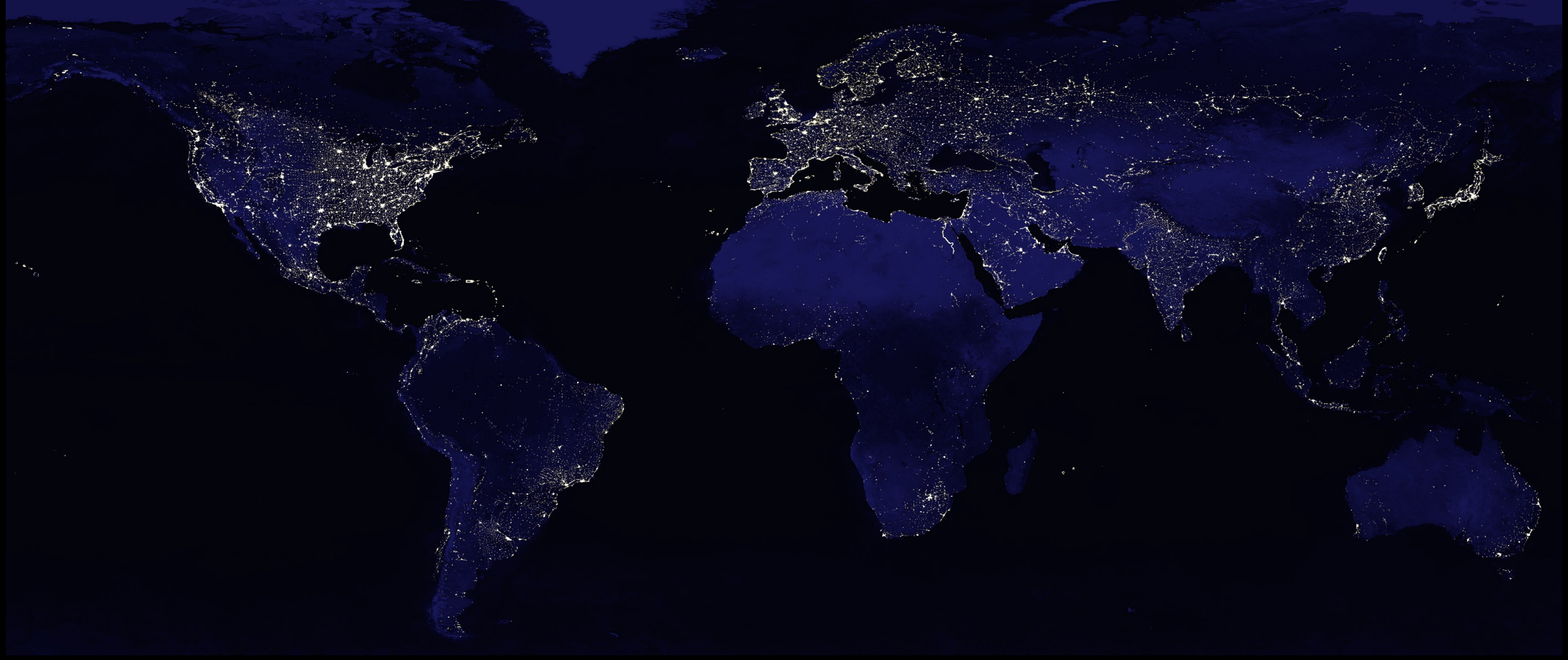

Regime Shifts in the Anthropocene

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The Anthropocene

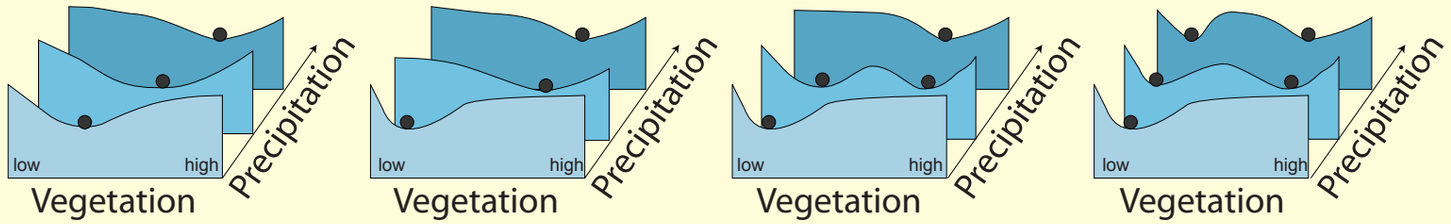
The Anthropocene

Social challenge: Understand patterns of causes and consequences of regime shifts

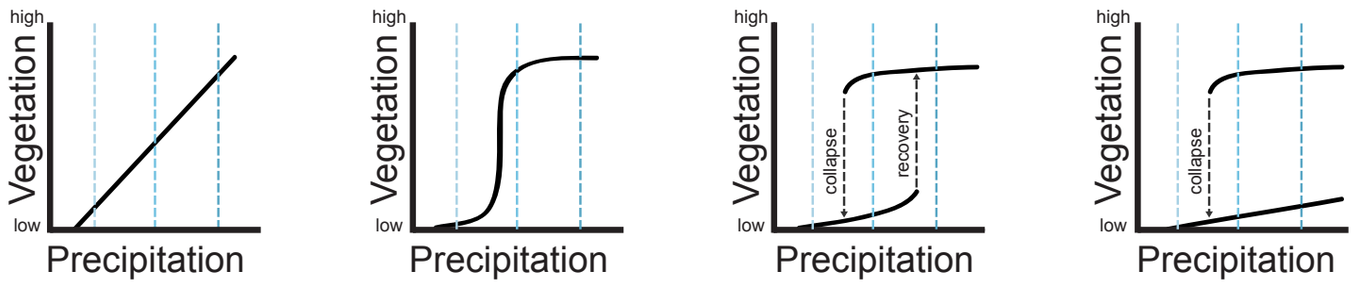
- How common they are? What are the main drivers?
- Where are they likely to occur?
- Who will be most affected?
- What can we do to avoid them?
- What possible interactions or cascading effects?

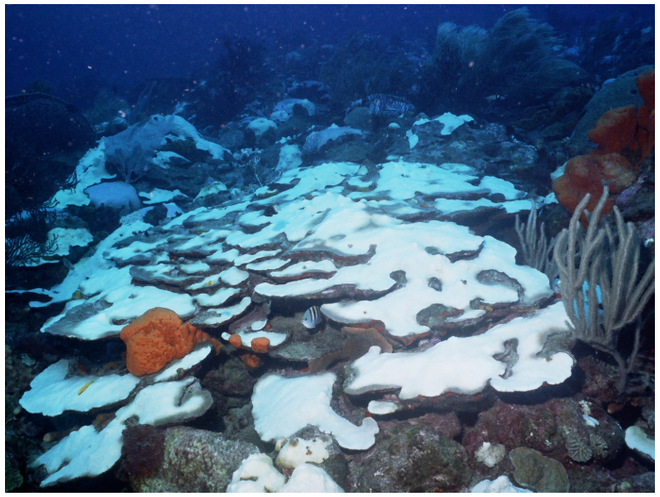
Science challenge: understand phenomena where experimentation is rarely an option, data availability is poor, and time for action a constraint

Stability Landscape

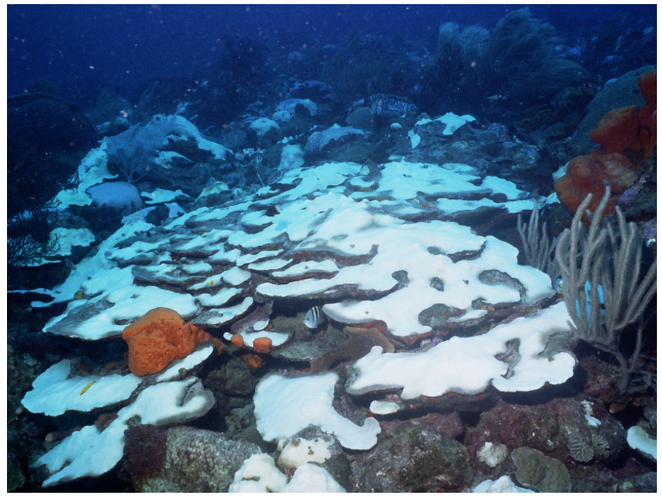


Equilibria





Regime shifts are abrupt reorganisation of a system's structure and function.



