Title: Agnostic fungi: plant traits and tissue stoichiometry explain nutrient transfer in common arbuscular mycorrhizal networks of temperate grasslands

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Supplemental Information

Table S1. List of species at each site with number of leaf samples per species. Donor species are indicated in bold.

Species	**Annual/ perennial**	**Grass/forb**	**WC**	**TW**	**DC**	**Fungal symbiont**
***Agrostis capillaris* L.**	Perennial	Grass	121	--	--	AM[1]
***Alopecurus pratensis* L.**	Perennial	Grass	--	210	--	AM[1]
Aphanes occidentalis L.	Annual	Forb	3	--	--	AM*[2]
Bromus diandrus Roth	Annual	Grass	49	--	--	AM*[1]
Bromus hordeaceus L.	Annual	Grass	35	42	96	AM*[1]
Elymus repens (L.) Gould	Perennial	Grass	--	--	63	AM*[1]
Eriophyllum lanatum (Pursh) Forbes	Perennial	Forb	8	--	--	AM[2]
Festuca idahoensis Elmer ssp. *roemeri* (Pavlick) S. Aiken	Perennial	Grass	18	--	--	AM*[1]
Geranium dissectum L.	Annual	Forb	15	81	--	AM[2]
Holcus lanatus L.	Perennial	Grass	--	6	--	AM[1]
Koeleria macrantha (Ledeb.) Schult.	Perennial	Grass	18	--	--	AM[2]
Lotus corniculatus L.	Perennial	Forb	--	9	--	AM[1]
***Schedonorus arundinaceus* (Schreb.) Dumort.**	Perennial	Grass	--	--	130	AM[1]
***Sidalcea malviflora* ssp. *virgata* (DC.) A. Gray ex Benth.**	Perennial	Forb	66	129	119	AM[3]
Trifolium subterraneum L.	Annual	Forb	48	--	--	AM[1]
Veronica arvensis L.	Annual	Forb	3	--	--	AM[1]
Vicia sativa L.	Annual	Forb	--	14	--	AM*[1]
Vulpia spp.	Annual	Grass	54	8	21	AM[1]
		Total samples	438	499	429	

Notes: Fungal symbiont data derived from [1]Chaudhary et al. (2016), [2]Soudzilovskaia et al. (2020), and [3]Dickie et al. (2013). * indicates "to genus," that strategy was extrapolated from a sister species given a lack of data on this species. Nutrient-use strategies include arbuscular mycorrhizal (AM) and nitrogen fixation (N-fixer).

Table S2. Collection dates for each time point at each site. Days since labeling given in parentheses after date.

Site	**Label application (time point 0)**	**Time point 1**	**Time point 2**	**Time point 3**
Ideal days since labeling	*0*	*4*	*10*	*21*
Northern	June 10	June 14 (4)	June 20 (10)	July 2 (22)
Middle	May 29	June 3 (5)	June 11 (13)	June 18 (20)
Southern	May 9	May 13 (4)	May 22 (9)	May 30 (21)

Table S3. Baseline values used to calculate amount derived from label (DFL).

		Roots						**Leaves**			
Site	*Drought treatment*	*N atm%*	*±SD*	*C atm%*	*±SD*	*Annual/perennial*	*Grass/forb*	*N atm%*	*±SD*	*C atm%*	*±SD*
North	Control	0.370	0.001	1.073	0.001	Annual	Forb	0.367	0.001	1.07	0.001
							Grass	0.367	0.000	1.071	0.003
						Perennial	Forb	0.367	0.000	1.072	0.001
							Grass	0.368	0.000	1.075	0.001
	Rain exclusion treatment	0.370	0.001	1.073	0.001	Annual	Forb	0.367	0.001	1.072	0.001
							Grass	0.367	0.000	1.073	0.000
						Perennial	Forb	0.367	0.000	1.072	0.002
							Grass	0.368	0.000	1.075	0.001
Central	Control	0.368	0.001	1.073	0.001	Annual	Forb	0.367	0.001	1.071	0.001
							Grass	0.366	0.001	1.073	0.001
						Perennial	Forb	0.368	0.003	1.071	0.001
							Grass	0.367	0.003	1.074	0.002
	Rain exclusion treatment	0.368	0.001	1.073	0.001	Annual	Forb	0.367	0.001	1.071	0.001
							Grass	0.367	0.001	1.072	0.001
						Perennial	Forb	0.366	0.000	1.071	0.001
							Grass	0.366	0.000	1.075	0.002
South	Control	0.368	0.000	1.074	0.001	Annual	Forb	0.366	0.000	1.071	0.000
							Grass	0.368	0.001	1.074	0.001
						Perennial	Forb	0.367	0.000	1.074	0.001
							Grass	0.367	0.000	1.074	0.000
	Rain exclusion treatment	0.368	0.001	1.074	0.001	Annual	Forb	0.366	0.000	1.071	0.000
							Grass	0.367	0.001	1.074	0.002
						Perennial	Forb	0.367	0.001	1.074	0.001
							Grass	0.367	0.000	1.074	0.001

