

11. Supplementary Figures

Fig. S1. Total Mn concentrations in A) soil and B) grass litter in 46 sites along the Kohala gradient. Soil and grass Mn concentrations were measured using X-ray fluorescence (XRF). Soils were sampled as continuous 10-cm soil cores, manually homogenized, and sieved to 2 mm. Grasses were cut at their bases to limit collection to aboveground mass. Samples were collected in 1 or 2 of the summers in 2018 and/or 2019 and were measured in triplicate ($n = 3-6$). Error bars symbolize the standard error of the mean (SEM).

Fig. S2. A) Representative litter bag used in the field and laboratory experiments. Litter bags were constructed from 6cm x 12cm sections of 0.011-gauge fiberglass insect screen cloth folded in half lengthwise and secured by ribbon sewn onto three sides of the resulting 6-cm² square. B) Experimental setup for the 10-month laboratory experiment. The control (left bin) and Mn-treatment (right bin) conditions received weekly additions of 495 ml of deionized (DI) water (no additional Mn) or 17.6 μ M manganese chloride (MnCl₂), respectively, to approximate the average daily rainfall of the wettest site, dispersed across the soil substrate and surface area of the incubation container's bottom. Litter bags are clipped together according to litter collection site (1, 2, or 3). C–F) We observed fungal hyphae while inspecting litter bags at the completion of the 10-month incubation. White arrows indicate the locations of suspected fungal hyphae C, E) through the mesh of the litter bag and D, F) in the open litter bag. Views of the same litter bag collected from Site 3: C) sealed and D) opened. Views of the same litter bag collected from Site 2: E) sealed and F) opened.

Fig. S3. μ XRF imagery of Mn oxidation states distributed across grass litter surfaces. Litter types are identified by the text under each respective image: A) Initial Site 1 (freshly senesced litter collected from Site 1); B) Initial Site 2; C) Initial Site 3; D) Litter 1, Site 1 (litter collected from Site 1 and decomposed in Site 1); E) Litter 1, Site 2; F) Litter 1, Site 3; G) Litter 2, Site 1; H) Litter 2, Site 2; I) Litter 2, Site 3; J) Litter 3, Site 1; K) Litter 3, Site 2; L) Litter 3, Site 3. Regions where Mn²⁺ was detected are shown in blue, Mn³⁺ in green, and Mn⁴⁺ in red. Regions of green-red overlap indicate areas of Mn^{3+/4+} oxides and litter-decomposition hot spots.

Fig. S4. C/N in grass litter over A) 5-month and B) 12-month decompositions. No statistically significant differences ($p \leq 0.05$, $n = 2-5$) were found within the 5-month or 12-month decompositions. Error bars indicate standard error of the mean (SEM). Litter 1, Litter 2, and Litter 3 reflect litter collected from sites 1, 2, and 3. Site 1, Site 2, and Site 3 designate litter decomposed in sites 1, 2, and 3.

Fig. S5. μ XRF imagery of Mn oxidation states distributed across grass litter surfaces. Litter treatment conditions are identified by the text in the columns to the right of each image: A) Control 1, B) Control 2, C) Control 3, D) Mn Treatment 1, E) Mn Treatment 2, F) Mn Treatment 3. Regions where Mn²⁺ was detected are shown in blue, Mn³⁺ in green, and Mn⁴⁺ in red. Regions of green-red overlap indicate areas of Mn^{3+/4+} oxides and litter-decomposition hot spots. The consolidated bright red lines in panel D) may suggest fungal hyphae colonizing the litter surface.

Fig. S6. Changes in carbon-to-nitrogen ratios (C/N) in litter incubated for 10 months. L1, L2, and L3 reflect litter collected from sites 1, 2, and 3. Hollow columns and black-filled columns

represent control and Mn-treatment litter, collected from sites 1, 2, and 3. Hollow boxes and black-filled boxes represent aggregated control and Mn-treatment litter. No significant differences were found between control and Mn-treatment litter when we compared them by litter type (collection site) (A) or by aggregated condition (B). Letters above columns indicate significant categories ($p \leq 0.05$, $n = 3$ per litter type, $n = 9$ per condition), and error bars indicate standard error of the mean (SEM). Boxplots show means (X) and inclusive quartiles.