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THE PONTOONS, GRIMSBY.
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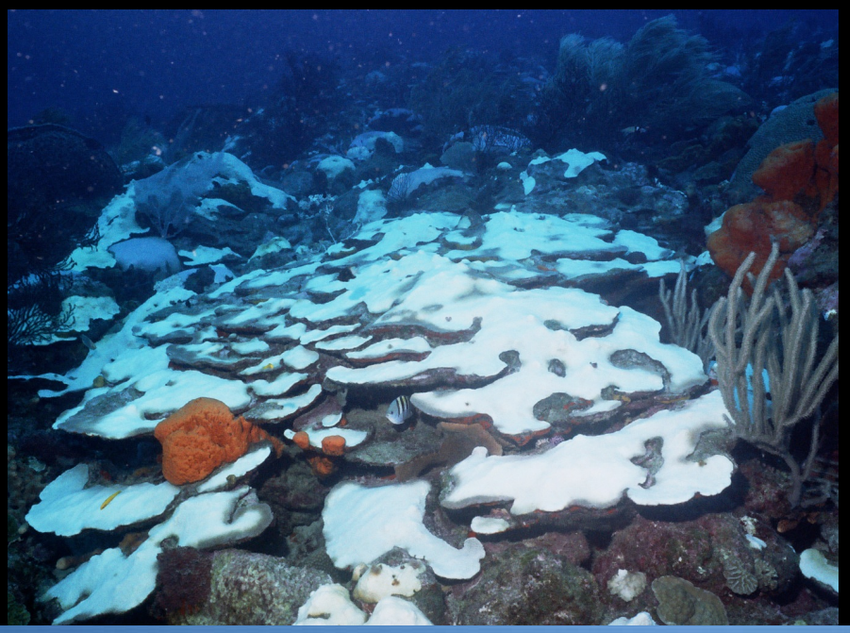
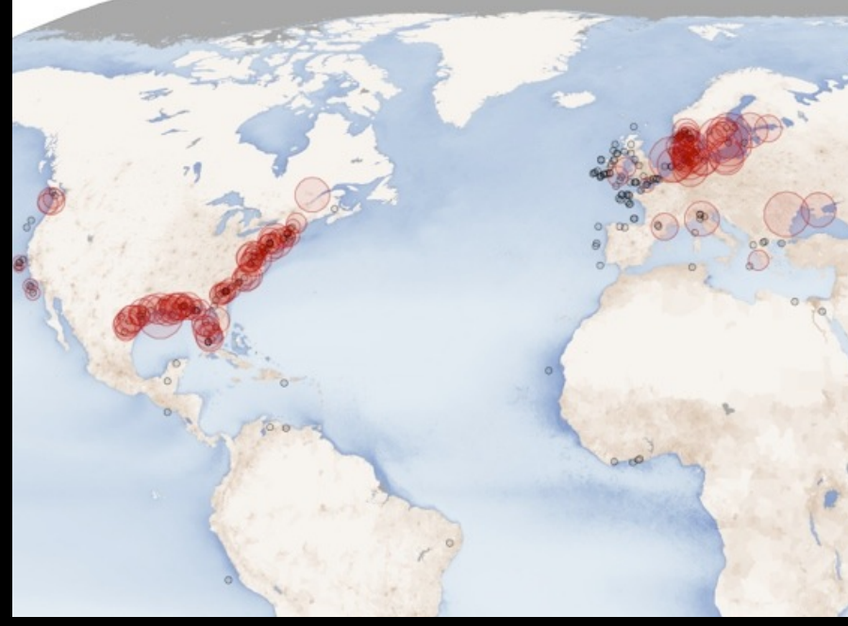
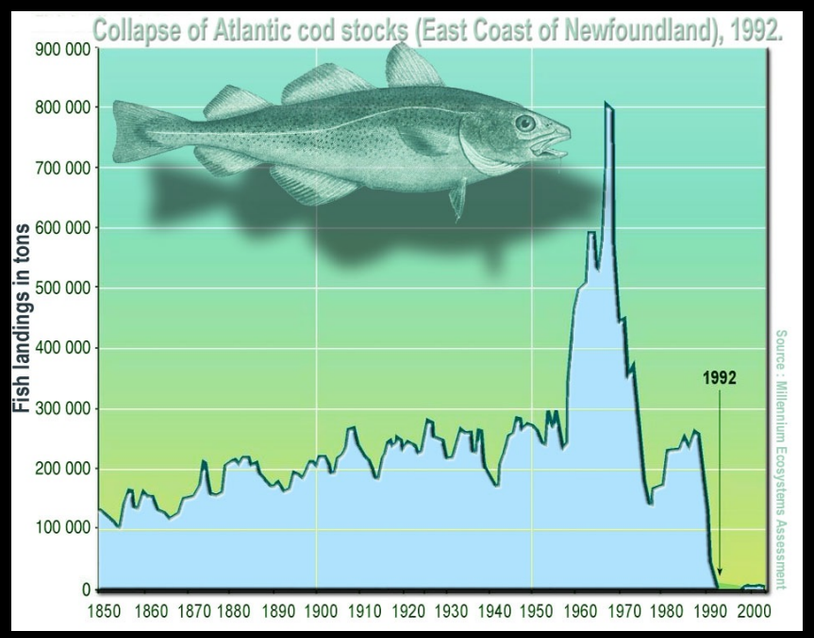
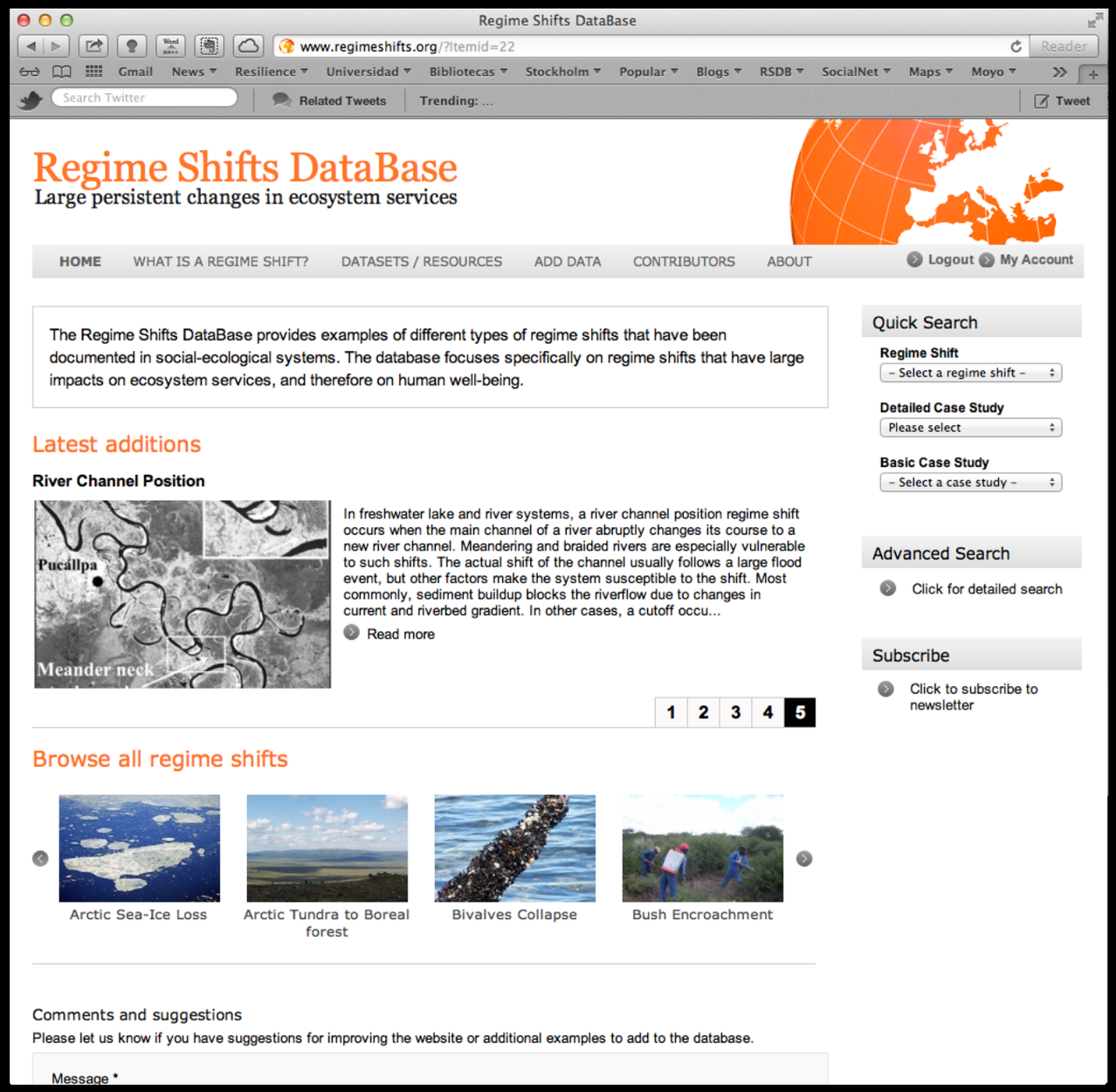





Collapse of Atlantic cod stocks (East Coast of Newfoundland), 1992.
Fish landings in tons
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
0
1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
1992
Source : Millennium Ecosystems Assessment