Table S4. ANOVA results effects on leaf carbon derived from label (%CDFL). Only receiver leaves enriched with ^{13}C with associated DNA data were included in the analysis (n = 92). Leaf %NDFL results available in Table 1.

	DF	χ^2	P-value
Fixed effects			
Annual/perennial	**1**	22.91	**<0.001**
Grass/forb	1	12.59	**<0.001**
Same species as donor	1	11.76	**0.001**
Degree of connectivity	1	1.77	0.183
iWUE	1	0.18	0.674
C:N	1	2.30	0.130
Site	**2**	6.32	**0.043**
Drought treatment	1	1.27	0.260
Restoration treatment	1	2.80	0.094
Distance from donor	1	0.00	0.958
Time from labelling	1	1.38	0.241
Annual/perennial: Grass/forb interaction	NA	NA	NA
Random effect			
Plot			**<0.001**

Table S5. List of fungal ASVs by annuals and perennials.

Fungal taxon	No. of perennial plants assoc. with	No. of annual plants assoc. with
Acaulospora sp877	13	0
Claroideoglomus sp744	20	7
Claroideoglomus sp745	18	5
Claroideoglomus sp746	18	7
Claroideoglomus sp749	14	4
Claroideoglomus sp751	25	10
Claroideoglomus sp757	11	1
Claroideoglomus sp758	11	1
Claroideoglomus sp781	18	13
Claroideoglomus sp782	59	36
Claroideoglomus sp783	38	20
Claroideoglomus sp784	47	21
Claroideoglomus sp811	19	9
Claroideoglomus sp812	12	4
Claroideoglomus sp813	15	10
Claroideoglomus sp815	21	11
Claroideoglomus sp816	19	7
Claroideoglomus sp817	30	8
Glomus sp1024	11	1
Glomus sp1025	12	4
Glomus sp1029	23	4
Glomus sp1031	20	7
Glomus sp104	12	3
Glomus sp113	23	10
Glomus sp114	6	16
Glomus sp115	21	15
Glomus sp1349	13	8
Glomus sp1351	18	8
Glomus sp1352	15	5
Glomus sp148	22	11

Fungal taxon	No. of perennial plants assoc. with	No. of annual plants assoc. with
Glomus sp149	12	6
Glomus sp150	27	14
Glomus sp168	21	12
Glomus sp169	13	6
Glomus sp170	15	6
Glomus sp177	11	1
Glomus sp191	14	10
Glomus sp470	15	6
Glomus sp472	14	4
Glomus sp488	13	2
Glomus sp539	13	3
Glomus sp541	19	3
Glomus sp565	15	7
Glomus sp566	12	1
Glomus sp612	13	3
Glomus sp614	11	6
Glomus sp648	12	2
Glomus sp651	25	10
Glomus sp661	11	4
Glomus sp662	14	3
Glomus sp663	12	8
Glomus sp667	13	1
Glomus sp668	14	3
Glomus sp669	14	5
Glomus sp670	20	2
Glomus sp692	14	1
Glomus sp700	11	2
Glomus sp701	12	12
Glomus sp703	19	13
Glomus sp83	11	0
Glomus sp85	12	3

Fungal taxon	No. of perennial plants assoc. with	No. of annual plants assoc. with
Glomus sp904	18	3
Glomus sp905	11	2
Glomus sp906	17	6
Glomus sp917	29	12
Glomus sp918	85	48
Glomus sp919	45	32
Glomus sp92	11	0
Glomus sp920	53	33
Glomus sp921	17	3
Glomus sp938	14	8
Glomus sp986	12	1
Paraglomus sp301	19	4
Paraglomus sp302	26	5
Paraglomus sp303	15	4
Paraglomus sp304	25	5
Scutellospora sp1080	12	6
Unknown sp21	12	4

Table only includes fungal species associated with at least 10 plants.

