

Supplementary Information

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Table S1. Tree parameters for the three species in this study

Parameter	<i>Pinus halepensis</i>	<i>Quercus calliprinos</i>	<i>Pistacia lentiscus</i>
Functional group	Conifer (evergreen)	Broadleaf (evergreen)	Broadleaf (evergreen)
Forest layer	Canopy	Sub-canopy	Understory
Height (m)	13.6±0.6	4.1±0.3	2.0±0.3
DBH (cm)	26.9±3.2	14.3±1.9	<2
Root system in the soil layer (kg C)	17.0	11.7	12.8
Root system in the rock layer (kg C)	13.4	13.7	9.2
Annual root growth (kg C year ⁻¹)	3.4±0.9	1.5±0.3	1.1±0.0
Annual root litter (kg C year ⁻¹)	2.0±0.6	1.4±0.0	0.2±0.0
Annual aboveground litter (kg C year ⁻¹)	6.9±1.8	4.0±0.3	1.6±0.2
Annual root exudation (kg C year ⁻¹)	13.0±1.2	2.0±0.2	1.0±0.1

Table S2: Summary of plot characteristics of the six plots studied at Yishi Forest. Mean $\pm$ SE values are shown for: stem diameter (cm; for *Pinus* and *Quercus*) and shrub stem scope (cm; for *Pistacia*), tree height (m), and “% of dominant tree” represents the relative dominance of the canopy-forming species in each microsite. Richness of annual plants refers to the mean number of herbaceous species per 0.09 m² quadrat, and tree species richness denotes the number of woody species present within the plot.

Forest type	Microsite	Stem diameter/scope (cm)	Height (m)	% of dominant tree	Richness of annual plant (species per 0.09 m ²)	Tree species richness
Mono-specific forest	<i>Pistacia lentiscus</i>	2210.0 $\pm$ 425.56	2.02 $\pm$ 0.25	38.46	10.00	4
Mono-specific forest	<i>Pinus halepensis</i>	107.2 $\pm$ 9.66	17 $\pm$ 1.34	43.75	12.66	4
Mono-specific forest	<i>Quercus calliprinos</i>	223.8 $\pm$ 46.58	3.94 $\pm$ 0.3	58.33	10.00	4
Mixed-forest	Mix (<i>Pistacia</i>)	1373.33 $\pm$ 214.58	1.6 $\pm$ 0.21	67	6.625	8
Mixed-forest	Mix (<i>Pinus</i>)	131.67 $\pm$ 10.14	20.67 $\pm$ 0.67			
Mixed-forest	Mix (<i>Quercus</i>)	202.33 $\pm$ 105.39	5.33 $\pm$ 0.67			

Table S4: Results of the principal component analysis (PCA) for soil physicochemical properties. Loadings on the first two principal components (PC1 and PC2) are presented, along with their loading magnitudes. The values indicate the strength and direction of each variable's contribution to the PCA.

Variable	PC1	PC2	Loading Magnitude
Clay & silt content	-0.121	-0.244	0.272
Soil Bulk density	0.356	0.085	0.366
Litter dry mass	-0.405	0.194	0.449
Soil pH	0.319	-0.054	0.323
Soil EC	-0.363	-0.212	0.421
Extractable Magnesium	-0.442	-0.034	0.443
Extractable Chloride	0.029	-0.330	0.331
Inorganic nitrogen	-0.418	0.079	0.425
Extractable Phosphorus	0.253	-0.372	0.450
Soil Temperature	-0.158	-0.525	0.548
CaCo3	0.023	0.404	0.405
C/N ratio	-0.031	0.393	0.394

Table S5. Structural equation model results. Unstandardized estimates, standard errors, z-values, p-values, 95% confidence intervals and standardized coefficients (β) are given for every direct, indirect and total effect estimated in the final model, including non-significant paths retained to preserve the a priori causal structure. Indirect effects are listed as specific causal pathways; where a predictor reaches an outcome through more than one pathway, the sum of those pathways is given as a separate row. Total effects are the sum of the direct and all indirect effects of a predictor on an outcome. The model was fitted by diagonally weighted least squares (WLSMV) in lavaan, with microsite treated as an ordered factor; N = 62. Significance: *** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10 (marginal); ns, not significant.

