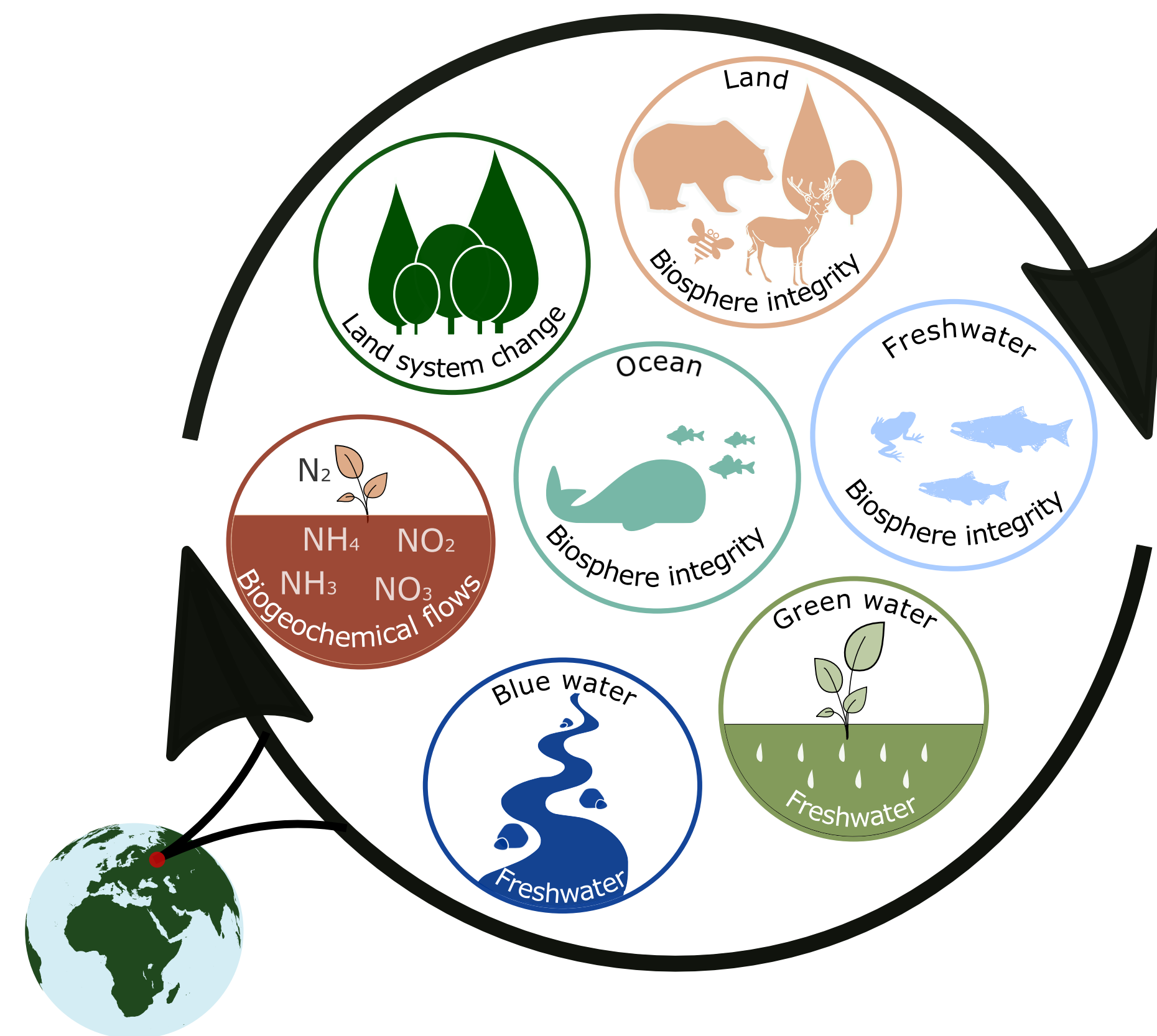


A. Chrysafi*, V. Virkki, M. Jalava,
V. Sandström, J. Piipponen,
M. Porkka, M. Kummu

Improving current estimates of the sustainability of the future food supply: Integrating and distributing Planetary Boundaries at sub-national level

Water & Development
Research Group
*anna.chrysafi@aalto.fi

1. Planetary Boundaries (PBs) of interest



2. Background and aims

The safe operating space (SOS) for future food systems **is potentially shrunk** when considering PBs interactions.

The interactions' effects can **cascade to larger scales**, thus we need to pay special attention to them.

