Supplymentary materials

Table S2. Topological properties of co-occurrence networks

	Austre	Damma	Franz josef	Sand dune
Node	1133	1267	603	859
Edge number	7425	16511	3285	11232
Negative edge ratio	0.6%	9.5%	0.8%	1.2%
Positive edge ratio	99.4%	90.6%	99.2%	98.8%
Average path length	3.8	3.4	3.8	2.9
Average clustering coefficient	0.5	0.5	0.3	0.6
Average degree	8.1	18.7	5.2	6.4
Closeness centralization	1.3	1.3	1.2	1.0

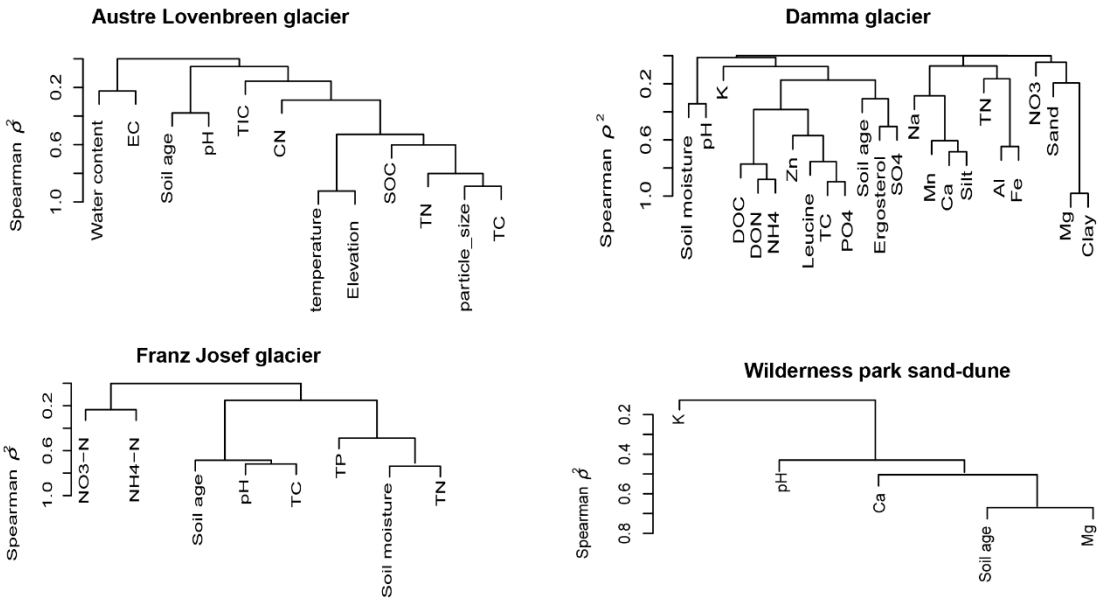
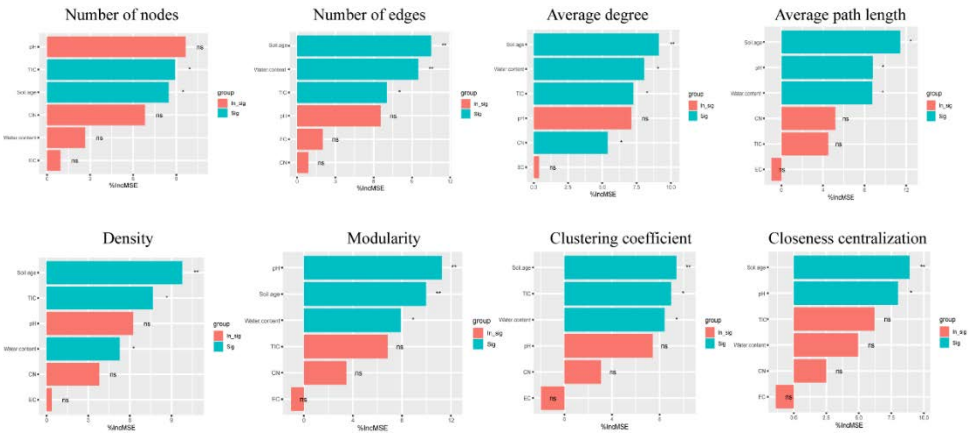


Fig S1. Hierarchical clustering of environmental factors from times since glacier retreat. Varclus analysis was done using average linkage based on Euclidean distances using the standardized dataset, and groups were determined by cubic clustering criterion.