Path	Estimate	SE	z	p	95% CI	β	
Direct effects							
Forest type → Microsite	-0.115	0.316	-0.362	0.717	[-0.734, 0.505]	-0.057	ns
Microsite → Aboveground biomass	0.598	0.147	4.063	<0.001	[0.310, 0.887]	0.615	***
Microsite → Litter density	0.631	0.127	4.987	<0.001	[0.383, 0.879]	0.766	***
Litter density → Soil properties (PC1)	0.791	0.196	4.033	<0.001	[0.407, 1.175]	0.657	***
Clay + silt content → Soil properties (PC1)	-0.421	0.089	-4.716	<0.001	[-0.595, -0.246]	-0.411	***
Forest type → Microbial richness	0.769	0.245	3.133	0.002	[0.288, 1.249]	0.376	**
Soil properties (PC1) → MAOC	0.552	0.155	3.558	<0.001	[0.248, 0.857]	0.544	***
Clay + silt content → MAOC	0.676	0.093	7.271	<0.001	[0.494, 0.858]	0.650	***
Soil properties (PC1) → POC	0.561	0.172	3.257	0.001	[0.223, 0.898]	0.639	**
Microsite → POC	0.574	0.203	2.820	0.005	[0.175, 0.972]	0.659	**
Litter density → POC	-0.710	0.426	-1.668	0.095	[-1.544, 0.124]	-0.672	†
Clay + silt content → POC	-0.221	0.127	-1.736	0.083	[-0.471, 0.029]	-0.246	†
Indirect effects							
Forest type → Microsite → Aboveground biomass	-0.069	0.190	-0.360	0.719	[-0.442, 0.305]	-0.035	ns
Forest type → Microsite → Litter density	-0.072	0.201	-0.360	0.719	[-0.465, 0.321]	-0.043	ns
Forest type → Microsite → Litter density → Soil properties	-0.057	0.156	-0.367	0.714	[-0.363, 0.248]	-0.028	ns

Forest type → Microsite → Litter density → Soil properties → MAOC	-0.032	0.086	-0.368	0.713	[-0.200, 0.137]	-0.015	ns
Forest type → POC (sum of all indirect pathways)	-0.046	0.131	-0.356	0.722	[-0.302, 0.209]	-0.026	ns
Microsite → Litter density → Soil properties	0.499	0.097	5.120	<0.001	[0.308, 0.690]	0.503	***
Microsite → Litter density → Soil properties → MAOC	0.276	0.090	3.051	0.002	[0.099, 0.453]	0.274	**
Microsite → Litter density → Soil properties → POC	0.280	0.109	2.563	0.010	[0.066, 0.494]	0.321	*
Microsite → Litter density → POC	-0.448	0.261	-1.719	0.086	[-0.959, 0.063]	-0.515	†
Microsite → POC (sum of all indirect pathways)	-0.168	0.186	-0.905	0.365	[-0.532, 0.196]	-0.193	ns
Litter density → Soil properties → MAOC	0.437	0.148	2.954	0.003	[0.147, 0.727]	0.357	**
Litter density → Soil properties → POC	0.443	0.213	2.083	0.037	[0.026, 0.861]	0.419	*
Clay + silt content → Soil properties → MAOC	-0.232	0.084	-2.757	0.006	[-0.397, - 0.067]	-0.223	**
Clay + silt content → Soil properties → POC	-0.236	0.088	-2.688	0.007	[-0.408, - 0.064]	-0.262	**
Total effects (direct + indirect)							
Forest type → Microsite	-0.115	0.316	-0.362	0.717	[-0.734, 0.505]	-0.057	ns
Forest type → Aboveground biomass	-0.069	0.190	-0.360	0.719	[-0.442, 0.305]	-0.035	ns
Forest type → Litter density	-0.072	0.201	-0.360	0.719	[-0.465, 0.321]	-0.043	ns
Forest type → Soil properties (PC1)	-0.057	0.156	-0.367	0.714	[-0.363, 0.248]	-0.028	ns
Forest type → Microbial richness	0.769	0.245	3.133	0.002	[0.288, 1.249]	0.376	**
Forest type → MAOC	-0.032	0.086	-0.368	0.713	[-0.200, 0.137]	-0.015	ns
Forest type → POC	-0.046	0.131	-0.356	0.722	[-0.302, 0.209]	-0.026	ns
Microsite → MAOC	0.276	0.090	3.051	0.002	[0.099, 0.453]	0.274	**
Microsite → POC	0.405	0.063	6.407	<0.001	[0.281, 0.529]	0.466	***
Litter density → MAOC	0.437	0.148	2.954	0.003	[0.147, 0.727]	0.357	**
Litter density → POC	-0.267	0.285	-0.934	0.350	[-0.826, 0.293]	-0.252	ns
Clay + silt content → MAOC	0.444	0.103	4.313	<0.001	[0.242, 0.645]	0.427	***
Clay + silt content → POC	-0.457	0.109	-4.192	<0.001	[-0.671, - 0.243]	-0.509	***

