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Extreme-by-design urban lagoons: functional resilience and trophic reorganization under chronic urban stress

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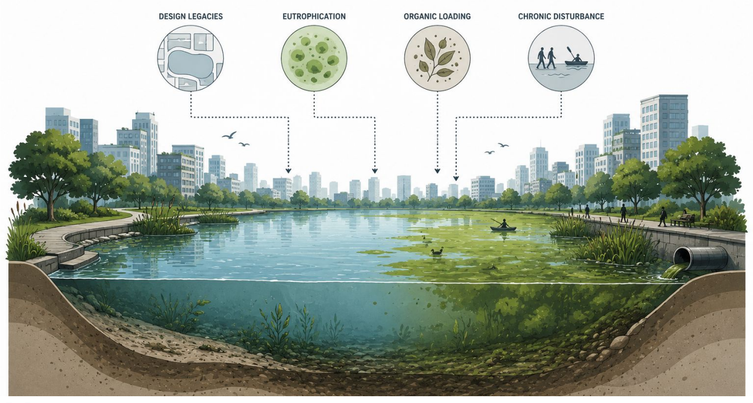
INTRODUCTION & AIM



Aim

To test whether ecological functioning persists through non-random functional reorganization rather than structural complexity.

HYPOTHESES

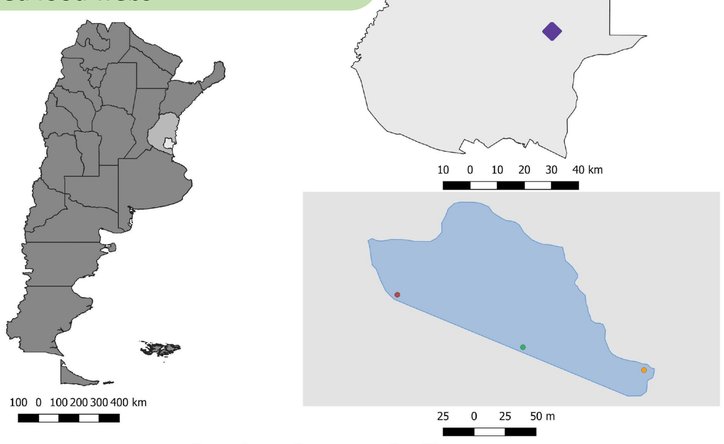
Central hypothesis → Chronic urban stress simplifies taxonomic food-web structure, but functional redundancy and modularity buffer energy flow.

- H1: functioning is maintained through non-random functional reorganization.
- H2: taxonomic loss does not necessarily imply functional collapse.
- H3: structural webs are simplified, while functional webs retain modular pathways.

METHOD

Study system

Parque Unzué urban lagoon, Gualeguaychú, Argentina.
Long-term monitoring: 2015–2019; 25 sampling events; 16 temporally resolved food webs



Analytical workflow

Multi-trophic community data

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Structural + functional food webs

↓

Degree-preserving null models

↓

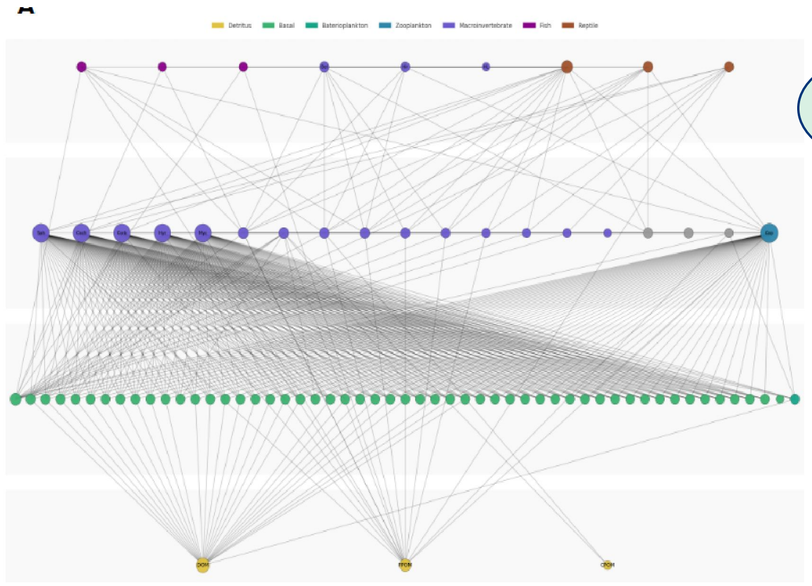
Correlations + piecewise SEM

Functional webs included basal-resource pathways (DOM, FPOM, CPOM, periphyton) and trophic roles such as collectors, scrapers, mixotrophs, and predators.

