Supporting Information. McGlinn, D.J., T. Engel, S.A. Blowes, N.J. Gotelli, T.M. Knight, B.J. McGill, N. Sanders, and J.M. Chase. 2020. A multiscale framework for disentangling the roles of evenness, density, and aggregation on diversity gradients. Ecology.

Appendix S1. Multimetric MoB Gradient Analysis

The multimetric version of MoB uses several traditional diversity metrics and total number of individuals computed at two spatial grains (α and γ) to describe how diversity is changing across a gradient (Chase et al. 2018, McGlinn et al. 2019). Specifically, multimetric MoB examines:

N: the total number of individuals which may result in increases of S simply due to more individuals being sampled

S: species richness or the number of species - this metric is sensitive to rare species

S_n: rarefied richness for n individuals which effectively controls for differences in individual density (i.e., differences in N) on S

S_{PIE}: the effective number of species for the probability of interspecific encounter index which is more sensitive to common species and a popular metric of evenness.

Multiplicative β-diversity or the ratio of γ over α is also computed for each of these metrics (with the exception of N) to provide estimates of species turnover that are sensitive to different aspects of community structure (Chase et al. 2018).

Multimetric MoB provides a complementary analysis to multiscale MoB because it requires less information and provides subtly different inferences. Specifically, multimetric MoB does not:

- require spatial coordinates of samples,
- examine all possible scales of comparison, and
- decompose change in richness directly.

To illustrate the differences between the two analyses, we conducted a multimetric MoB analysis on the case study examined in the main text (ants along an elevational gradient). First we examined the relationship between the total number of individuals (*N*) and elevation. We found that *N* decreased with elevation but this only occurred at the γ-spatial grain (Fig. S1). This indicates that it is at least possible that higher elevations have lower diversity because they have fewer individuals.

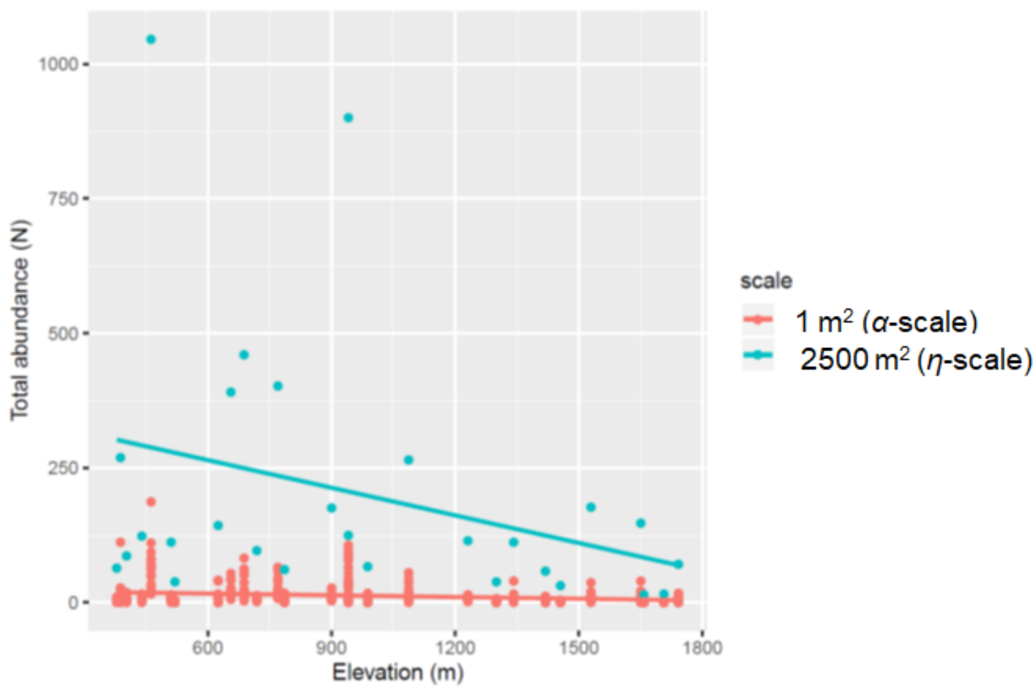

Fig. S1. The relationship between the total number of individuals and elevation at two spatial grains.

The examination of the traditional diversity metrics (Fig. S2) illustrates several important points in relation to the multiscale MoB analysis presented in the main text:

- *S* decreased with elevation (Fig. S2A) but was steeper at the *γ*-scale (i.e., scale-dependance is present).

    - Multiscale MoB uses a range of scales to more clearly examine this scale dependence which indicated that several sites on the gradient change rank in diversity depending on the scale of consideration (Fig. 4A-C).
- S_n also decreased with elevation (Fig. S2B) which indicates that even after controlling for density, richness still decreased with elevation. The observation that *N* decreases with elevation (Fig. S1) does not provide a sole explanation for lower *S* at high elevations, but the density effect cannot not completely ruled out because the strength of this effect on *S* is not directly estimated in this analysis.
    - The multiscale MoB quantitatively estimates the *N* effect on *S* across scales (Fig. 4H). It demonstrated that the density effect was negligible at all but the smallest sampling effort.
- The effective number of species as measured by S_{PIE} also decreased with elevation (Fig. S2C). This indicates that higher elevation sites were more dominated by a few species (i.e., the species abundance distribution [SAD] changed across elevations).
    - In multiscale MoB, this pattern was captured as the negative slope of the SAD effect along the gradient which reflected the fact that rarefied richness was lower at higher elevation sites particularly at larger sampling efforts (Fig. 4I) .
- β-diversity tended to decrease slightly with elevation indicating that high elevations sites may have less spatial aggregation, but β_{Sn} which is the cleanest metric of within-species aggregation (Chase et al. 2018) does not vary noticeably.
    - Multiscale MoB, indicated within-species aggregation was weaker at high elevations such that high elevations were pushed to have higher richness at least at some spatial grains (Fig. 4G).