Regime Shifts DataBase

- The shift substantially affect the set of ecosystem services provided by a social-ecological system
- Established or proposed feedback mechanisms exist that maintain the different regimes.
- The shift persists on time scale that impacts on people and society

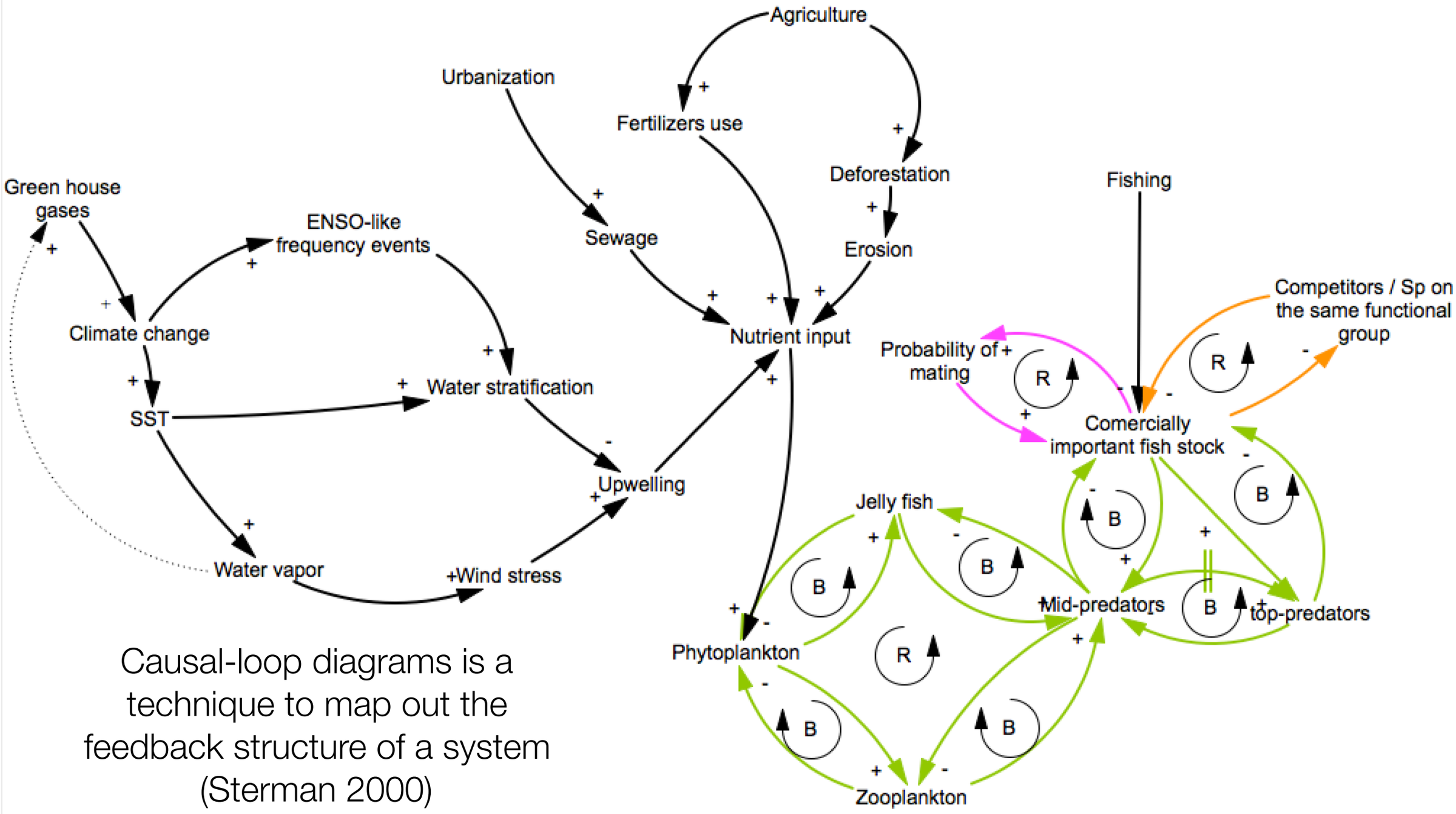


Drivers, Risk & Resilience

Rocha, et al. PLoS ONE 10:e0134639

Drivers

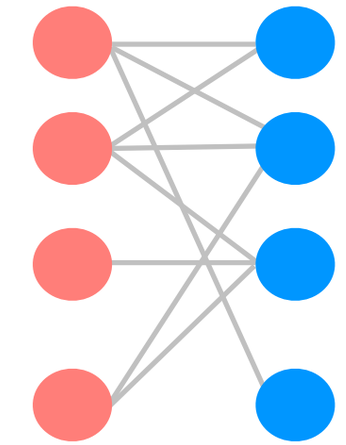
Natural or human induced changes that have been identified as directly or indirectly producing a regime shift



Causal-loop diagrams is a technique to map out the feedback structure of a system (Sterman 2000)

Methods

- Bipartite network and one-mode projections: 25 Regime shifts + 57 Drivers
- 10^4 random bipartite graphs to explore significance of couplings: mean degree and co-occurrence statistics on one-mode projections.
- ERGM models using Jaccard similarity index on the RSDB as edge covariates & MDS



Drivers Regime shifts

Regime Shift Database

A	1	0	1	1	0	0	0	0	1	1	1	1	0	1	0	1
B	1	0	0	0	1	1	0	0	1	1	1	0	0	1	0	1
C																

	Ecosystem services		Spatial scale
	Ecosystem processes		Temporal scale
	Ecosystem type		Reversibility
	Impact on human well being		Evidence
	Land use		...

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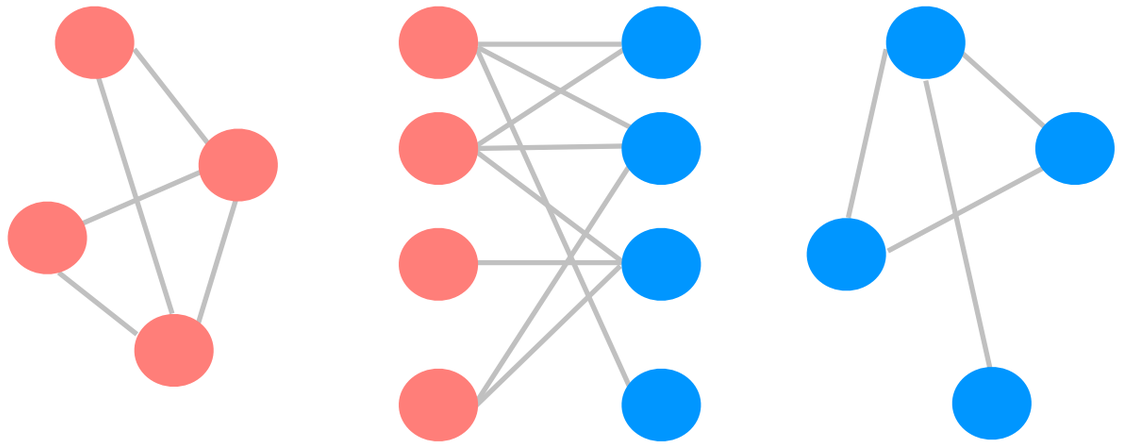

