and/or soil type)*
- N supply from soil reserve
*(Humic content of soil)*
- Previous crop type
*(recommendation from Fertilizer Ordinance tables)*

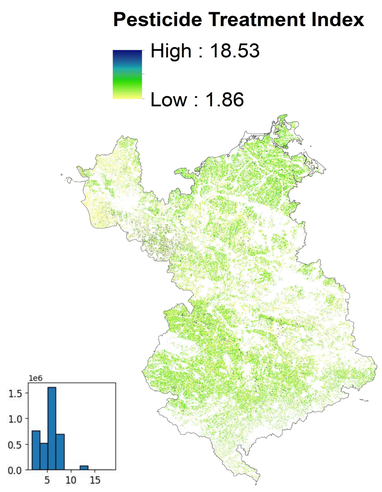
**P input** = Target crop yield × P content of the crop
*(Landkreis/state level annual average yields, P content from Fertilizer Ordinance tables)*




Inputs derived for year 2017

## *Pesticide inputs*

- Pesticide treatment index based on ***crop type*** and ***year*** derived in Panel Pflanzenschutzmittel-Anwendungen survey by JKI[3].
- Indices are also available for ***fungicides***, ***herbicides***, ***insecticides***, and ***growth regulators***.



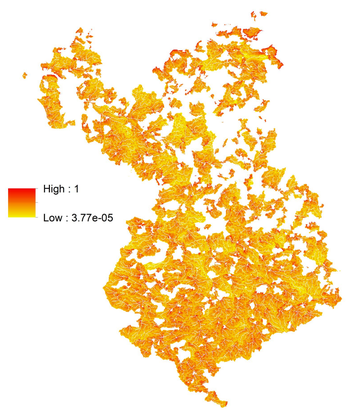

## *Surface connectivity*

$$C_i = (FA_i + 1)(FL_i + 1)^{-1}$$

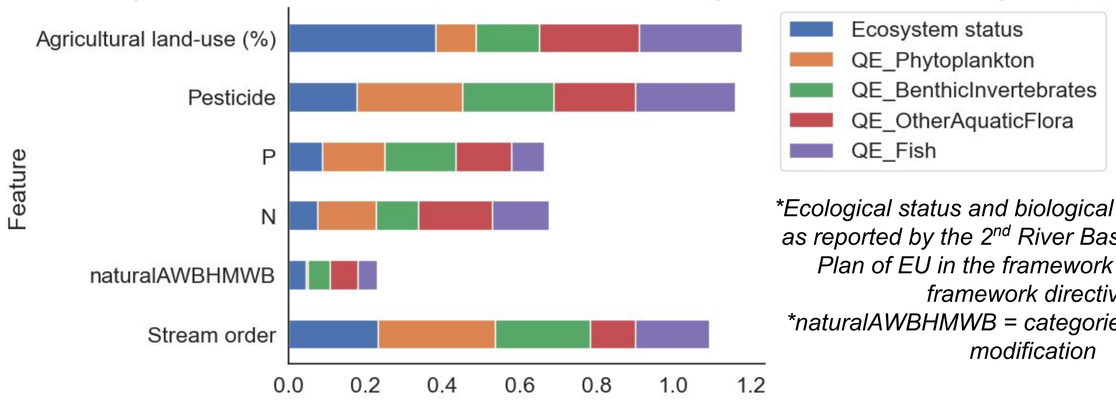
$$Input_{cat} = \sum_{i=1}^{n} Input_i A_i C_{std,i}$$

$i$ = 1…n are the pixels in the sub-catchment
$C_i$ = Connectivity of pixel $i$
$C_{std,i}$ = Transformed and standardized connectivity of pixel $i$
$FA_i$ = Flow accumulation in pixel $i$ ($m^2$)
$FL_i$ = Flow length distance of pixel $i$ (m)
$Input_{cat}$ = Sum of inputs for a catchment
$Input_i$ = Nitrogen/phosphorus/pesticide input in pixel $i$
$A_i$ = Area of pixel $i$