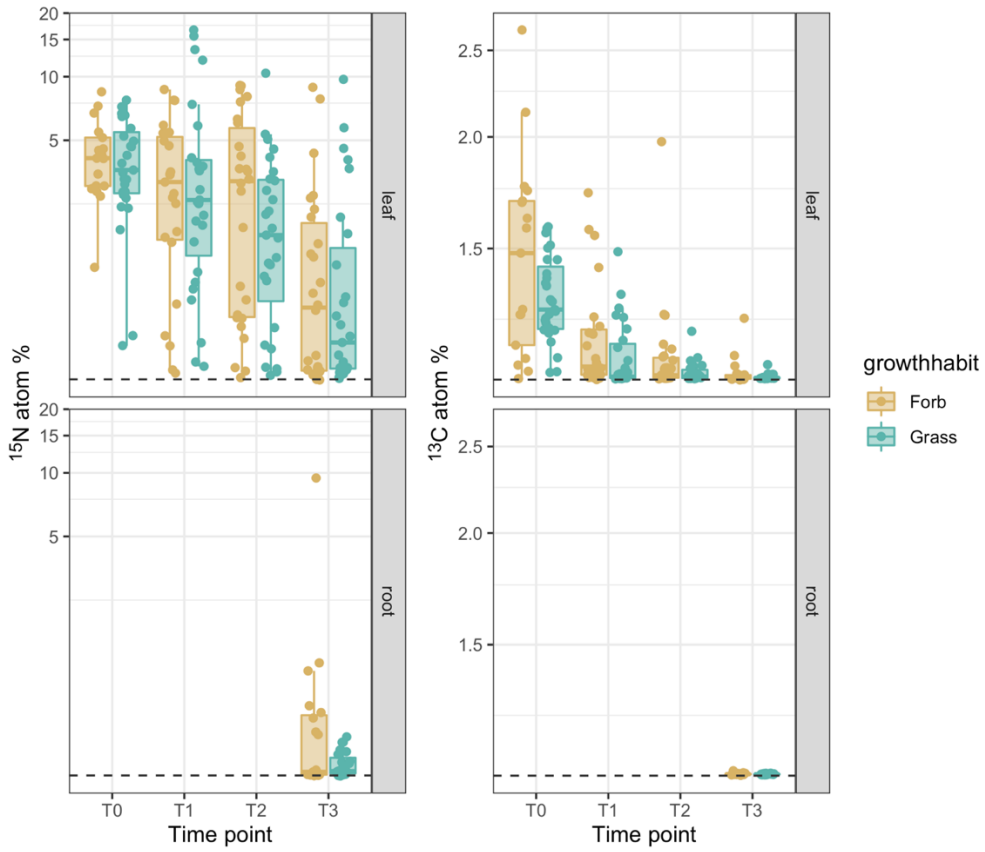

Figure S1. Enrichment decreases over time in labelled plants. Time points roughly correspond with T0 = time of labelling, T1 = 4 days later, T2 = 10 days later, T3 = 21 days later. Y-axis is in log10 scale.