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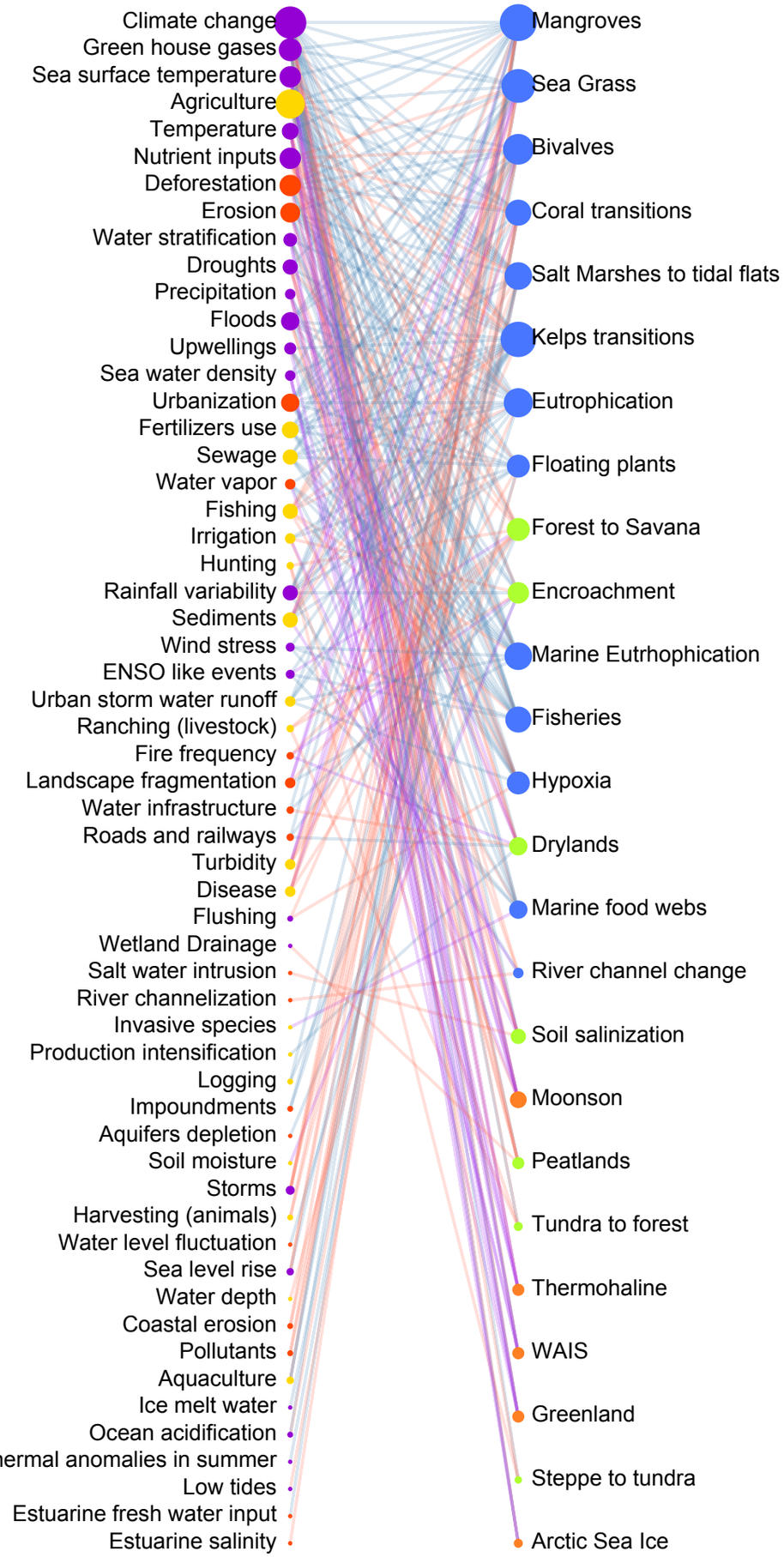
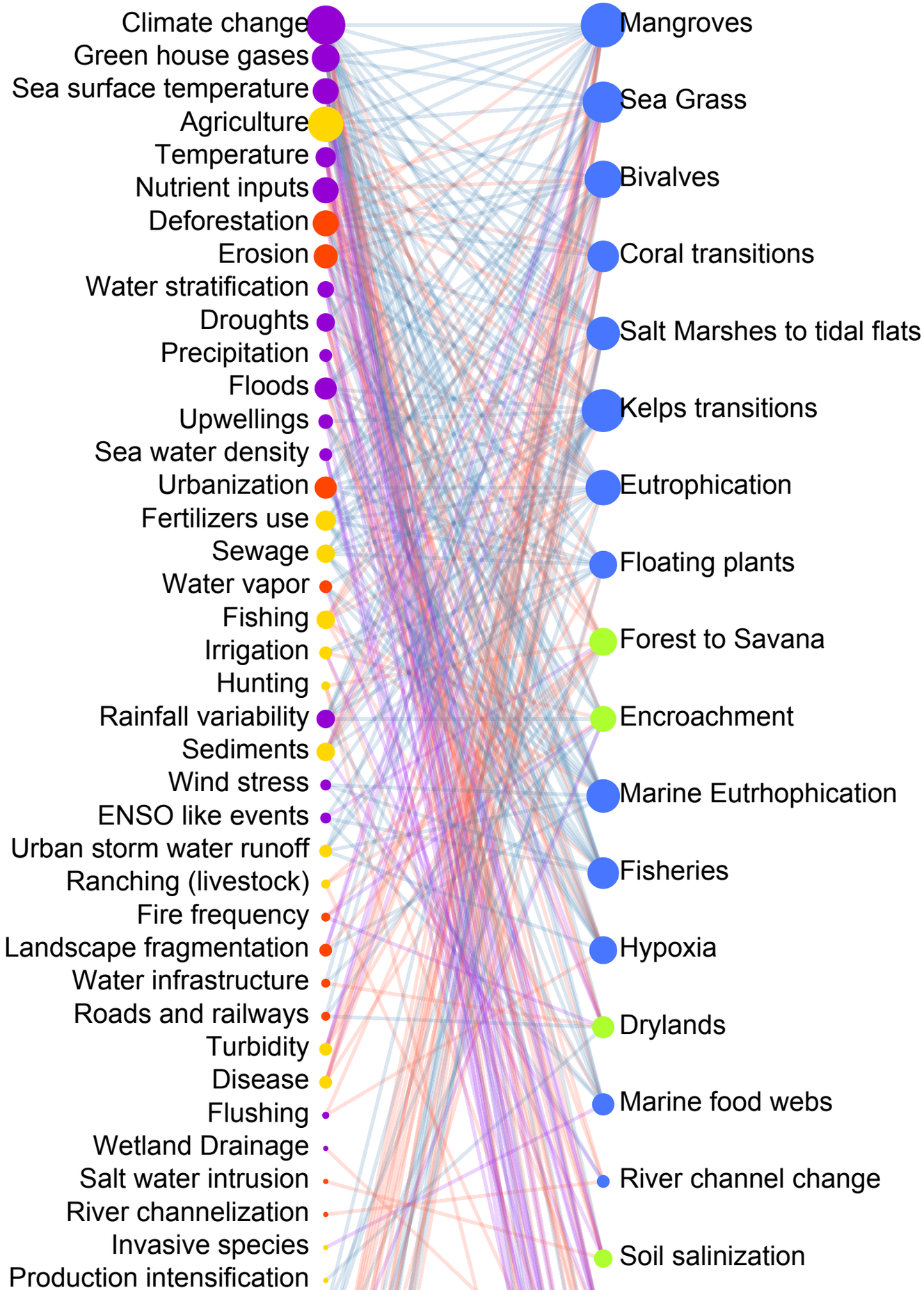