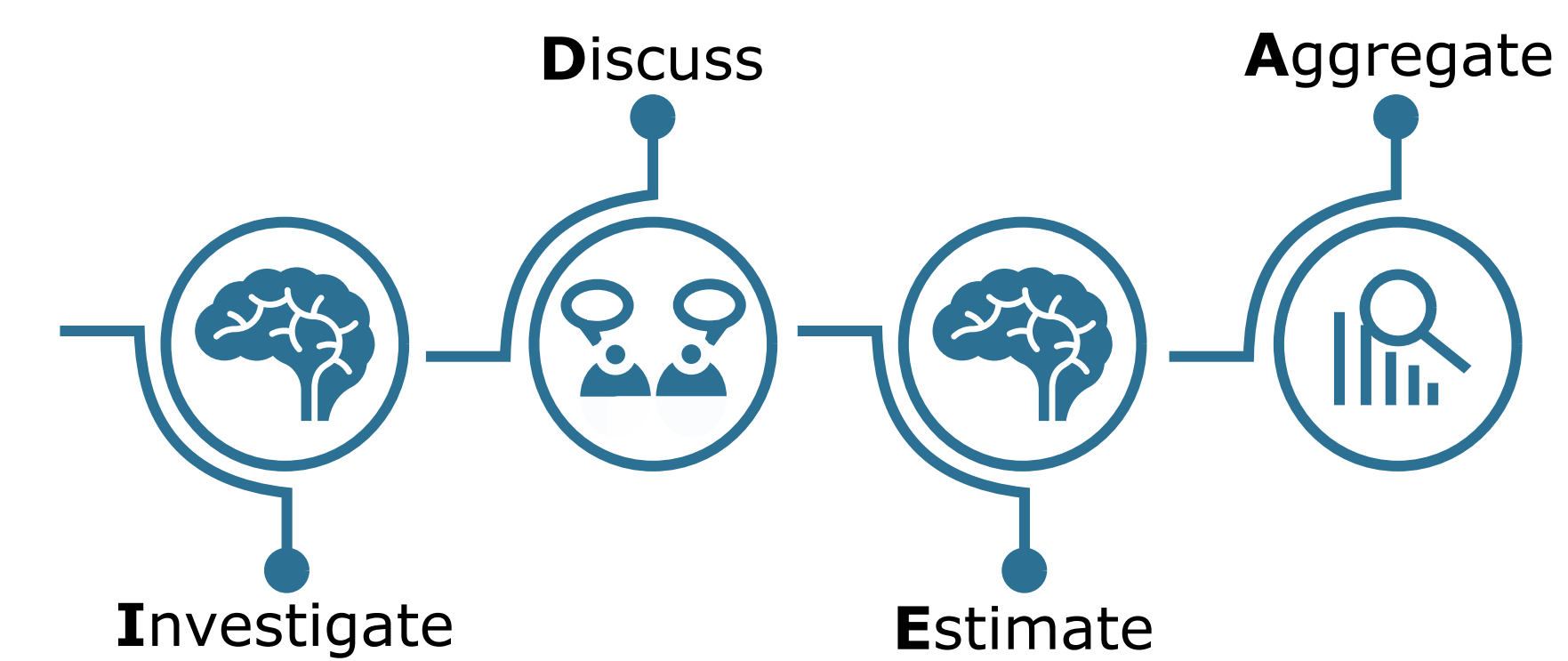
We wanted to quantify how strongly these PBs **interact at the local scale** (Interactions N=42).

We focus on the PBs for which **agriculture is a strong driver** of change.

3. Expert knowledge elicitation

We conducted a **remote elicitation** with a custom-made on-line application. [Go to App!](#)

We followed the **IDEA elicitation protocol**, a modified Delphi procedure.