Soil properties (PC1) → MAOC	0.552	0.155	3.558	<0.001	[0.248, 0.857]	0.544	***
Soil properties (PC1) → POC	0.561	0.172	3.257	0.001	[0.223, 0.898]	0.639	**

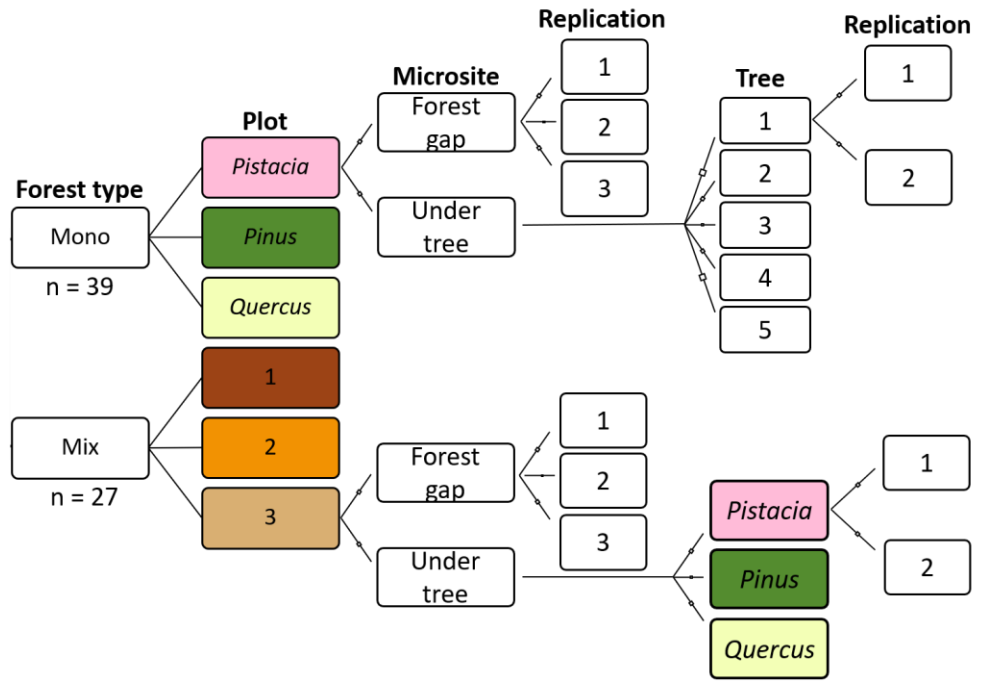


Fig. S1. Experimental sampling design. Monospecific forest plots comprised *Pistacia*, *Pinus*, or *Quercus* stands. Within each plot, soil samples were collected from different microsites: three replicate forest gaps, while under-tree sampling included five individual trees with two soil samples collected per tree, resulting in 39 samples across monospecific plots. Mixed forests comprised three replicate plots containing all three tree species. Within each mixed plot, three soil samples were collected from forest gaps and two soil samples were collected beneath each tree species, resulting in 27 samples across mixed plots.