Climate change
Green house gases
Sea surface temperature
Agriculture
Temperature
Nutrient inputs
Deforestation
Erosion
Water stratification
Droughts
Precipitation
Floods
Upwellings
Sea water density
Urbanization
Fertilizers use
Sewage
Water vapor
Fishing
Irrigation
Hunting
Rainfall variability
Sediments
Wind stress
ENSO like events
Urban storm water runoff
Ranching (livestock)
Fire frequency
Landscape fragmentation
Water infrastructure
Roads and railways
Turbidity
Disease
Flushing
Wetland Drainage
Salt water intrusion
River channelization
Invasive species
Production intensification
Logging
Impoundments
Aquifers depletion
Soil moisture
Storms
Harvesting (animals)
Water level fluctuation
Sea level rise
Water depth
Coastal erosion
Pollutants
Aquaculture
Ice melt water
Ocean acidification
Thermal anomalies in summer
Low tides
Estuarine fresh water input
Estuarine salinity
Mangroves
Sea Grass
Bivalves
Coral transitions
Salt Marshes to tidal flats
Kelps transitions
Eutrophication
Floating plants
Forest to Savana
Encroachment
Marine Eutrhophication
Fisheries
Hypoxia
Drylands
Marine food webs
River channel change
Soil salinization
Moonson
Peatlands
Tundra to forest
Thermohaline
WAIS
Greenland
Steppe to tundra
Arctic Sea Ice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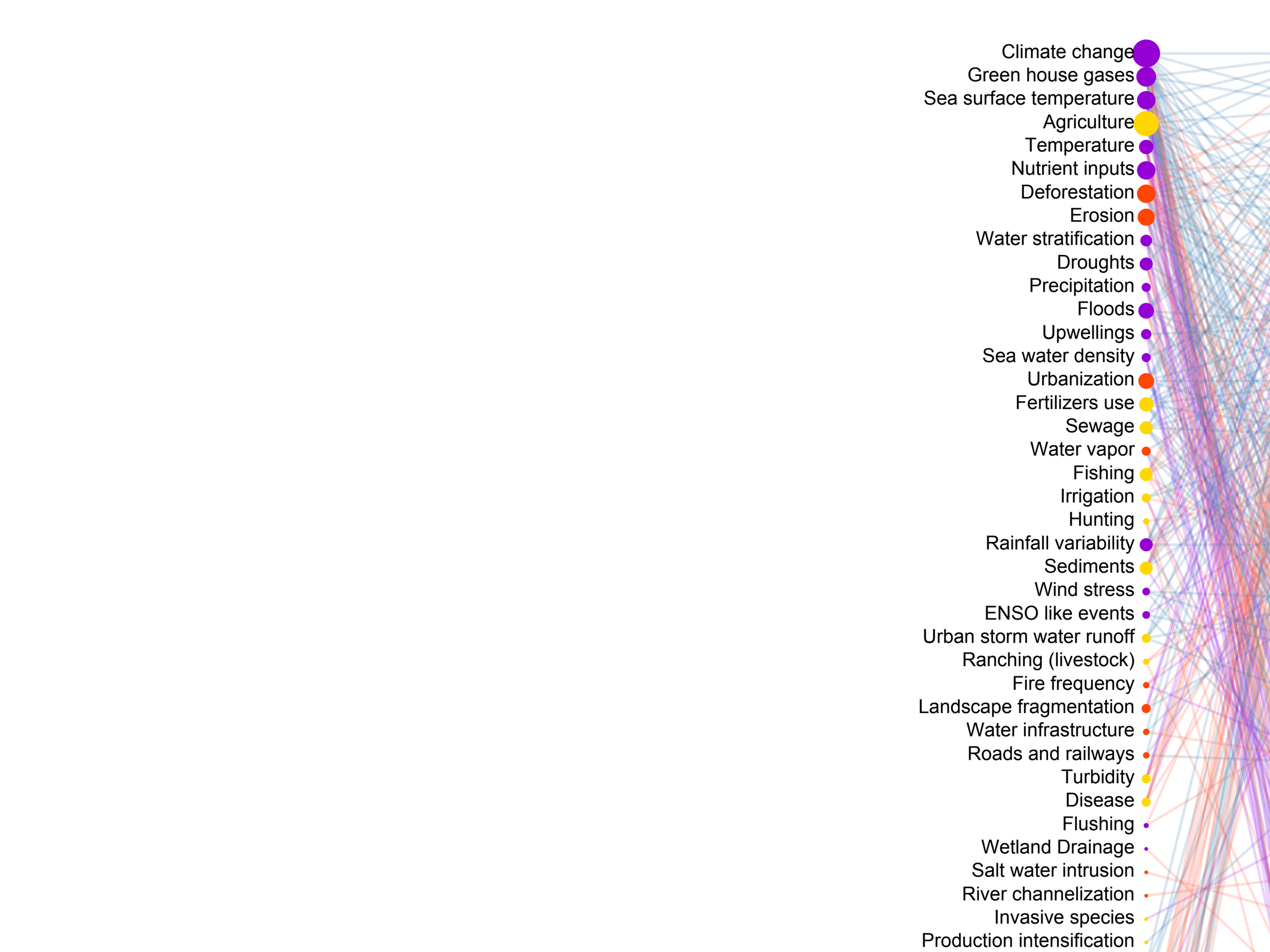
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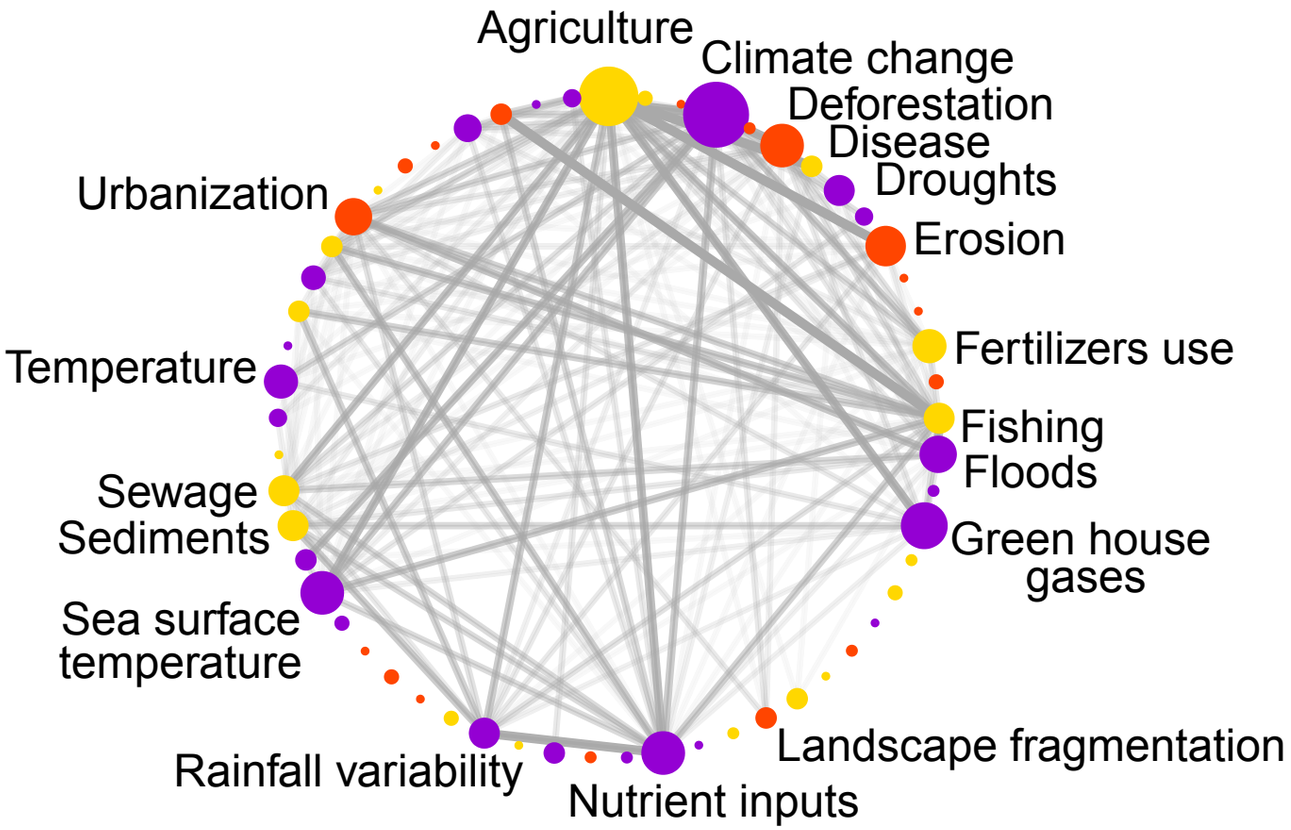
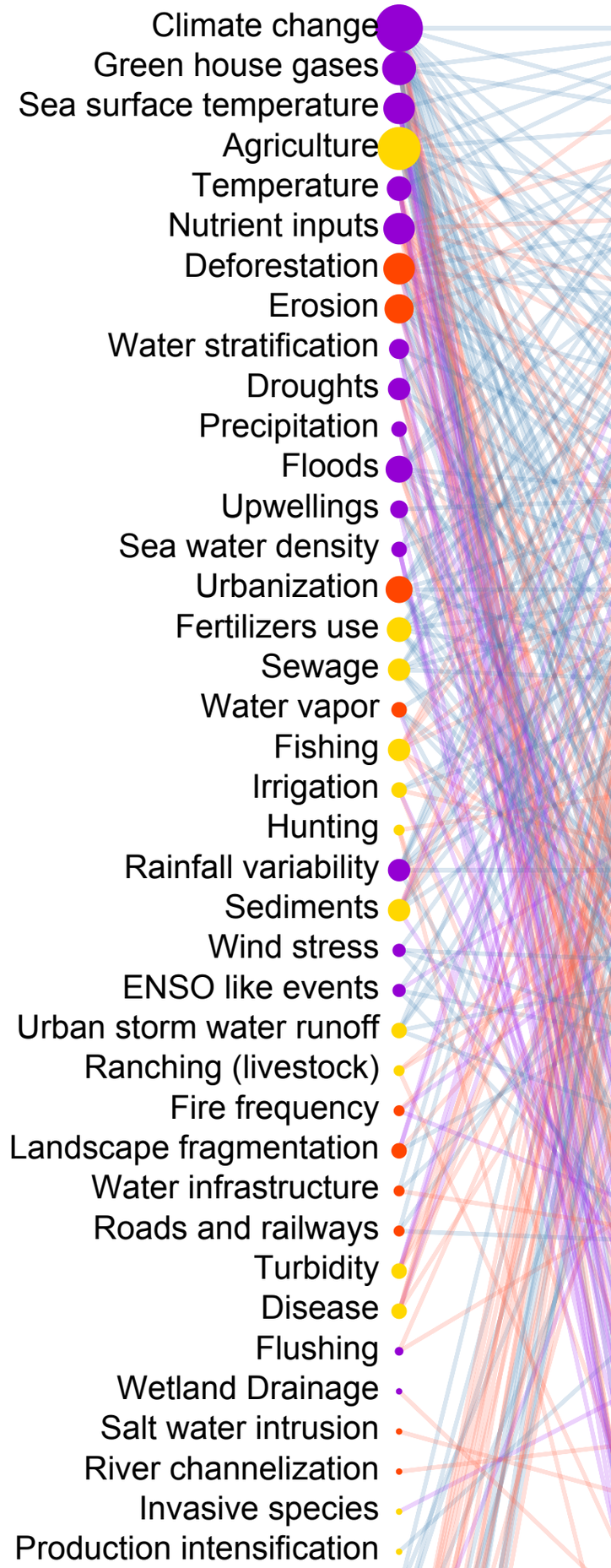
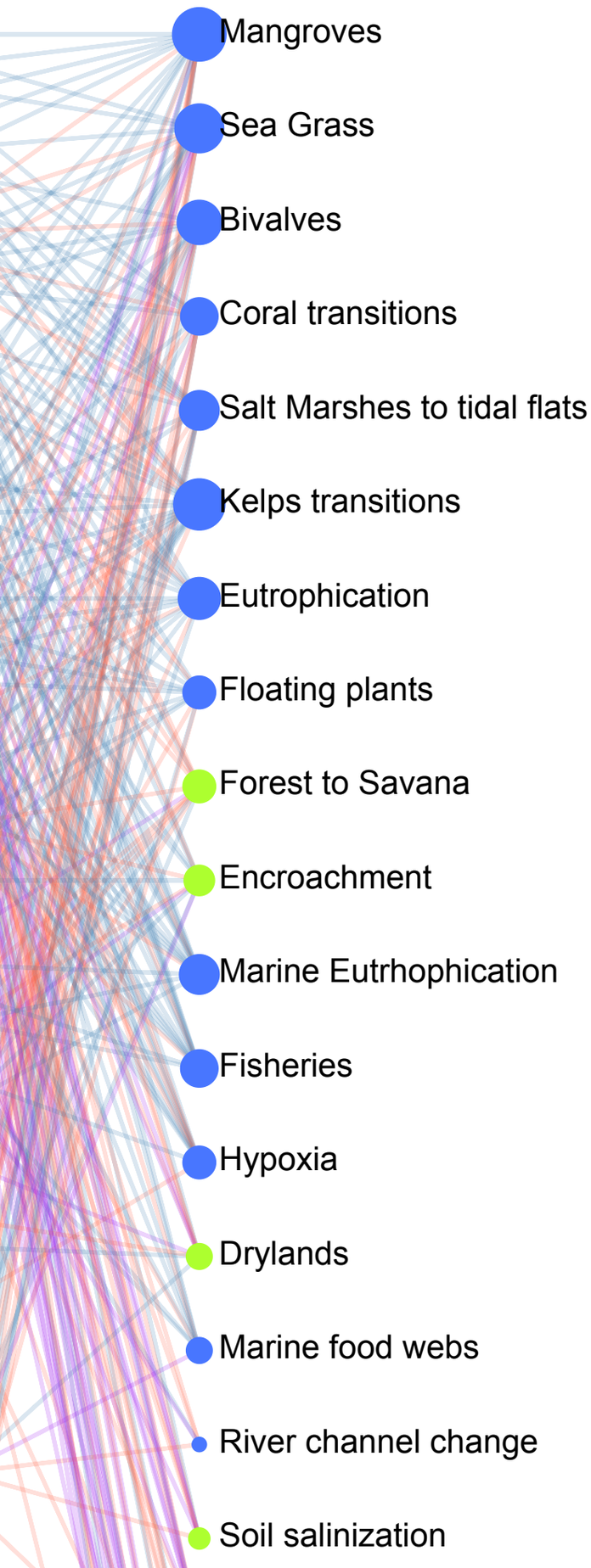