(a)



(b)

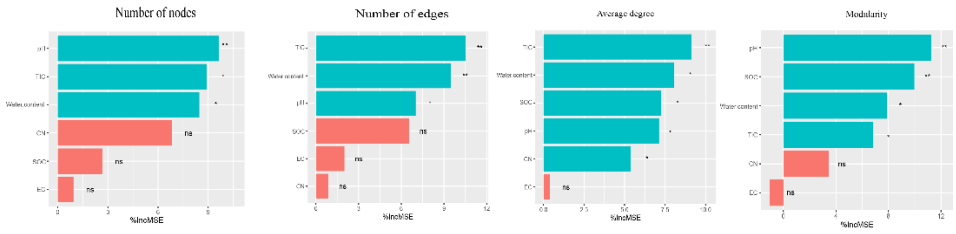
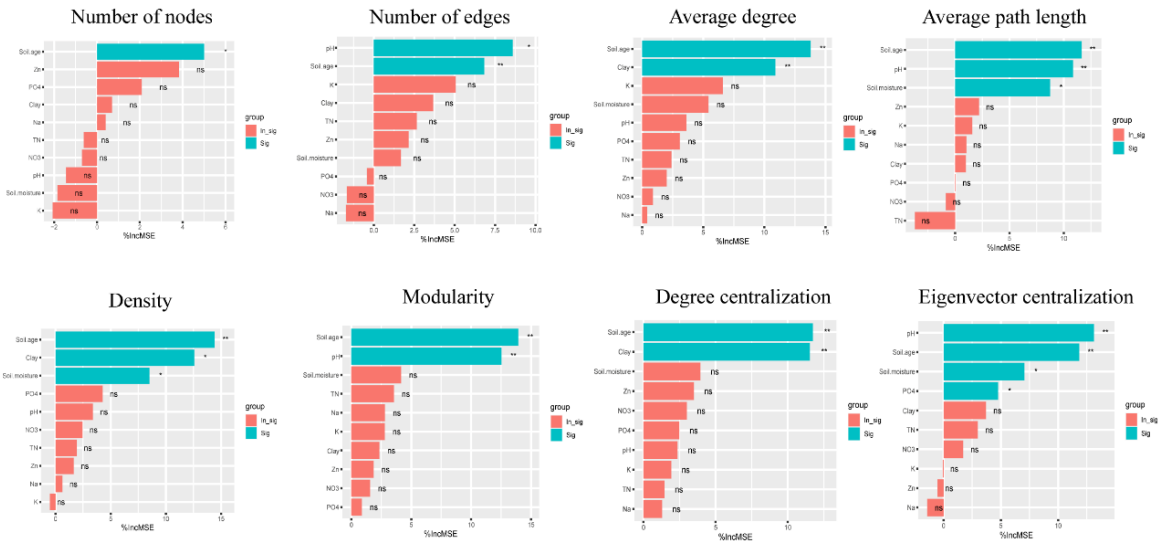


Fig S2. Potential drivers of variation in network-level topological features in Austre

lovenbreen glacier. The random forest means predictor importance of environmental factors as drivers of the network-level topological features of the co-occurrence network for soil microbiota. (b) Potential drivers of variation in main topological features after taking away the temporal factor. The accuracy importance measure was computed for each factor. $*P < 0.05$, $**P < 0.01$ and $***P < 0.001$.

(a)



(b)

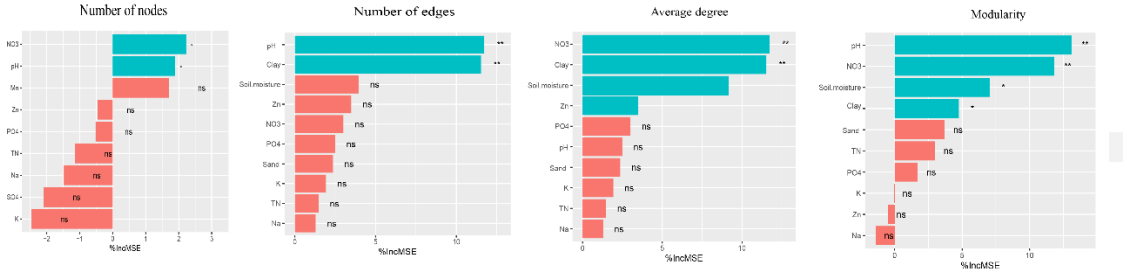


Fig S3. Potential drivers of variation in network-level topological features in Damma glacier. The random forest means predictor importance of environmental factors as drivers of the network-level topological features of the co-occurrence network for soil microbiota. (b) Potential drivers of variation in main topological features after taking

away the temporal factor. The accuracy importance measure was computed for each factor. *$P < 0.05$, **$P < 0.01$ and ***$P < 0.001$.

(a)

(b)

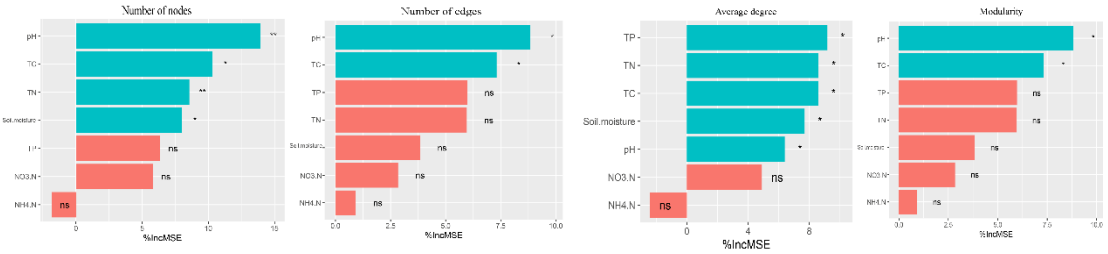


Fig S4. Potential drivers of variation in network-level topological features in Franz josef glacier. The random forest means predictor importance of environmental factors as drivers of the network-level topological features of the co-occurrence network for soil microbiota. (b) Potential drivers of variation in main topological features after taking away the temporal factor. The accuracy importance measure was computed for each factor. *$P < 0.05$, **$P < 0.01$ and ***$P < 0.001$.

