Our microcosm experiment shows, as a proof-of-concept, that ecosystem size asymmetry can mediate the effects of bidirectional resource flows on diversity and function. Meta-ecosystems with asymmetric ecosystem sizes (SLLS) had more similar communities (lower β-diversity) and lower function (lower total biomass) but maintained higher diversity across the two patches (higher mean α-diversity) than asymmetric yet unconnected meta-ecosystems (SL). The fact that these effects were not observed in meta-ecosystems with symmetric ecosystem sizes indicates a mediating role of ecosystem size. These results could be explained by the connection of the small ecosystem to a larger ecosystem increasing the diversity and biomass of the small ecosystem (SL had greater diversity and biomass than SS and S) while leaving the diversity of the large patch unchanged (diversity was similar between Ls, LL, and L) and decreasing the biomass of the large patch (LS had lower biomass than LL, and L). As small and large ecosystems were identical aside from their size (resources, community composition, etc.), the effects of the connection can be attributed to ecosystem size. Ultimately, our findings suggest that considering the size of interconnected ecosystems can help us understand how bidirectional resource flows shape diversity and function.

Notably, we found resources flowing between ecosystems of different sizes impacted both α- and β-diversity by increasing the diversity of the smaller patch within the meta-ecosystem. Furthermore, they decreased total meta-ecosystem biomass by increasing the biomass of small patches and decreasing the biomass of large patches. We suggest three ways small patches may have gained diversity and biomass while large patches lost biomass. These include how ecosystem size might have created differences between ecosystems, which caused resources in ecosystems of different sizes to have different (i) quantity, (ii) quality, and (iii) heterogeneity.

First, resource quantity: small ecosystems may have had a net import of resources. Although the volume exchanged between ecosystems was equivalent, larger ecosystems had a greater dominance of photosynthetic species than small ecosystems (Fig. S9), which might have increased carbon availability more in large versus small ecosystems. Consequently, small ecosystems may have imported a greater quantity of newly fixed carbon from large ecosystems relative to what they exported, creating an emergent source-sink dynamics of resources (sensu Gravel, Guichard, et al., 2010 and Loreau et al., 2013).This net import of resources could have allowed small ecosystems to sustain more diversity as more resources allow more individuals to persist, promoting a greater abundance of rare species and preventing their extinction (species energy theory, see Wright, 1983). The net import of biomass to small patches and net export from large patches could have increased the biomass of small patches and decreased it in large patches, as the amount of resources would determine the available material for biomass production **(reference showing how more resources in the environment produce more biomass)**. A decrease in meta-ecosystem biomass caused by a larger decrease in biomass in large patches than the increase in biomass in small patches could be explained by moving resources from the large to the small patch could have meant moving them from a patch with higher to lower recycling which would cause resources to be more slowly turned into biomass. Higher recycling in larger patches is reasonable to expect, as it can be found in nature (Donghao et al., 2021; LeCraw et al., 2017; Yang et al., 2021). Furthermore, large patches in our experiment had higher biodiversity, which can be related to recycling rates (van der Plas, 2019).

We also would expect in natural ecosystems differences in ecosystem sizes to lead to differences in the quantity of resources exchanged. The trophic island biogeography theory (Gravel et al., 2011; Holt, 2009) predicts variation in the autotrophic-to-heterotrophic individuals’ ratio between ecosystems of different sizes. Gravel et al. (2011) supported this prediction by parameterising a trophic metacommunity model using 50 pelagic food webs (Havens, 1992) and showing that larger ecosystems contained more consumers relative to autotrophs. The explanation for this result is that in larger ecosystems consumers are more likely to find one of their prey and, therefore, establish.

Second, resource quality: small ecosystems may have had a net import of good quality detritus (protist detritus). As large ecosystems were more productive in terms of protist biomass per volume, more protist detritus was moved from large to small ecosystems despite the same volume being exchanged. If the detritus of protists was of higher quality as a resource for the local community compared to other resource forms (e.g., bacterial detritus, inorganic nutrients), it would have sustained a higher growth of individuals and, therefore, higher diversity in the small ecosystem. This could be the case as protist growth can be driven by polyunsaturated fatty acids (PUFAs) (Strom, 2000) and protists can be rich in PUFAs (Boëchat et al., 2007; Martin-Creuzburg et al., 2005, 2006) while most bacteria seem to lack them (Okuyama et al., 2007; Ratledge, 2001). The movement of good quality resources to the small ecosystem and bad quality resources to the large ecosystem would have increased the function of small ecosystems and decreased the function of the large ecosystem, as a meta-ecosystem model showed that good quality subsidies should increase the function of the receiving ecosystem and bad quality subsidies should decrease it (Osakpolor et al., 2023). The decrease in the meta-ecosystem's total biomass could be explained by the fact that good–quality resources—the most important resources to be turned into biomass–were moved to small ecosystems, which potentially had lower recycling rates.

Furthermore, it could be that, in our experiment, differences in functional traits between ecosystem sizes led to differences in biomass stoichiometry and nutrient limitation. Large ecosystems created more autotrophic individuals, which should have brought carbon into the system and decreased carbon limitation. Resource flows between ecosystems of different sizes and, therefore, different carbon limitations could have redistributed nutrients so that the extra carbon was exported to the ecosystem lacking carbon, and other nutrients that might be limiting, such as nitrogen, would have been imported to the large carbon-rich system.In this configuration, resource flows stoichiometric asymmetry could be the vector of spatial complementarity in resource use: one ecosystem needs carbon and gives away other nutrients such as nitrogen and the other needs other nutrients such as nitrogen and gives away carbon (Harvey et al., 2023; Pichon et al., 2023). This could increase the productivity at the bottom of the connected food webs (where the resources are taken up) and possibly influence diversity in a bottom-up fashion.