> likelihood of drivers co-occurrence if drivers that can be managed at local - regional scales and if they are indirect & generalist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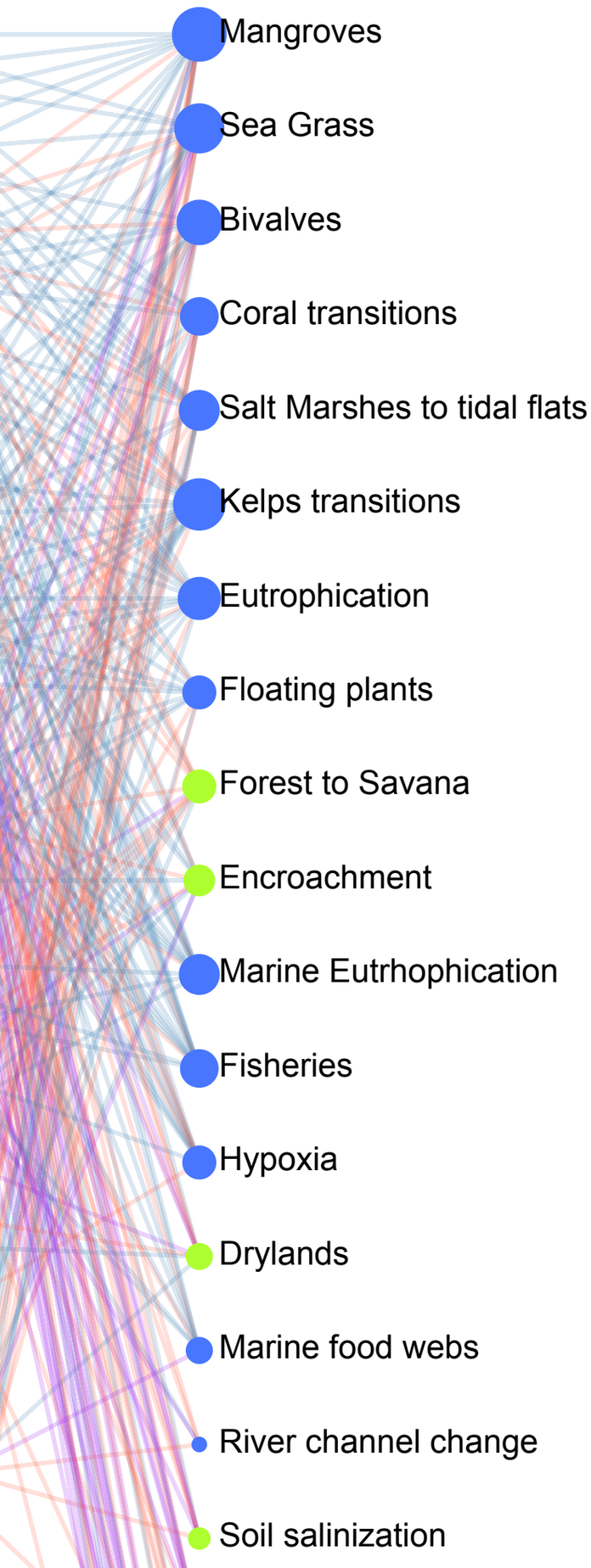

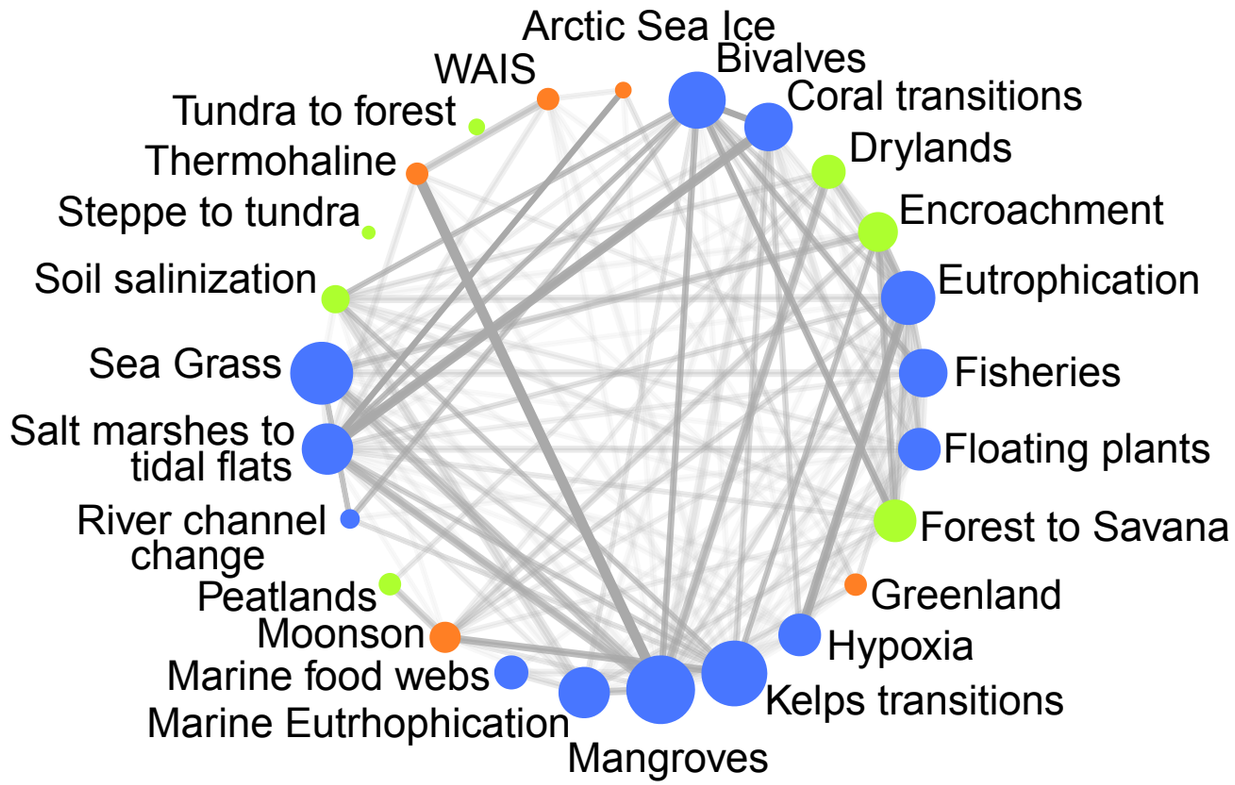

Aquatic share more and more or less the same set of drives while terrestrial and sub-continental are more drivers diverse. Higher driver co-occurrence if regime shifts share: ecosystem type, ecosystem processes, impacts on ES and scales.