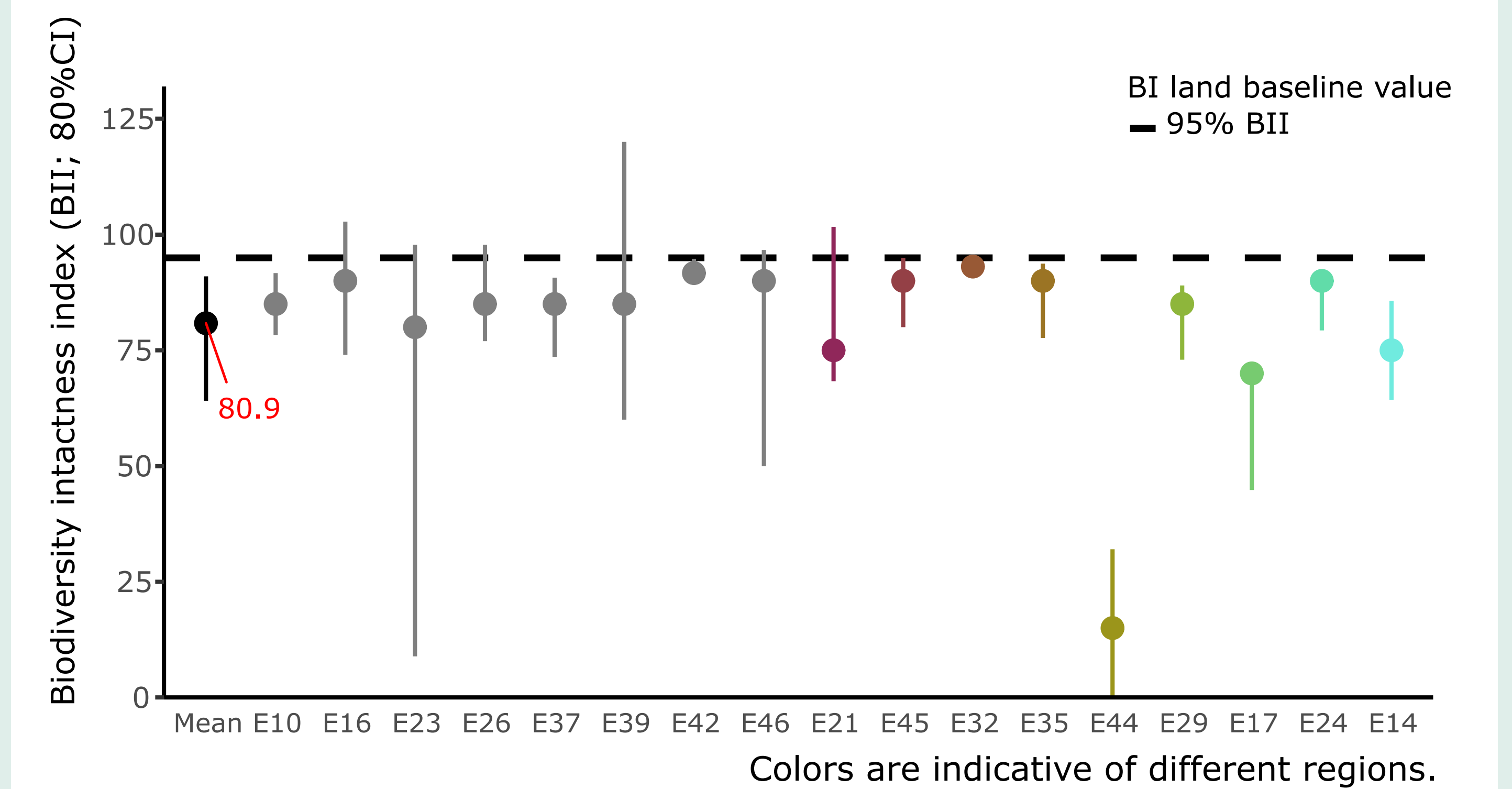
This protocol is well suited for **natural resources** management.

Experts that have published on PBs were invited via email.