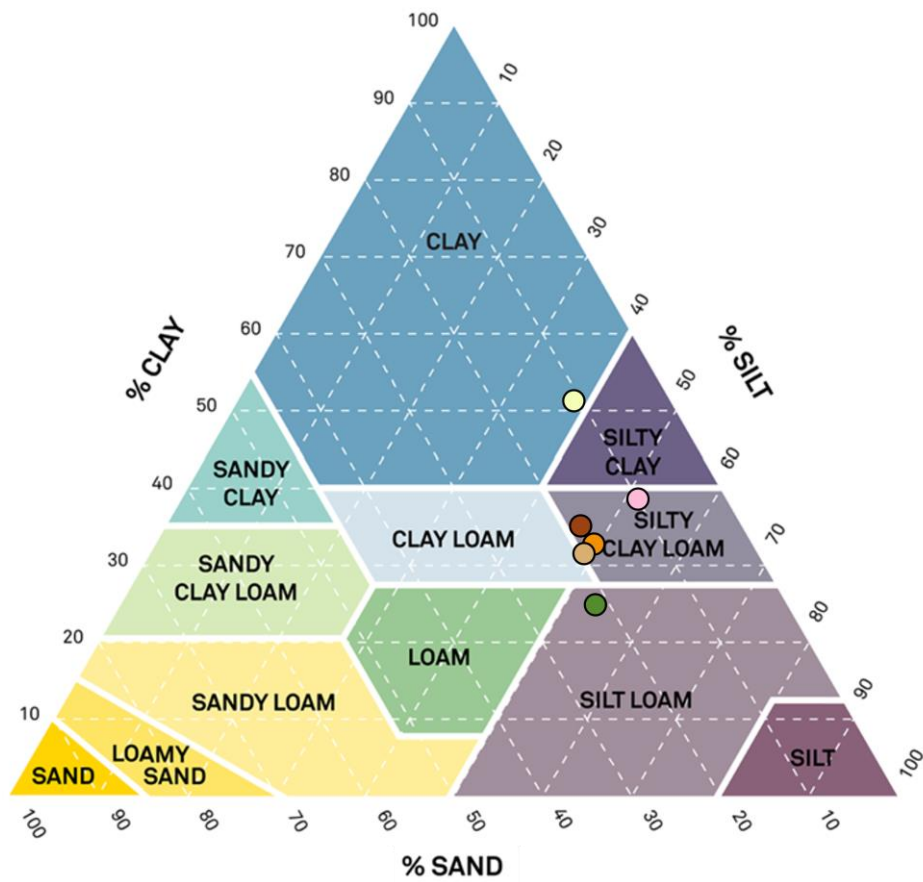


Fig. S2. Soil texture classes in the plots of Yishi Forest. *Pistacia*, *Pinus* and *Quercus* mono-specific plots are represented in pink, green and yellow circles, respectively. The three mixed-forest plots are in brown-orange colors.