Drivers diversity & impacts are shaped by ecosystem type

- Spill over effects are shared by all RS especially related to climate.

- Marine RS -> fisheries, water purification, disease control and aesthetic values

- Subcontinental -> climate regulation, scale of centuries

- Terrestrial RS -> water cycling, provision of livestock and freshwater, climate regulation, occur in land uses related to crops & livestock and occur on time horizon of decades.

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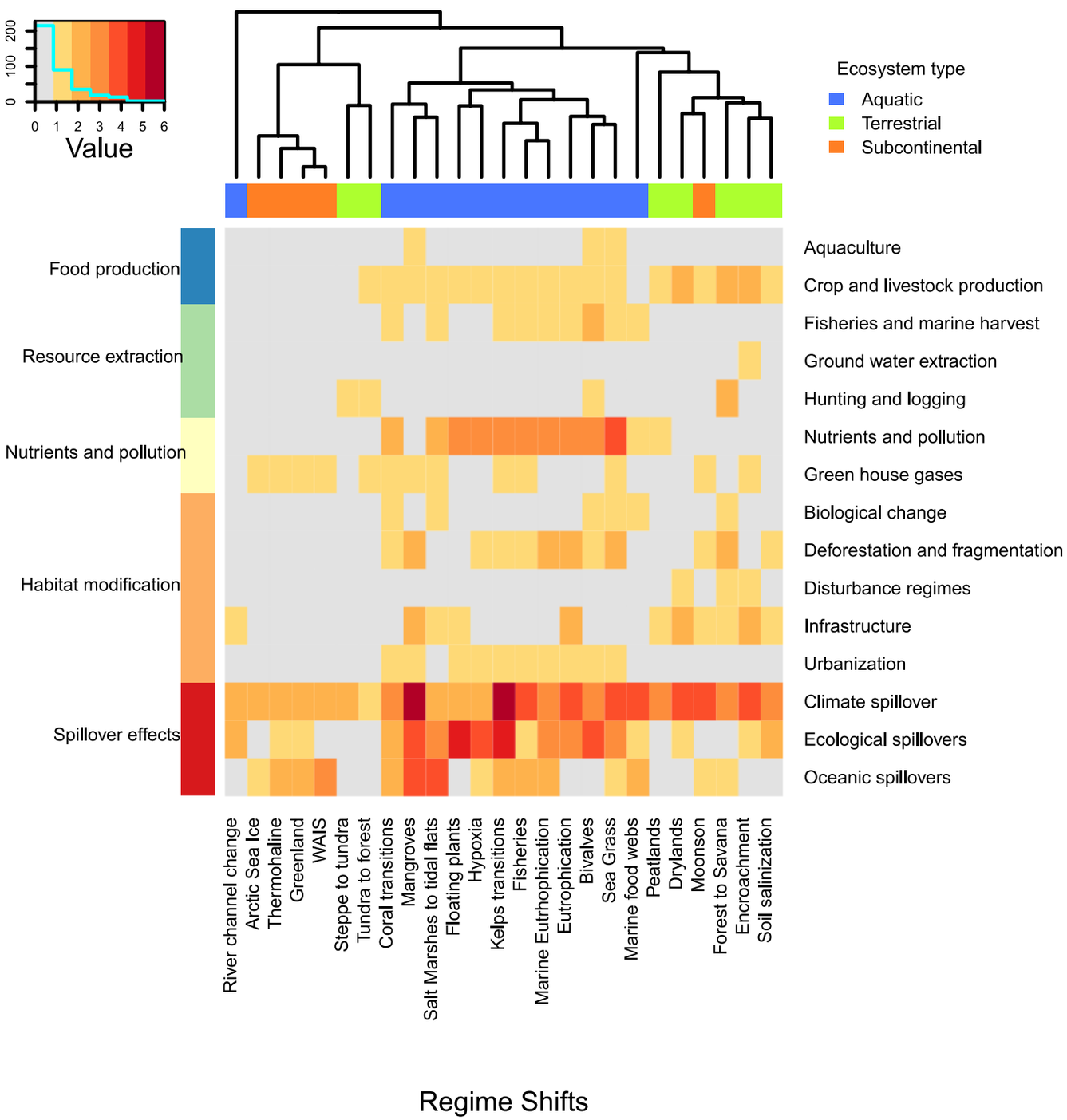

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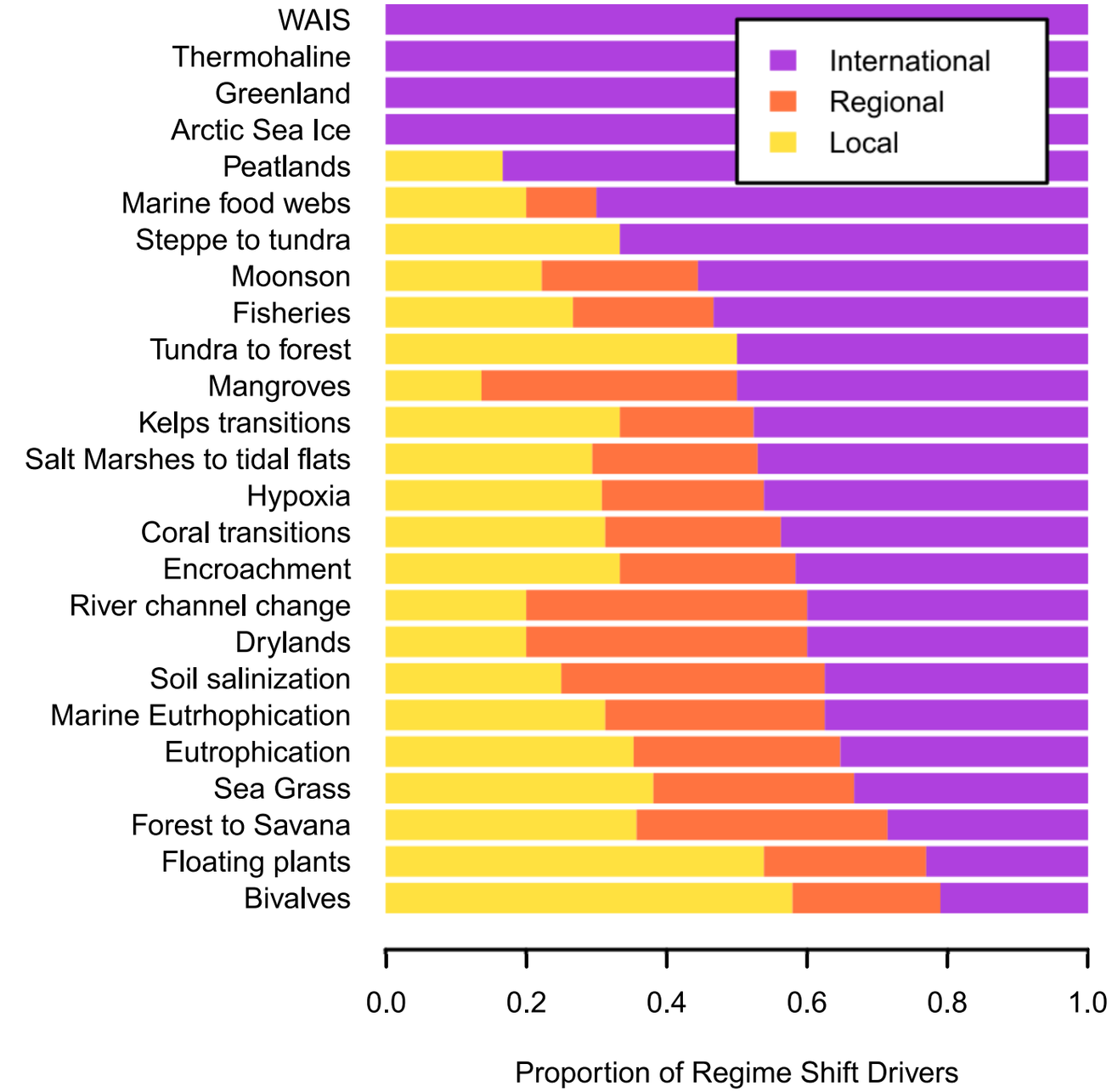
The governance & management challenge

- Managerial actions need to be coordinated across scales.