We would also expect this mechanism, where size differences between connected ecosystems create differences in the quality of the resources they exchange, which cascade to influence diversity and function, also to be present in natural ecosystems. For example, ecosystems of different sizes can have different biomass distributions (Petermann et al., 2015). In this case, the relative quantity of biomass in trophic levels will determine the quality of the resources exchanged as the biomass of different trophic levels differs in quality. For example, consumers can have more nitrogen than producers (Elser et al., 2000). Furthermore, ecosystems of different sizes can have different functional diversity (functional-diversity-area relationship, Karadimou et al., 2016; Kunz et al., 2024; Smith et al., 2013; Tew et al., 2022), which allows them to take up resources at different rates **(reference)** and therefore causes them to be limited by different nutrients **(reference)**. We would expect, therefore, in nature, that differences in resource quality could relax different limitations of ecosystems of different sizes.

Third, resource heterogeneity: small ecosystems might have imported resources that were more heterogeneous than their own. As there was greater protist diversity in large ecosystems, the corresponding exported detritus might have been more diverse with respect to carbon compounds and biomolecules, potentially creating more niches for protists to coexist in small ecosystems (resource diversity hypothesis, Lawton, 1983). **Add references on different detritus types creating more diversity of detritivores from Moore 2004.**Moving resource heterogeneity more to the small patches could have decreased the productivity of the meta-ecosystem by moving them to an ecosystem with lower recycling.

We would expect that also, in nature, differences in ecosystem size would cause differences in resource heterogeneity and, therefore, cause resource flows to influence diversity and ecosystem function.Larger ecosystems generally have higher diversity within trophic levels (horizontal diversity, MacArthur & Wilson, 1963, 1967) and higher number of trophic levels (vertical diversity or maximum food chain length, Guo et al., 2023; Post et al., 2000; Ward & McCann, 2017). Such higher diversity should translate into a change in their biomass composition (e.g., diversity can be related to stoichiometry, Striebel et al., 2009) and higher resource heterogeneity, which would constitute more heterogeneous resources when these species die, and their compounds remain in the environment, creating more niches for species to coexist.

Our study highlights that the size of the donor ecosystem, where resource flows originate, can shape the effect of resource flows on a recipient ecosystem’s diversity. In particular, in our experiment, diversity increased in a small ecosystem when connected to a larger one. The subsidised island biogeography theory (Anderson & Wait, 2001) states that resources flowing into an ecosystem can influence its diversity, making its diversity deviate from what we would expect from species-area relationships, especially in small ecosystems. This has been supported by field studies, for instance, with resource flows increasing the diversity of bird species more in smaller than in large islands (Obrist et al., 2020). Our results align with this finding, showing that resource flows between small ecosystems changed their diversity but not between large ecosystems. However, the characteristics of the connected ecosystem have been overlooked by this theory. Through integration with the meta-ecosystem framework, we add to the subsidised island biogeography that the effects of the resource flows may also be mediated by the characteristics of the exporter ecosystem, notably its size.

Decades of research on spatial subsidies have documented that donor ecosystems commonly vary in size. For example, islands which export nitrogen to coral reefs (Lorrain et al., 2017), kelp forests which exchange non-living resources with their adjacent intertidal zone (**cite here**), and forests that export leaf litter to streams (Larsen et al., 2016). Moreover, evidence from natural systems supports our finding that the size of donor ecosystems can influence the diversity and function of recipient ecosystems. Such evidence is found in lakes and rivers embedded in terrestrial watersheds of different sizes. Notably, studies found that larger watersheds can (i) increase lake primary production, as they export more phosphorus (Knoll et al., 2003), (ii) sustain fewer lake consumers that rely on sediments, as they export lower quantities of sediments (lower water flow, gentler slopes, and increased sedimentation in terrestrial ecosystems) (Babler et al., 2011), and (iii) sustain longer river food chains, as they have more water flow, hence less hydrological variation and therefore a more stable environment (Sabo et al., 2010). This, in conjunction with our findings, suggests that subsidised island biogeography (Anderson & Wait, 2001) would gain in integrating how the size of the connected ecosystems mediates the effects of resources on the shape of species-area relationships and possibly changes this relationship. According to our results, we expect, for example, that the diversity of macroinvertebrates in a lake might be higher than expected by their area only (according to subsidies island biogeography) when the lake is connected to a larger rather than a small forest. **Add how in parallel, the size of ecosystems has also been studied for how subsidies influence ecosystem productivity. For example, Polis … and Gratton … We suggest also looking at the size of the donor.**

In conclusion, our experiment provides experimental evidence that asymmetry in ecosystem size can indirectly affect diversity and function in meta-ecosystems through its effects on a ubiquitous connection among ecosystems–spatial flows of resources. Consequently, this could imply that when aiming to understand what drives the diversity and function of a habitat, it might be necessary to consider how ecosystem size changes resource flow between ecosystems.

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