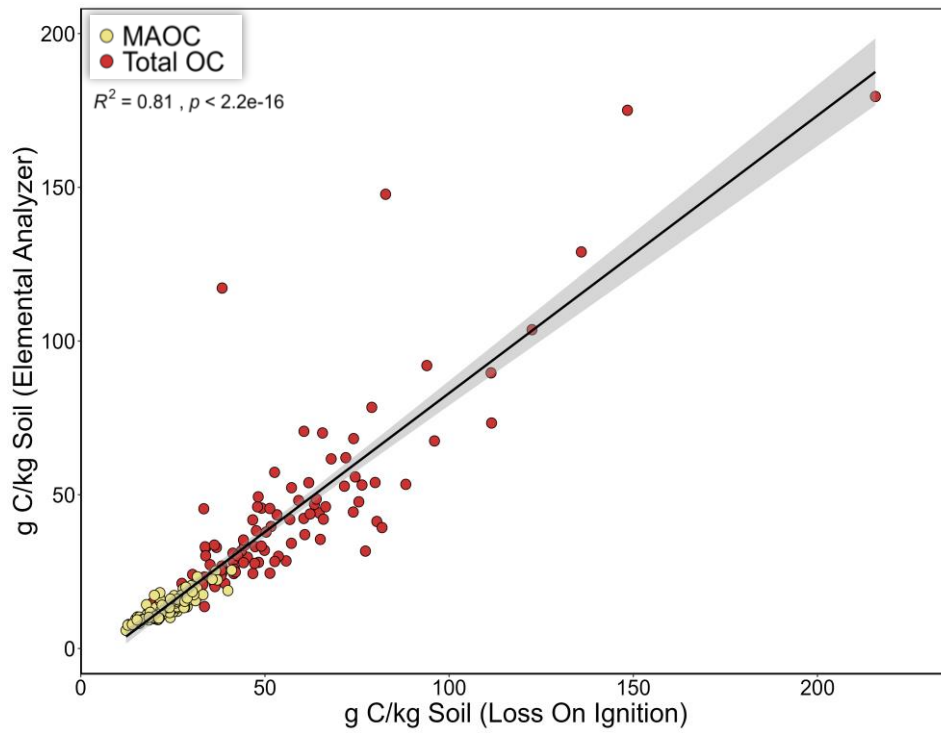


Fig. S3. Linear regression analysis comparing two methods for measuring soil organic carbon: Loss on Ignition (x-axis) versus Elemental Analyzer (y-axis). SOC was measured in the six plots of Yishi Forest. The gray-shaded area represents the 95% confidence interval of the linear model fit.