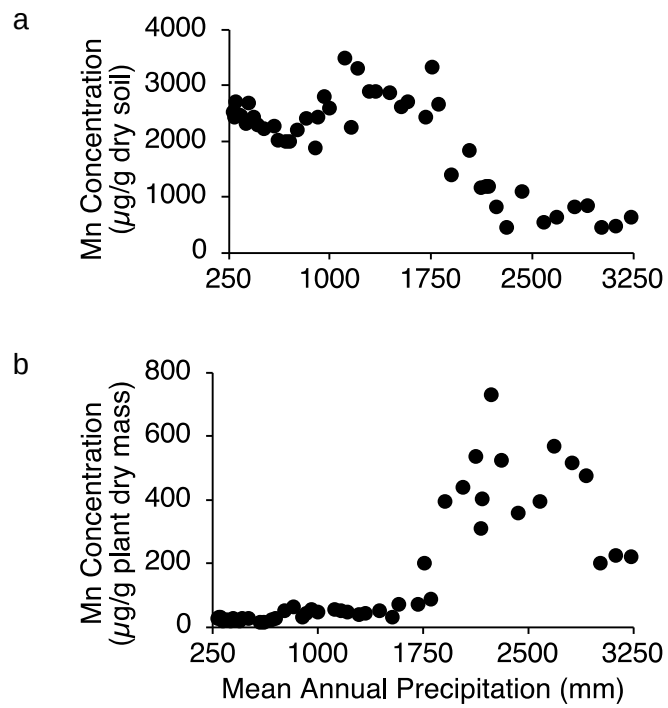


Fig. S1



Fig. S2

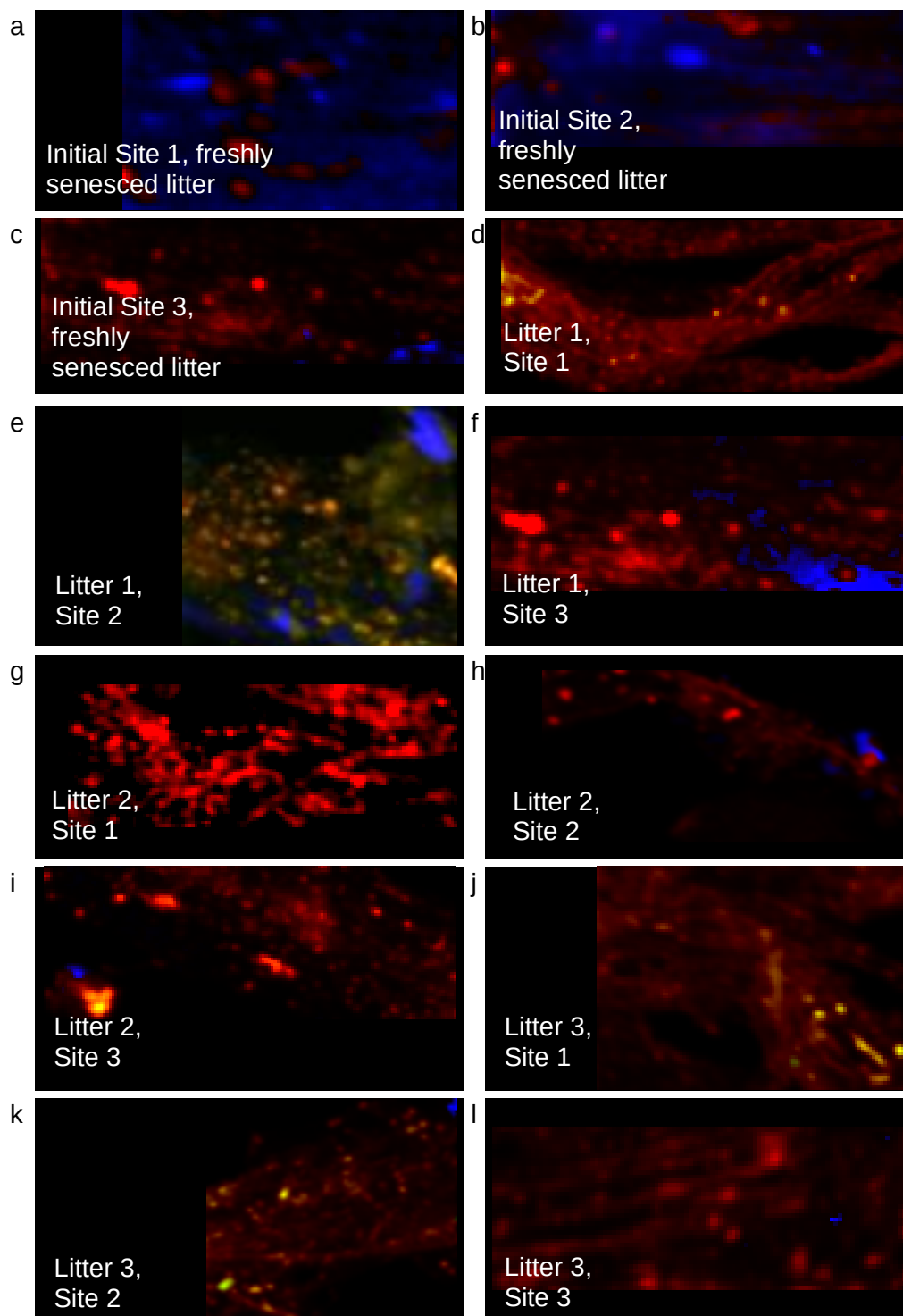