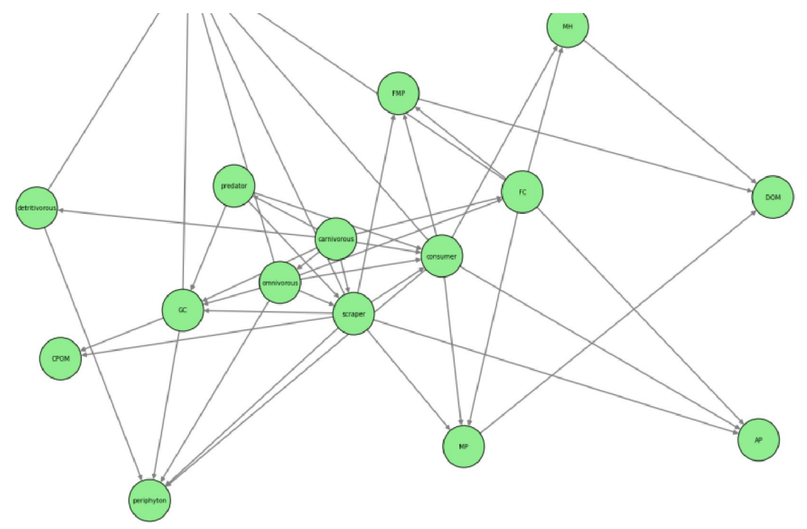
RESULTS & DISCUSSION

Structural simplification did not imply functional collapse.

Structural web: taxonomic wiring



Functional web: trait-based energy pathways



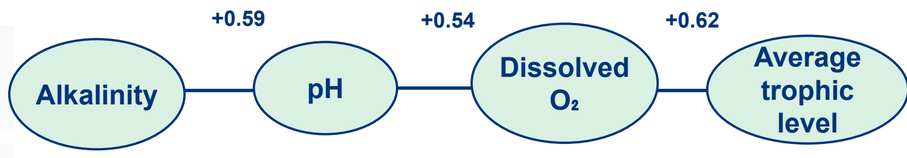
81	435	0.066	16
structural nodes	structural links	structural connectance	functional nodes
43	**5.06**	**86**	**48%**
functional links	redundancy index	basal-to-top paths	links from basal sources

Functional networks departed from null expectations: modularity was higher than expected by chance, while structural networks remained largely null-like.

Energy was canalized through detrital, periphytic, and mixotrophic pathways, revealing compensatory organization under chronic stress.

MECHANISM

A minimal SEM retained a physicochemical cascade linking chemical buffering to trophic organization.



Chemical buffer → oxygen dynamics → trophic extension

KEY FINDINGS

- Communities were taxonomically poor and dominated by tolerant, benthic-oriented guilds.
- Structural food webs were simplified, short-chained, and largely indistinguishable from degree-preserving nulls.
- Functional networks were more cohesive, modular, and redundant than expected by chance.
- Dual buffering emerged: carbonate alkalinity and functional redundancy sustained organization.

Structural loss ≠ functional collapse
Persistence arose from constrained, non-random functional organization.

CONCLUSION

Urban lagoons may operate as “extreme-by-design” systems: resilient but constrained ecosystems where chronic disturbance reshapes trophic organization rather than simply erasing function.

Structural loss ≠ functional collapse
Persistence arose from constrained, non-random functional organization.

FUTURE WORK / REFERENCES

- Integrate weighted energy fluxes and biomass data.
- Test the “extreme-by-design” concept across urban and rural anthropogenic lagoons.
- Translate functional metrics into monitoring tools for urban aquatic management.

Selected references: Crettaz-Minaglia & Gianello (2023); Hobbs et al. (2013); Thompson et al. (2012); Polazzo et al. (2022); Lefcheck (2016).

Keywords: Ecological networks; Functional redundancy; Novel ecosystems; Network modularity; Environmental filtering