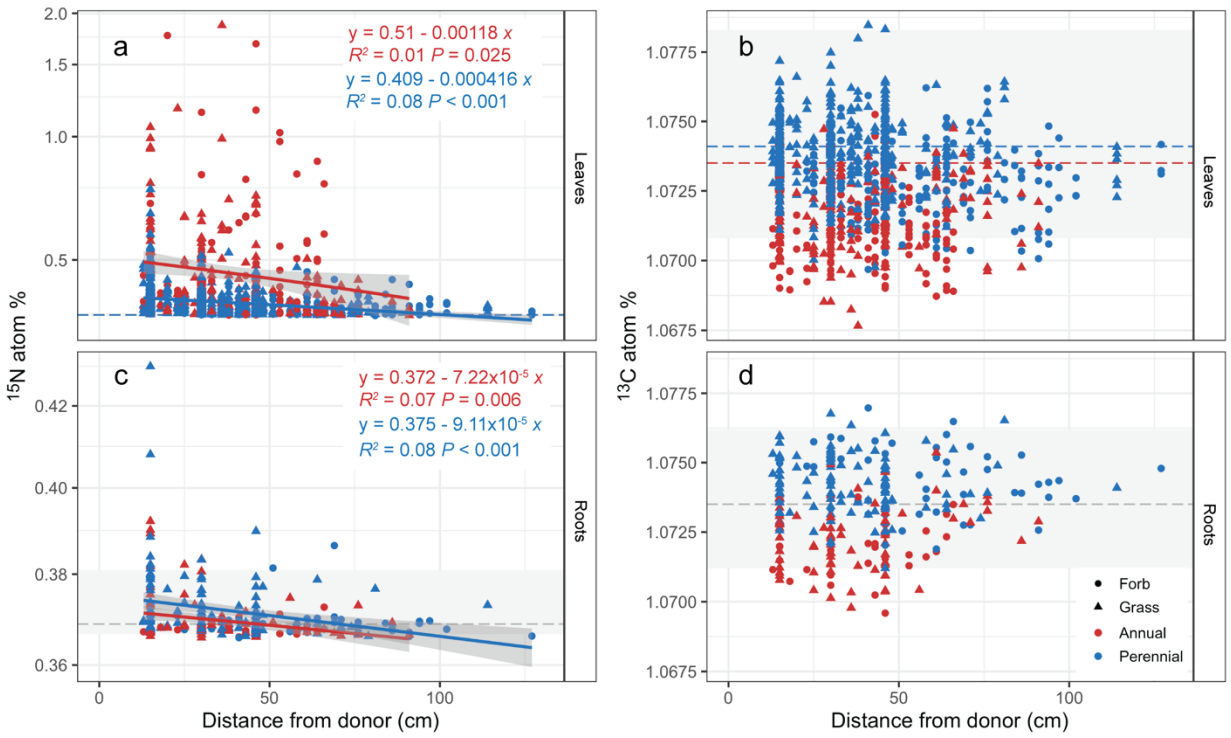

Figure S2. Decreased receiver enrichment with distance from donor in leaves and roots. Dashed lines indicate natural abundance means; grey boxes indicate range of natural abundance variation shown in Fig. 2. There is no systematic enrichment of ^{13}C; however, there is high ^{15}N enrichment in leaves. Y-axes are $\log_{10}$ scale. Note that the y-axis scales are different between ^{15}N leaves and ^{15}N roots. See Fig. 4 and Fig. S** for boxplots of enrichment data by grass/forb and annual/perennial.

