# Discussion

So, in our experiment we demonstrated that if we want to understand the functioning of a meta-ecosystem, we need to look at patch size. We need to do it when we look at the single ecosystems within it and when we look at the whole meta-ecosystem. This has implications for habitat fragmentation, which tells us that it might be better to keep two medium patches instead of a large one and a small one and also for habitat loss, which tells us that by shrinking the size of ecosystems that are important for other ecosystems, we are also affecting the latter ones.

Meta-ecosystem dynamics seem to depend on the relative size of its patches. The function of small patches increases when they receive resources coming from larger ecosystems. In regards to large patches, it would probably depend on how large they are. Probably at really large sizes, such as the one in our experiment, receiving little detritus from small ecosystems doesn’t change its function. However, it would probably happen when larger sizes are not way larger. The function of the meta-ecosystem will depend ultimately on two things: (1) How size itself changes the function of the patches and (2) Whether the increase in function of the small ecosystem is stronger than the decrease in function in the large ecosystem.

## Ecosystem function: patch level

So, what happened at a patch level? In other words, what happened in the single patches? As it was shown already in a paper from our lab, the larger species became less and less abundant, as they are too slow to recover before the next disturbance. However, their disappearance was delayed in patches that were connected to large patches instead of small ones (I need to make sure of this). This is because larger patches were more productive because of two reasons: (i) they were more robust to the perturbation by the design of the experiment and because (ii) they were more productive. In turn, they gave away more detritus during the resource exchange. Therefore, we demonstrated that it is possible that large ecosystems give away more detritus and have a larger effect on the functioning of the recipient ecosystem.

Small patches had **lower species richness** probably because of having smaller populations made them easier extinct (ecological drift). Also, maybe because smaller cultures have less heterogeneous conditions (less different environmental conditions maybe, find the protist experiment where they looked at the effects of patch size on metacommunity dynamics). Probably in small ecosystems we also have more genetic drift because of the small population sizes, but I don’t know if it was big enough in my experiment. But it should be looked at it in other systems.

It is also possible that the reason why we see differences in different patches is not because they have different species composition but because they have different body size distribution. But this needs to be better checked first.

## Ecosystem function: meta-ecosystem level

And what happened at the meta-ecosystem level? This is were it gets interesting and less intuitive. The meta-ecosystems in which the two patches were both of medium size, had higher functioning. The perturbations creating resource flow decreased more and more the biomass of the small patches. The extra biomass gained by the large ecosystem compared to the medium ecosystem was not enough to make up for the collapse of the medium patch. Therefore, the equal size of the patches of a meta-ecosystem maximises meta-ecosystem functioning.

A **possible mechanism** why the Medium-Medium meta-ecosystem was higher in biomass than the Small-Large meta-ecosystem is that the relationship between patch size and productivity is not linear, but it plateaus when a patch becomes big enough. Therefore, summing the productivity of small and large would not be enough to increase it to the levels of two medium patches. The problem here, however, is that we don’t have a model to parameterise to show this. Also, it will probably depend upon the ecosystem we consider to see how this relationship changes.

We need to remember that what we have done here was still an experiment with two patches. But remember, real-world landscape are meta-ecosystems made out of many ecosystems connected to multiple patches. It will be important in the future to study how patch size influences meta-ecosystems made out many patches. In particular, it would be important to understand how the **statistical distribution** of patch size influences the productivity of real meta-ecosystems. In other words, are meta-ecosystems with even patches functioning better than meta-ecosystems with mainly medium patches? Something we would also expect is that the **disposition of patch size matters**. In other words, where small or large ecosystems occur matters. It would matter if all large ecosystems are on one side and all small ecosystems are on the other, or if they are more uniformly distributed in the landscape. This has been already shown experimentally. For example, in experimental microcosm rivers, maintaining the real world distribution of patch sizes maintained rare species, increasing the evenness of the metacommunity (Carrara, Rinaldo, Giometto, & Altermatt, 2014). What is mechanism behind? The placing of different patch sizes also can change where we can find and whether invasive species persist (Holenstein, Harvey, & Altermatt, 2022). Also, is this dependent on ecosystem type? Let’s say, for example, is the size of forests more important than the size of rivers?

Our experiment shows a novel mechanism by which **habitat fragmentation** can modulate the relationship between biodiversity and ecosystem function. We already knew that habitat fragmentation had an effect on the relationship between biodiversity and ecosystem function. See (Liu et al., 2018) and (Hertzog et al., 2019) to expand this part. There has been a lot of attention on habitat fragmentation in the sense of: what are the effects of fragmenting an ecosystem in multiple smaller patches? What has not been done is to ask the question: how does the size of the patches we are fragmenting have an effect? I would bet that because there is a saturating effect as some point, we will see that actually the relative size doesn’t matter much. I would bet it matters only when the small patch is below a threshold where smaller patches are less diverse and have lower function. This experiment, however, is only relative to resource flow in habitats of the same type and under perturbation. I guess that if we were to relax any of these three assumptions, we would get some different result. Examples of this are, for example, mussel bed meta-ecosystems (Spiecker, Gouhier, & Guichard, 2016).

Thanks to studying how meta-ecosystem dynamics are influenced by patch size, we’ll be better able to study how the productivity of a landscape is influenced by the size of its patches. For example, this might be introduced into landscape models that will allow us to use remote sensing and draw a meta-ecosystem network and to better understand how productivity might be happening at a regional level.

## Future directions

Should be done in the future: look at the effects of unidirectional flow, look at the effects of dispersal, look at the effects of statistical distribution of patch size, look at the effects of spatial distribution of patch size (but maybe Carraro2014 was still a meta-ecosystem experiment).

## Where to test this

Example of where to test this are meta-ecosystems that are composed by the same type of habitats, such as mangroves, mussel beds, seagrass beds, and coral reefs. However, it might be also useful to study meta-ecosystems that are composed of different habitat types, such as forests connected to rivers.

## Implications for policy

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# Bibliography

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