- 62% of drivers can be managed locally or regionally

- Addressing local & regional drivers can build resilience and delay the effect of global ones; but there is not blue print solutions.



Conclusions

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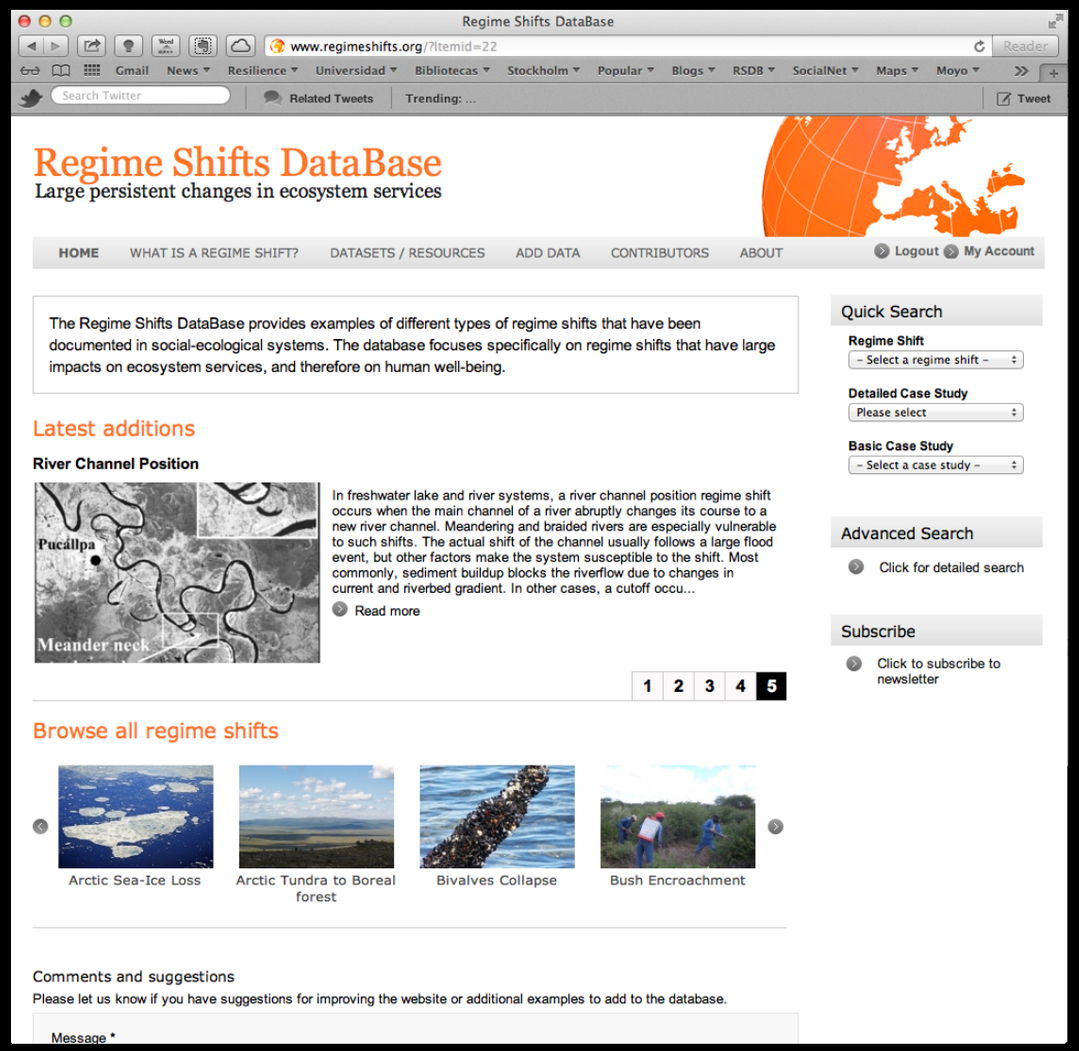

Biggs et al. bioRxiv:018473.

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Rocha, J., et al. 2015. Phil Trans R Soc B:20130273

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- Food production & climate change are the main drivers. High drivers co-occurrence suggest the risk of cascading effects but also present opportunities for management.
- Addressing local-regional drivers can built resilience to global ones. Embrace drivers diversity.
- Test a method for indirect detection of ecosystem service change: good for supporting & regulating services; but cultural services and pollination are elusive.

Questions??

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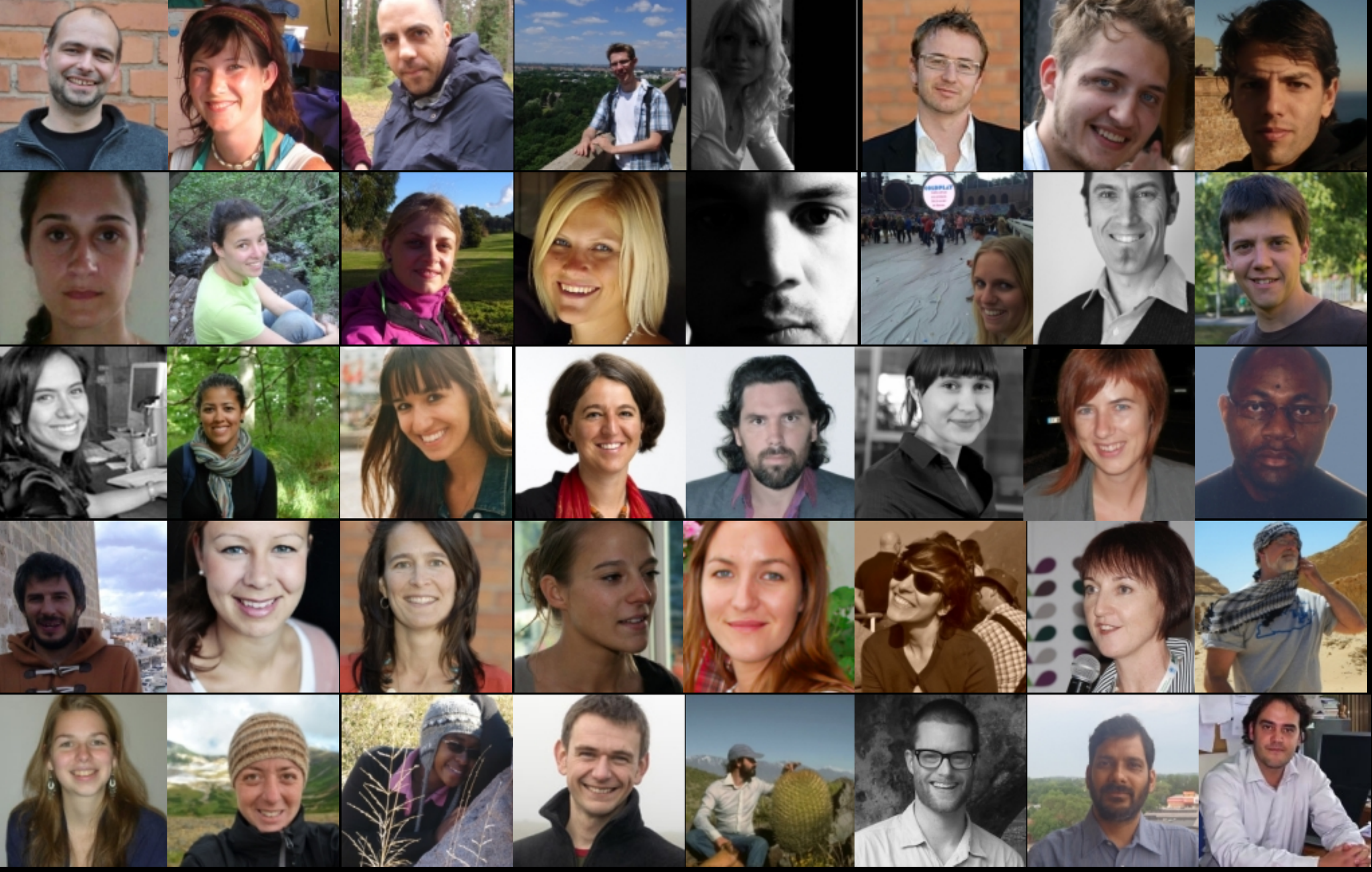
slides: http://criticaltransitions.wordpress.com/ | data: www.regimeshifts.rog



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