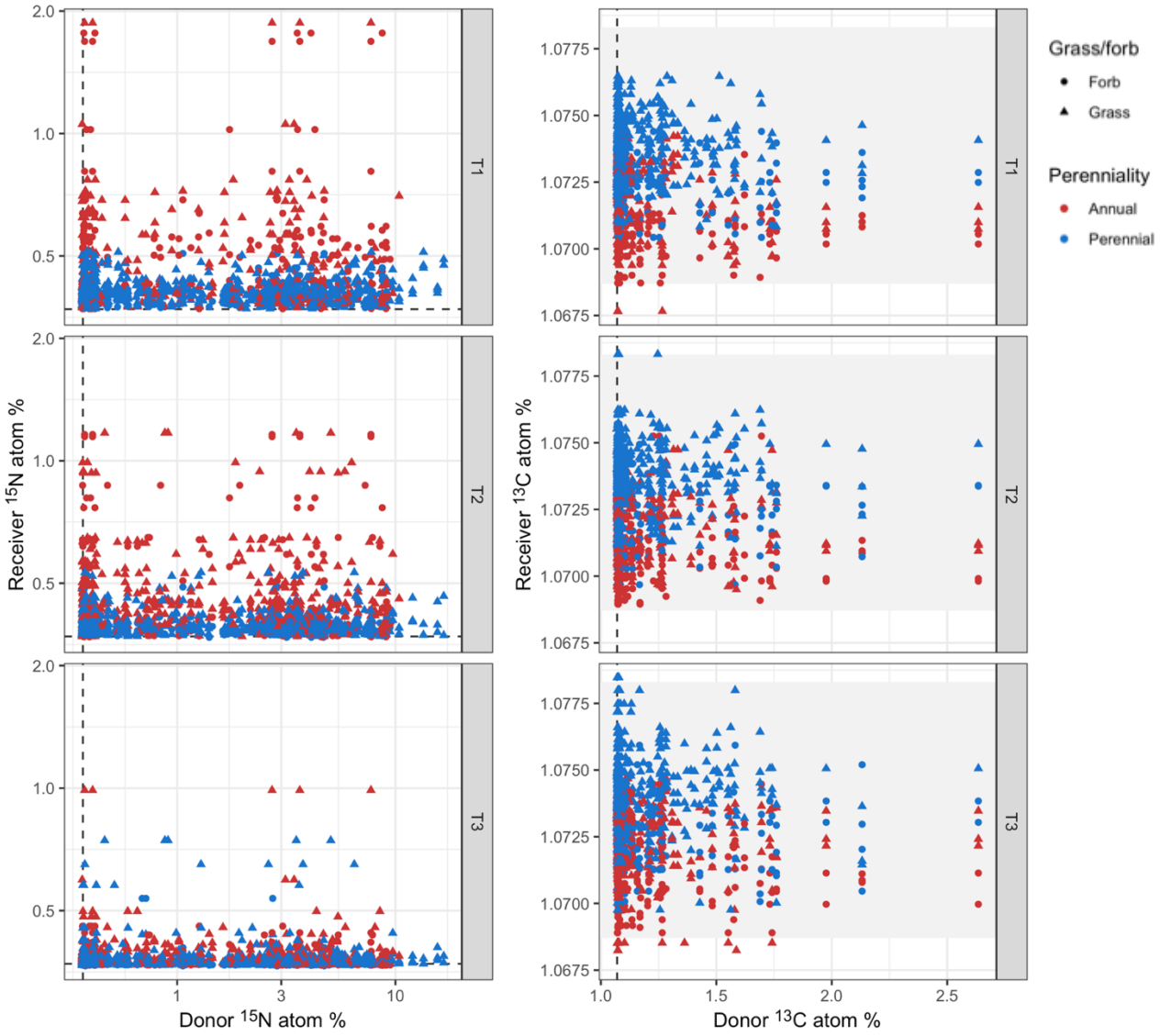

Figure S3. Receiver enrichment did not correlate with donor enrichment. Dashed lines indicate natural abundance means; grey boxes indicate range of natural abundance variation shown in Figure 2. (Grey boxes are too small to be visible for ^{15}N.) ^{15}N axes are log10 scaled. Note there is a sizeable difference between X- and Y-axes of both elements. Time point facets are time point 1 (~4 days post label), time point 2 (~10 days post label), and time point 3 (~21 days post label). Donors are all sampled at time point 0 (immediately after labelling). Note that five plots are missing from this graph (one each from northern/high diversity/control, northern/low diversity/rain exclusion, central/high diversity/rain exclusion, central/low diversity/rain exclusion, southern/high diversity/control) due to a lack of donor DNA data.