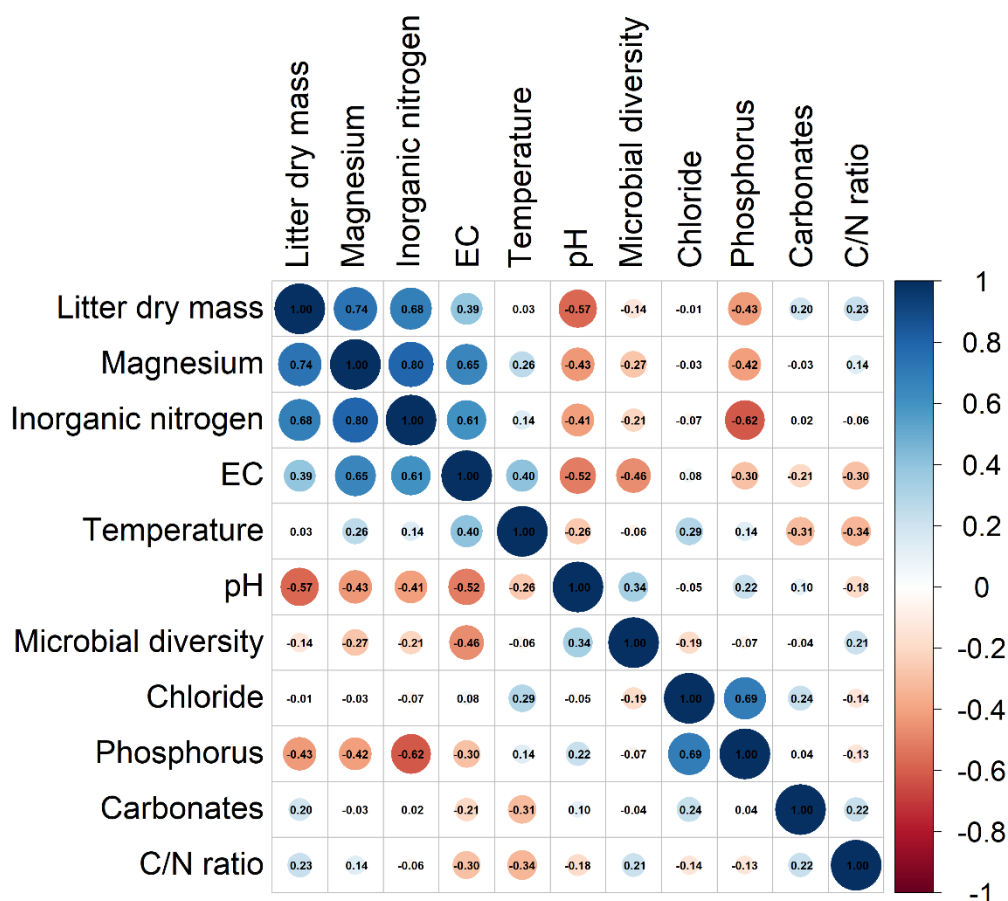


Fig. S4. Correlations between soil physical and chemical properties and environmental variables. The red and blue indicate negative and positive correlations, respectively. A correlation matrix is computed and plotted using the `corrplot` package. The correlation matrix is plotted with hierarchical clustering (`order = 'hclust')`. Text labels and color scales are adjusted for better readability.

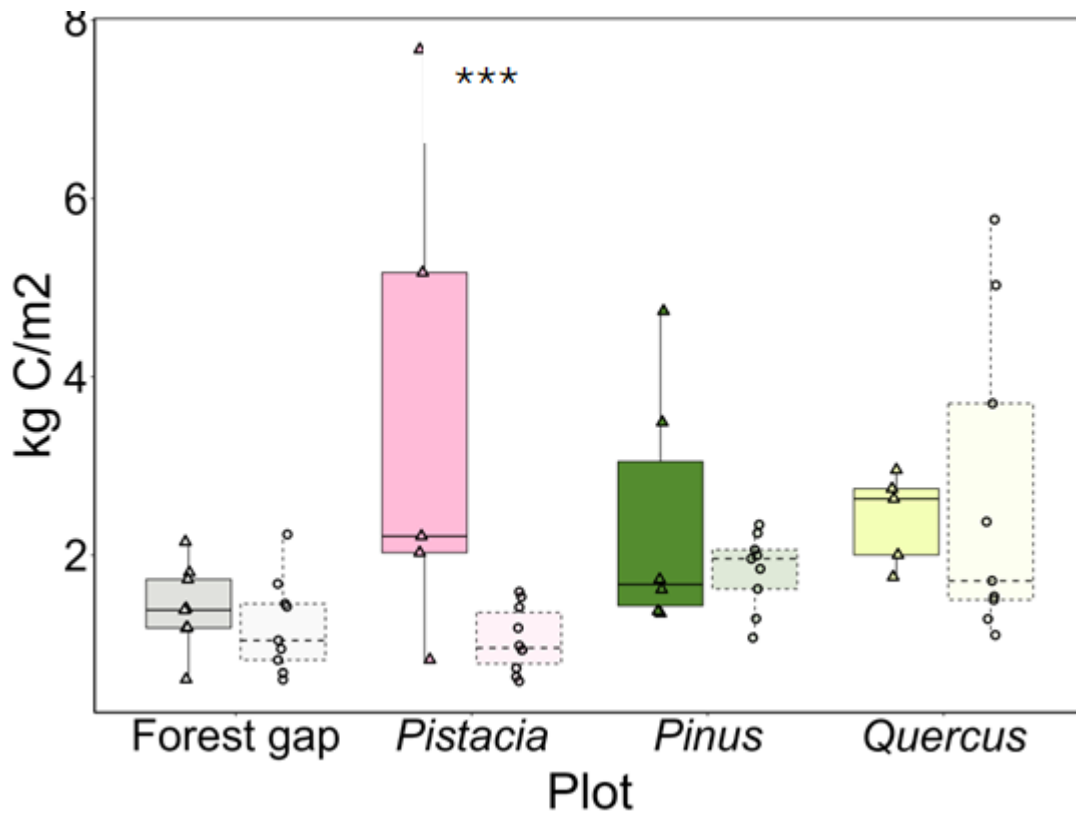


Fig. S5: SOC stocks partitioned across different forest types and microsites within the forest in Yishi. Box Plots are categorized by the microsite under the dominant tree canopy (i.e., *Pistacia*, *Pinus*, *Quercus*, or open forest gaps (n = 66)). Box plots are further categorized into two groups based on forest composition: mono-specific forest (faded color, dashed, plus shape, n = 39) and mixed forest (fully saturated color, plain, round shape, n = 27). Box plots display the median, first and third quartiles, and whiskers extending to 1.5 times the interquartile range. Asterisks indicate significant contrasts ($p < 0.05$) between mixed and mono-specific forest plots within microsites. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