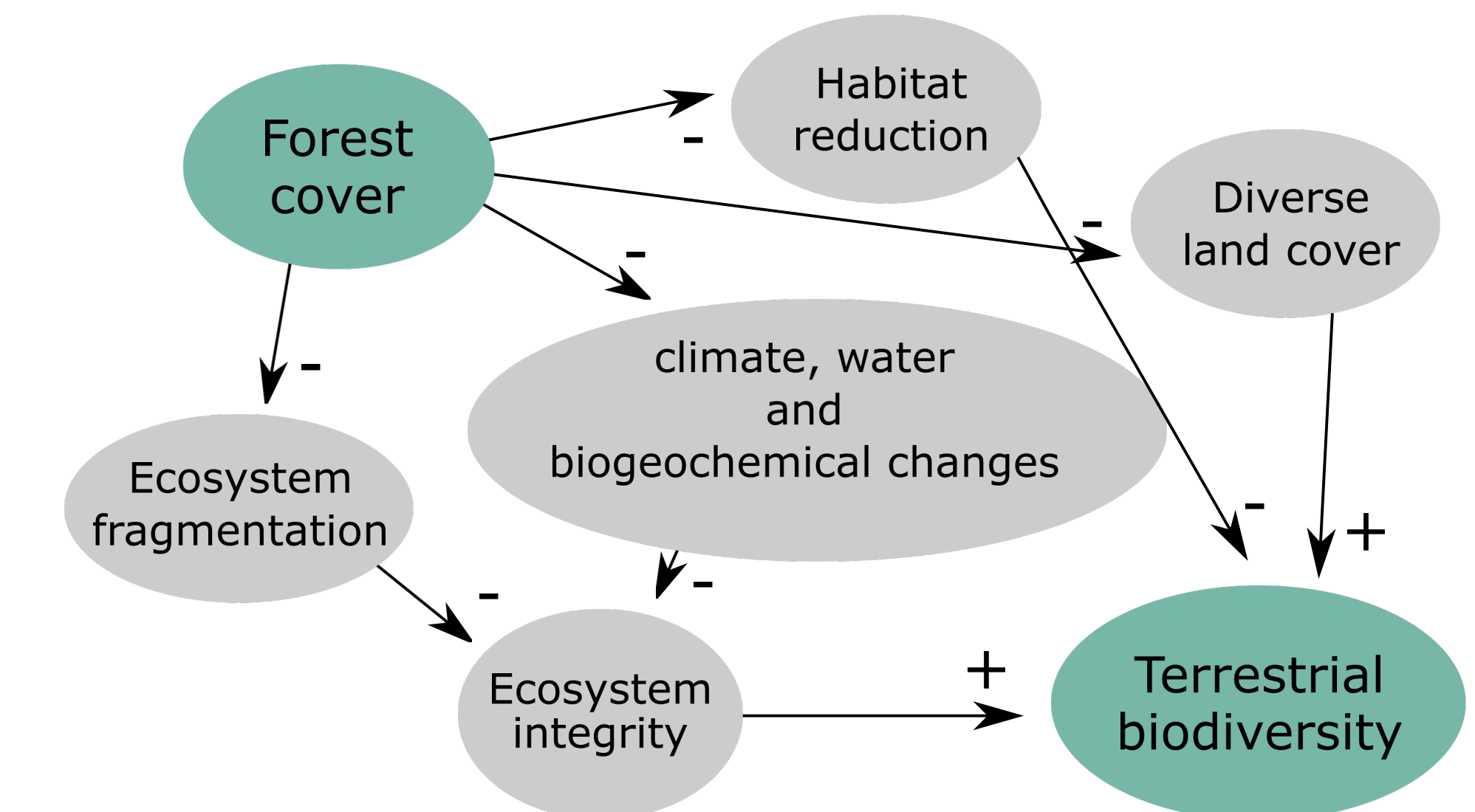
Total **N=37 experts** participated in the elicitation.

