

Connectivity can increase biodiversity resistance to pollution or magnify its impact if equalizing mechanisms are eroded

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Abstract

The environmental impact of pollutants on biodiversity is often viewed as a local process, neglecting the role of organism dispersal across landscapes. Pollutants dissolve into the environment, creating a disturbance gradient across communities. Dispersal can mitigate local impacts or propagate changes to the larger metacommunity. However, there is no comprehensive framework to understand the interplay between local and regional pollutant effects through metacommunity processes.

We used the Maldonado River basin in Uruguay as a model, focusing on a wetland ecosystem influenced by pollutants from four wastewater treatment plants. Using metacommunity simulations with varying pollutant discharge and species dispersal ability, we explored two mechanisms linking pollutant concentration to community assembly: a reduction in community carrying capacity, equally affecting all species, and trait-based filtering due to differences in species tolerance.

The interaction between pollutant impact mechanisms, species dispersal capacity, and community connectivity emerged as a key determinant of regional biodiversity outcomes. Notably, the connectivity-pollutant interaction changed depending on whether the pollutant affected species performance or reduced carrying capacity, driving either degradation or resistance to diversity. Furthermore, the extent of the pollutant's geographic impact

influenced how connectivity affected biodiversity. Dispersal capacity also influenced these alternative effects. Finally, biodiversity changes due to pollutants were not monotonically related to distance from the pollution source.

These results provide important insights for ecosystem management. Biodiversity impacts are influenced by species vulnerability and dispersal patterns. Local bioassays cannot be scaled to assess biodiversity threats without considering metacommunity dynamics.

Distance from pollutant sources may not accurately reflect true biodiversity impacts. Lastly, connectivity should be integrated when evaluating disturbance effects. Our findings suggest that pollutant impacts on biodiversity may be misrepresented in monitoring programs that fail to account for metacommunity effects.