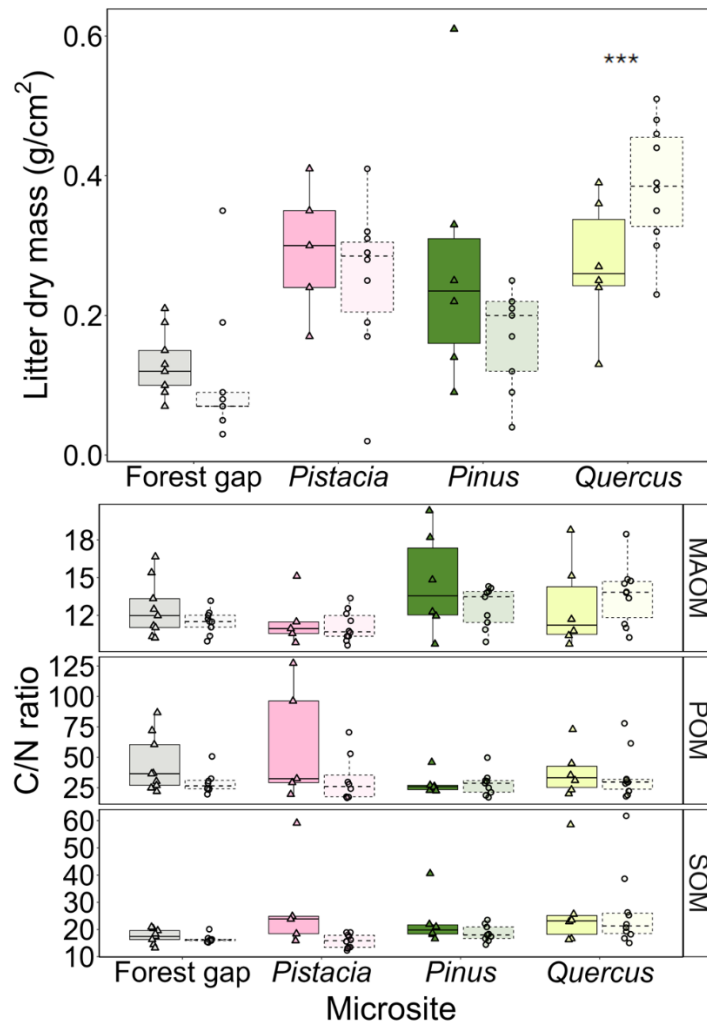


Fig. S6. a) Litter dry mass and b) Carbon to nitrogen ratio partitioned across different forest types and microsites within the forest in Yishi. Box Plots are categorized by the microsite under the dominant tree canopy (i.e., *Pistacia*, *Pinus*, *Quercus*, or open forest gaps (n = 66). Box plots are further categorized into two groups based on forest composition: mono-specific forest (faded color, dashed, plus shape, n = 39) and mixed forest (fully saturated color, plain, round shape, n = 27). Box plots display the median, first and third quartiles, and whiskers extending to 1.5 times the interquartile range. Asterisks indicate significant contrasts ($p < 0.05$) between mixed and mono-specific forest plots within microsites. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