6. Example results: Land system change → BI land

Effect on BI land caused by decrease in forest cover from 90% to 80%

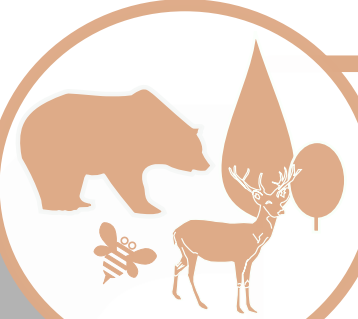

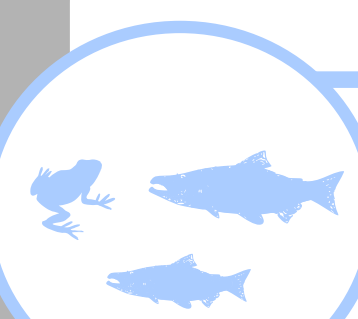

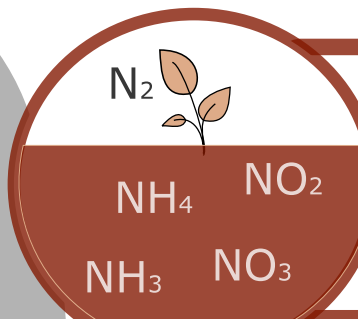




Mechanisms mediating the interaction described by the experts

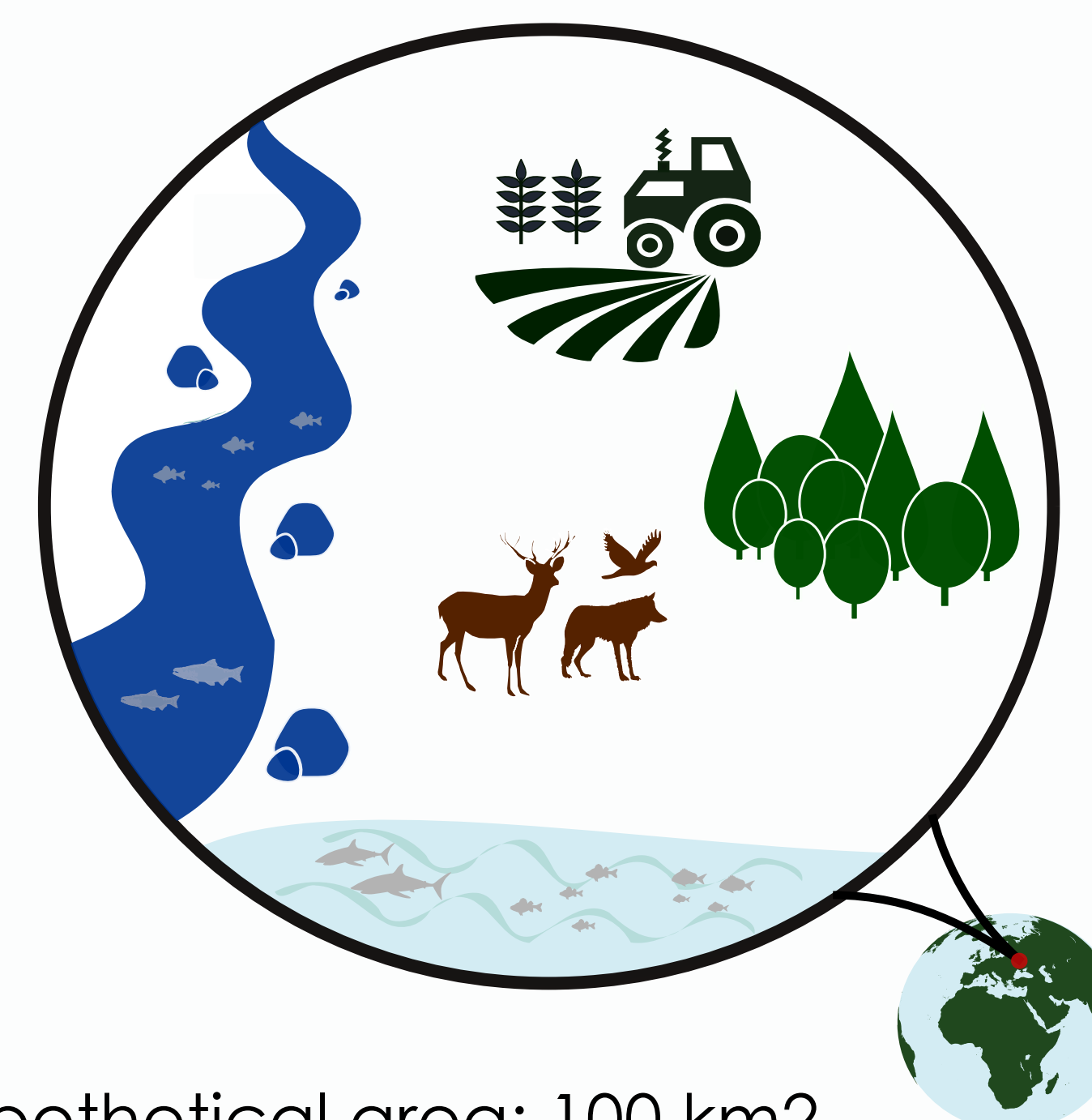


4. Control variables used to estimate the PBs interactions

Safe local limits and interaction strengths may vary among different contexts

	BI Land Biodiversity Intactness Index (BII) A proxy for functional diversity. The global boundary is set at 90% BII, relative to pre-industrial levels.	
	BI Freshwater Biomass of keystone fish species A proxy for ecosystem functioning. Biomass $\geq 0.5K$ is considered within safe biological limits (K is carrying capacity).	
	Land system change Forested land area Forest cover relative to potential forest in biome scale. Global boundary is set at 75% of original forest.	
	Biogeochemical flows Leached N concentration in runoff to surface waters A proxy for N concentration in surface waters. Concentration in runoff should not exceed 1 mg N/L to prevent aquatic eutrophication.	
	Blue water Seasonal river discharge River discharge should stay above local environmental flow requirements (EFRs), estimated relative to pre-industrial flows.	
	Green water Growing season soil moisture Growing season root-zone soil moisture is used as a proxy for Earth system functions of green water, relative to pre-industrial conditions.	

5. Area assessed and question format



Hypothetical area: 100 km².
Potentially located in any region.
Experts evaluated the interactions within the area.

Questions were formatted as follows:
"How would a decrease in control variable X alter control variable Y?"

7. Next steps in PBs integration

Quantifying the interaction strengths combining **expert knowledge elicitation** results and **literature**.

Derive region specific values where/if possible.

Qualitatively **map the mechanisms** mediating these interactions.

Model the interactions at the local scale and **estimate new SOSs**.

Updated local SOSs will be used as **constraints in crop optimization** modeling to estimate future sustainable food availability.