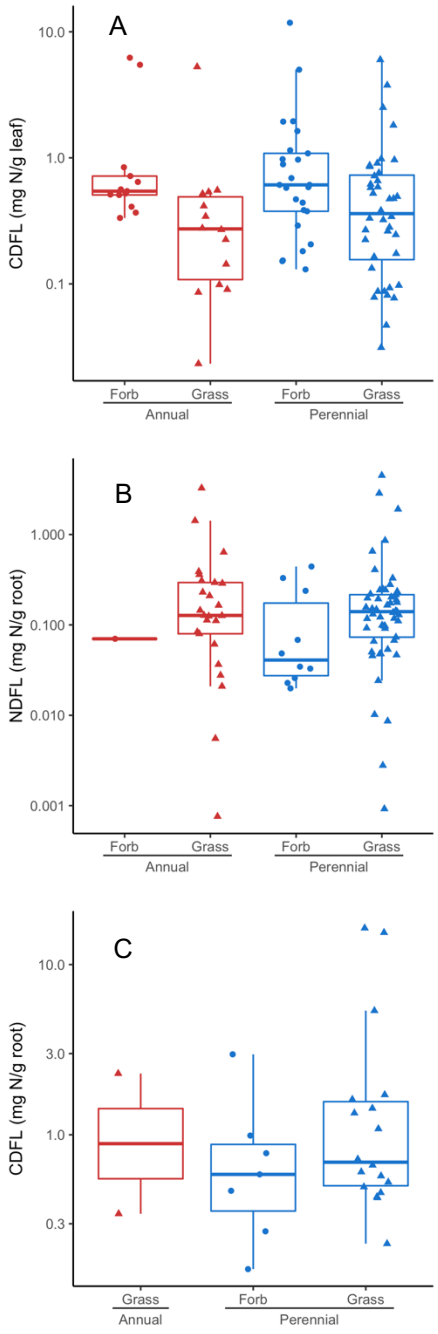

Figure S3: Enrichment derived from label for A) CDFL in leaves, B) NDFL in roots, and C) CDFL in roots. Points represent enriched individual receiver plants with associated DNA data at one time point of sampling. In A all three post-enrichment time points are shown; in B and C only time point 3 is shown. Y-axis is log10 scale. See Fig. S** for values over distance and Fig. 4 for NDFL in leaves.

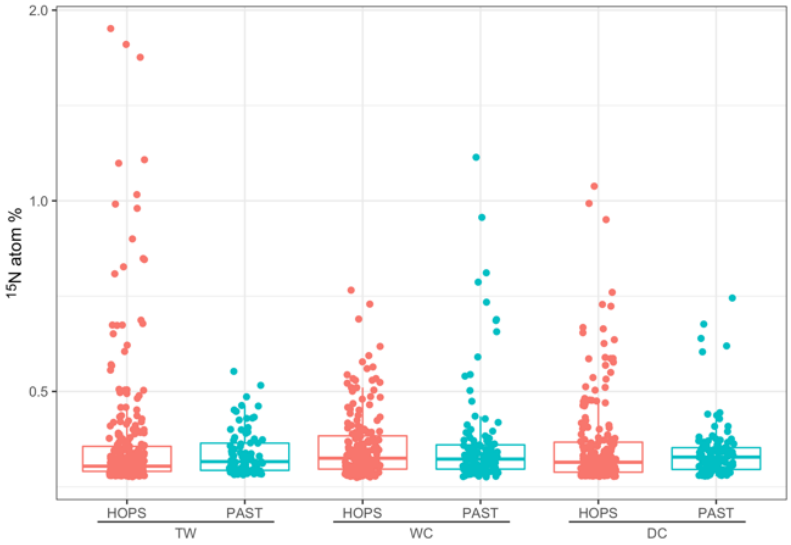

Figure S5. No trend in ^{15}N enrichment across site and rain exclusion treatment. Y-axis is in log10 scale. HOPS indicates restored prairie sites, PAST indicates pasture sites. Sites are ordered from north (TW) to central (WC) to south (DC).