Fig. S3

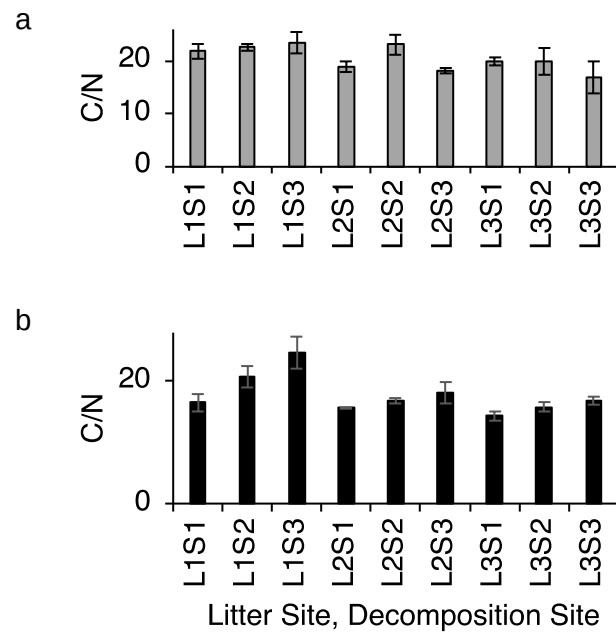


Fig. S4