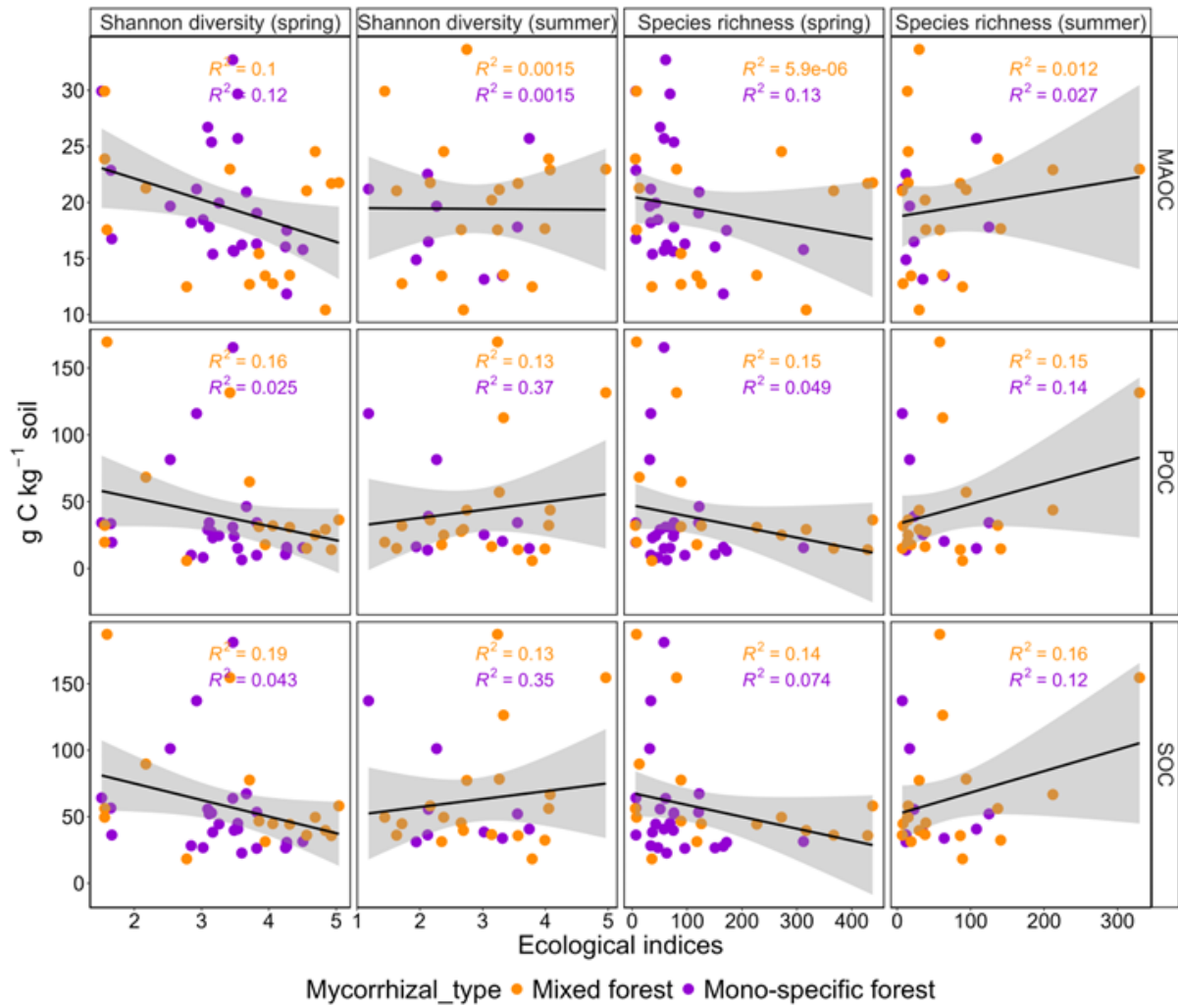


Fig. S7. Relationship between mineral-associated organic carbon (MAOC), particulate organic carbon (POC), and total soil organic carbon (Total OC) with microbial Shannon diversity and species richness (measured in both summer and spring) in the eight plots of Yishi Forest. The plots are categorized into two groups based on forest composition status: Mono-specific forest, (n=65) and Mixed forest (n=39). The gray-shaded area represents the 95% confidence interval of the linear model fit.