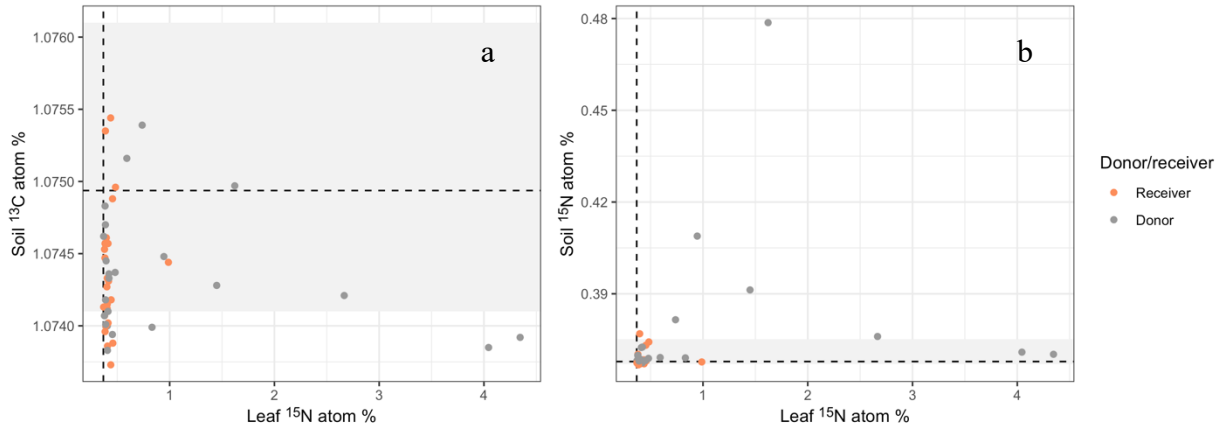

Figure S6. Limited soil enrichment 21 days after labelling. Dashed lines indicate average baseline enrichment. Grey boxes indicate range of baseline enrichment. Samples are subset to individuals most highly enriched with foliar ^{15}N at each site by restored prairie/introduced pasture as well as their associated donors.

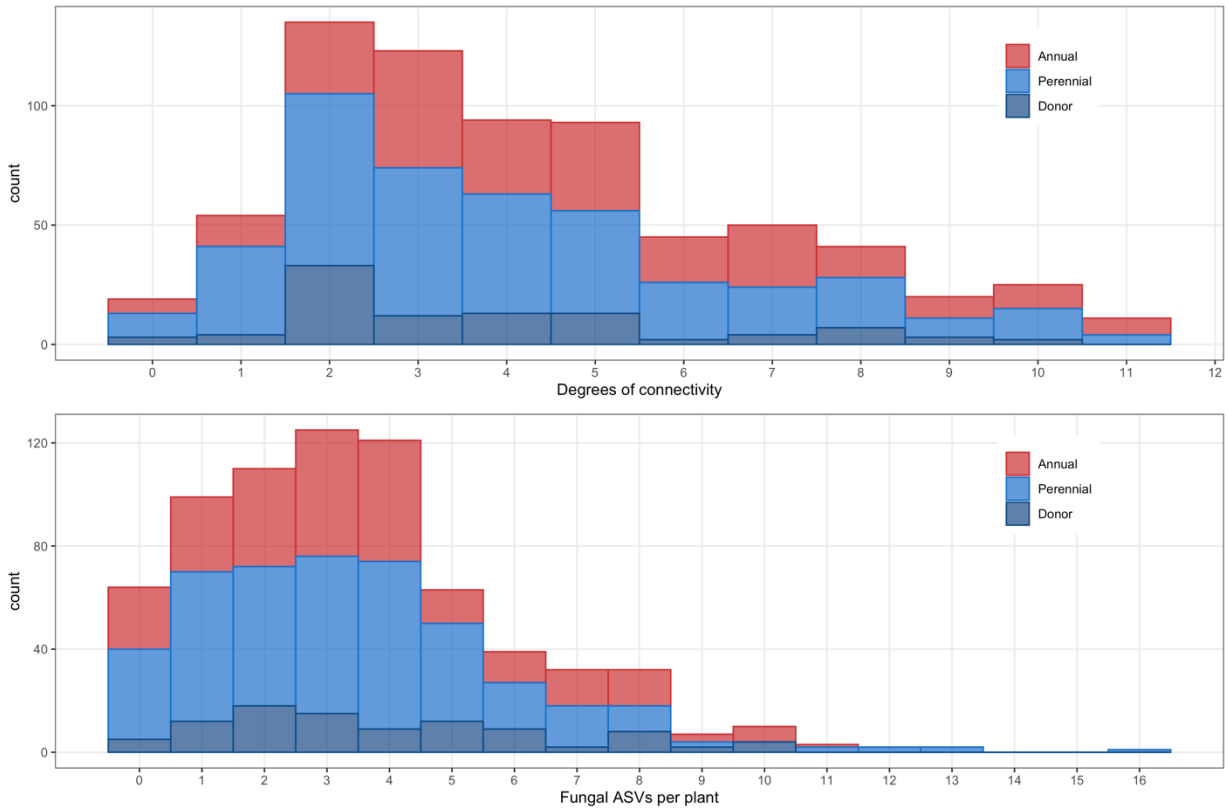

Figure S7. Histogram of connectivity metrics showing left skew. Degrees of connectivity indicate how many plants an individual shared at least one fungal ASV with in the same plot. Data are from time point 1 (approximately four days after labeling). Donors are the plants that we applied the isotopic label to.

SI References

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