**Surface connectivity ($C_{std,i}$)**




## *Preliminary assessment of the impact of LUIS on ecological status* and biological quality elements (QE)**

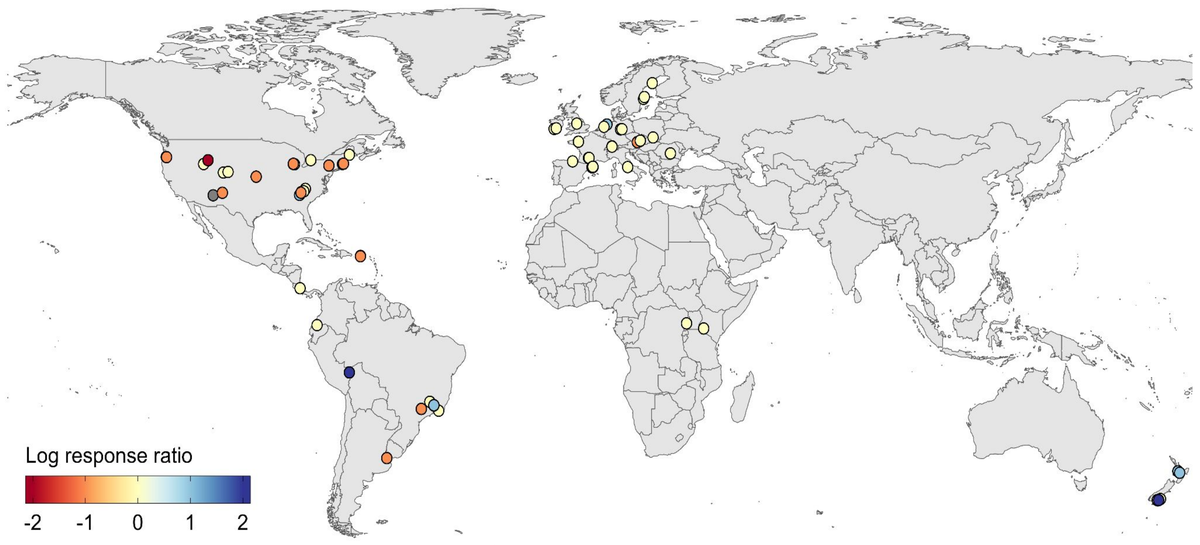



**Ecological status and biological quality elements as reported by the 2nd River Basin Management Plan of EU in the framework of the Water framework directive.*
**naturalAWBHMWB = categories showing river modification*

### *Future tasks*

- Validate LUIS inputs with in-stream nutrient and pesticide observations
- Relate to ecosystem status and ecosystem function variables
- Extend LUIS for Germany
- LUIS at inter and intra-annual scale

## *Meta-analysis linking ecosystem functions to land-use intensity metrics*

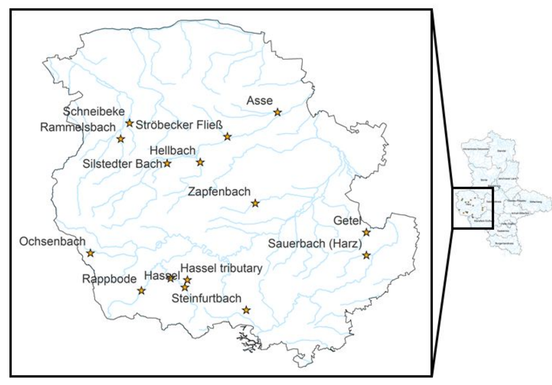



- Testing substantial variation can be explained by LUIS
- Derived from a global comparison of ecosystem functioning in streams draining from pristine and agricultural catchments[5]
- Ecosystem functions:
  - Metabolism
  - Nutrient uptake
  - Leaf litter decomposition
  - Secondary production
  - Food web

### *Future tasks*

- Extraction of land use data (GIS) and combined with calculated LUIS
- Scenario analysis for land management practices

## *Quantification of ecological thresholds among agricultural gradient*




- SOS for LUIS derived from relationships between LUIS and trophic transfer efficiency (TTE)

$$TTE\ \% = \frac{consumer\ ingestion}{resource\ production} \times 100$$

References:

1. Büttner, O. et al (2020). Ecological status of river networks: stream order-dependent impacts of agricultural and urban pressures across ecoregions. Environ. Res. Lett. 15 1040b3
2. Preidl, S., Lange, M., & Doktor, D. (2020). Introducing APiC for regionalised land cover mapping on the national scale using Sentinel-2A imagery. *Remote Sensing of Environment*, *240*, 111673.
3. Panel Pflanzenschutzmittel-Anwendungen. https://papa.julius-kuehn.de/
4. Peterson, E. E., Sheldon, F., Darnell, R., Bunn, S. E., & Harch, B. D. (2011). A comparison of spatially explicit landscape representation methods and their relationship to stream condition. *Freshwater Biology*, *56*(3), 590-610.
5. Brauns, M., Allen, D. C., Boëchat, I. G., Cross, W. F., Ferreira, V., Graeber, D., Patrick, C. J., Peipoch, M., von Schiller, D., & Gücker, B. (2022). A global synthesis of human impacts on the multifunctionality of streams and rivers. Global Change Biology, 00, 1–11.

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