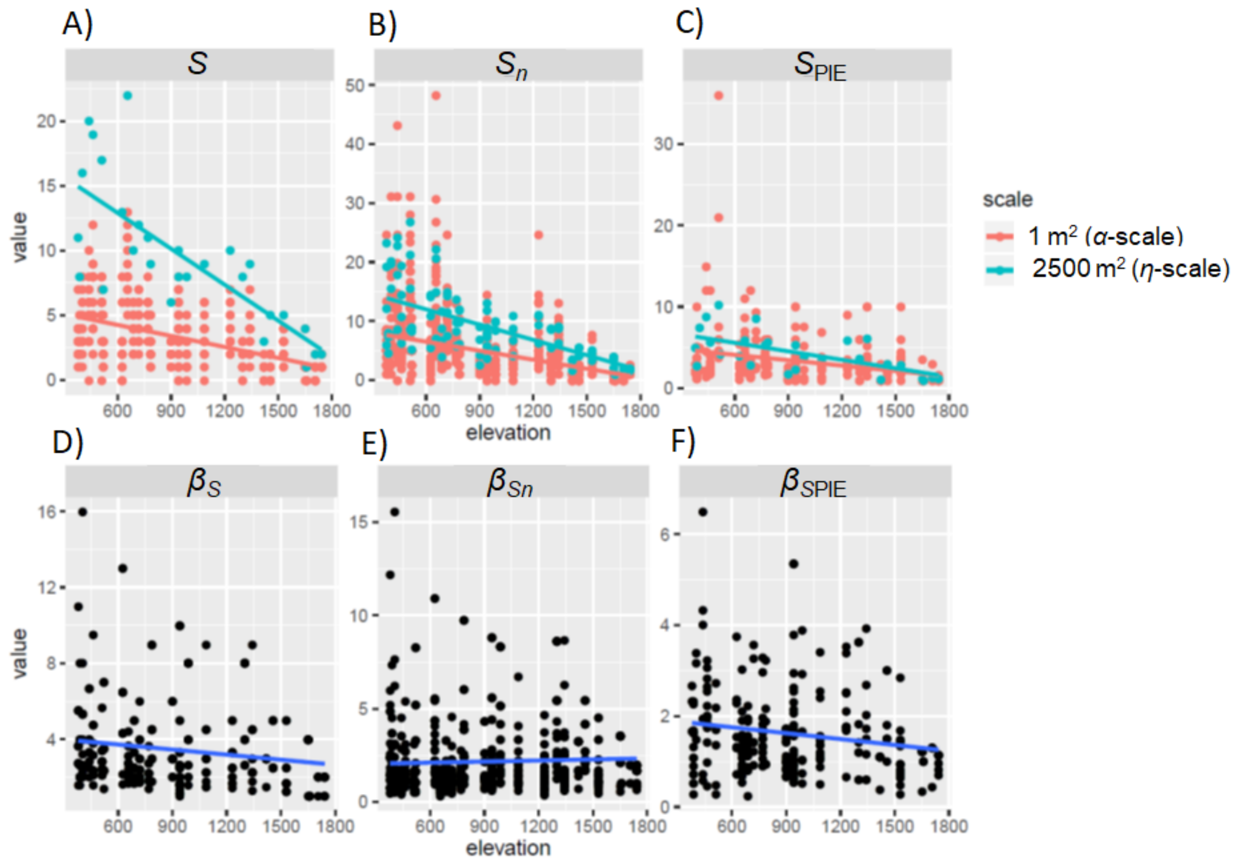

Fig. S2. The multimetric MoB analysis along the elevational gradient at two spatial scales: 1m^2 quadrats (*α*-scale, red points and line) and the 2500 m^2 sites (*γ*, green points and line). Panel A displays species richness (*S*), panel B displays rarefied richness (S_n) at n = 15 (*α*) and n = 80 (*γ*), and panel C displays the effective number of species for the Probability of Interspecific Encounter (S_{PIE}). Panels D-F display the multiplicative *β*-diversity metrics (*γ* / *α*) for *S*, S_n, and S_{PIE} respectively.

Taken together, the multimetric MoB analysis indicates that:

> Higher elevations sites have fewer species, lower evenness, slightly lower species turnover and that these changes cannot be fully attributed to the fact that higher

elevations have fewer individuals or to changes in the degree of spatial aggregation within species.

The multiscale MoB analysis indicates that:

> Decreases in species richness with elevation are primarily associated with decreases in evenness and the total number of species (i.e., SAD effects). The decrease in richness due to the SAD was partially negated by lower within-species spatial clustering at high elevations at a fine to intermediate spatial grains. The decrease in richness due to the decreased density of individuals at high elevations was negligible except at the finest spatial grain.

In many ways the two analyses overlap but it is hopefully clear that the multiscale MoB analysis provides a more synthetic multiscale decomposition of changes in richness that is easier to interpret than a collection of univariate diversity indices which are often employed in traditional biodiversity analyses even when those indices are deliberately chosen to reflect unique components of change in community structure.

Literature Cited

Chase, J. M. et al. 2018. Embracing scale-dependence to achieve a deeper understanding of biodiversity and its change across communities. Ecology Letters 21:1737–1751.

McGlinn, D. J. et al. 2019. Measurement of Biodiversity (MoB): A method to separate the scale-dependent effects of species abundance distribution, density, and aggregation on diversity change. Methods in Ecology and Evolution 10:258–269.