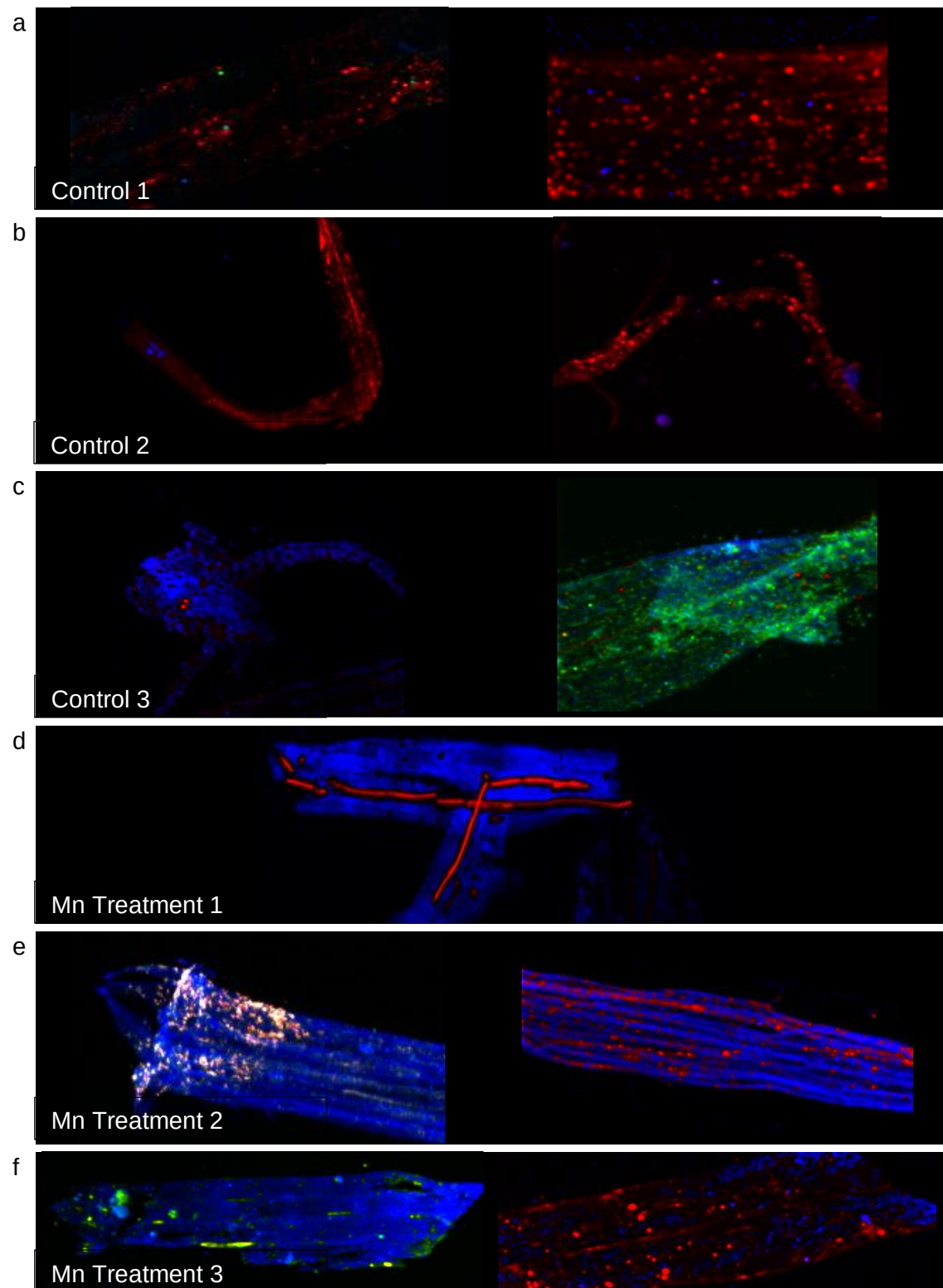


Fig. S5

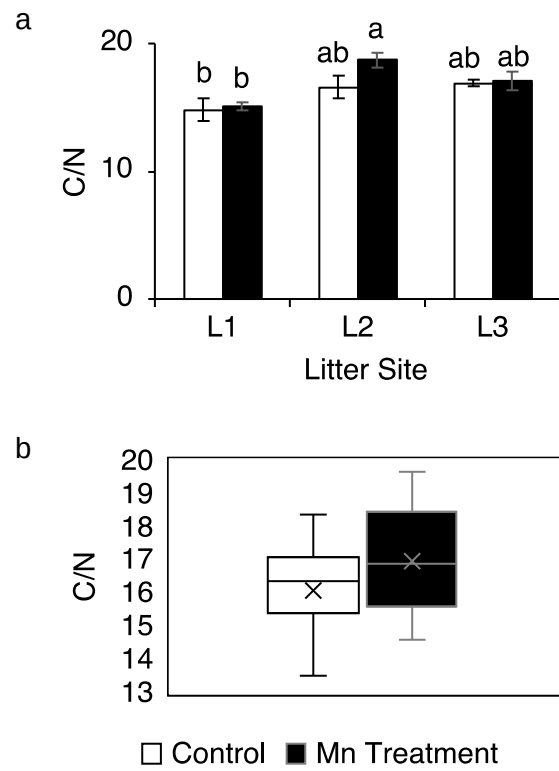


Fig. S6