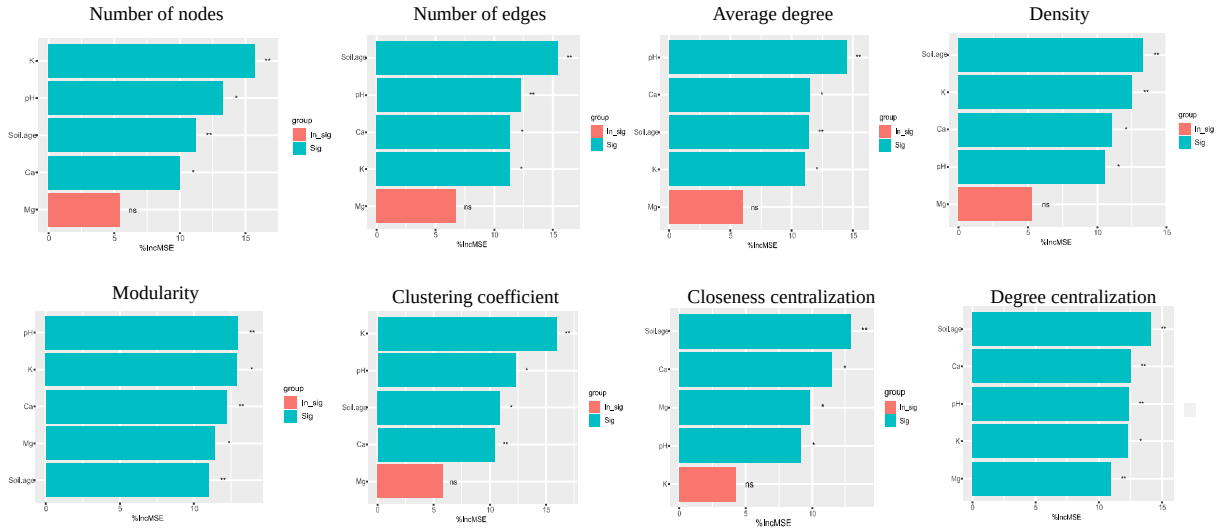


Fig S5. Potential drivers of variation in network-level topological features in Wilderness park sand dune series. The random forest means predictor importance of environmental factors as drivers of the network-level topological features of the co-occurrence network for soil microbiota. The accuracy importance measure was computed for each factor. $*P < 0.05$, $**P < 0.01$ and $***P < 0.001$.

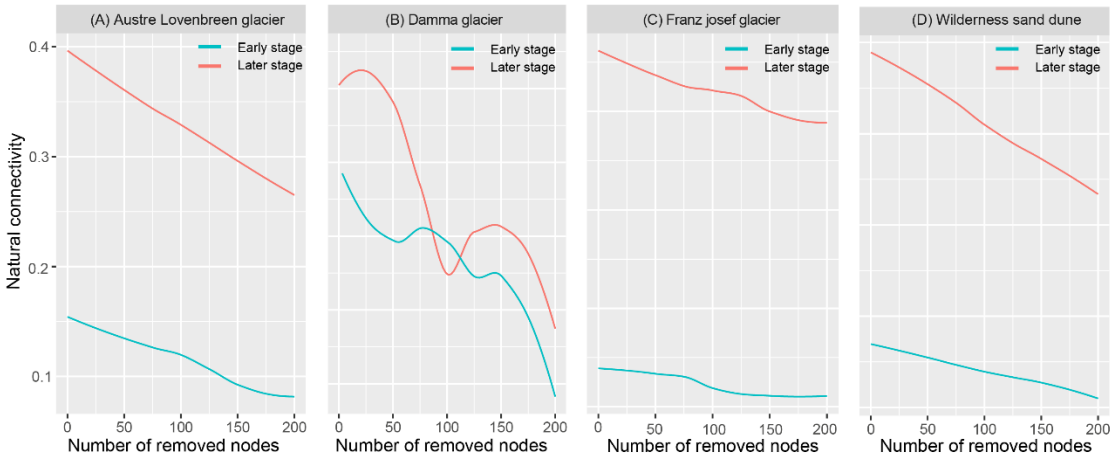


Fig S6. The natural connectivity of microbial network by different series. Robustness analysis indicates the relationship between the number of removed nodes and microbial natural connectivity. (A) Austre Lovenbreen glacier; (B) Damma glacier; (C) Franz Josef glacier; (D) Wilderness park sand dune

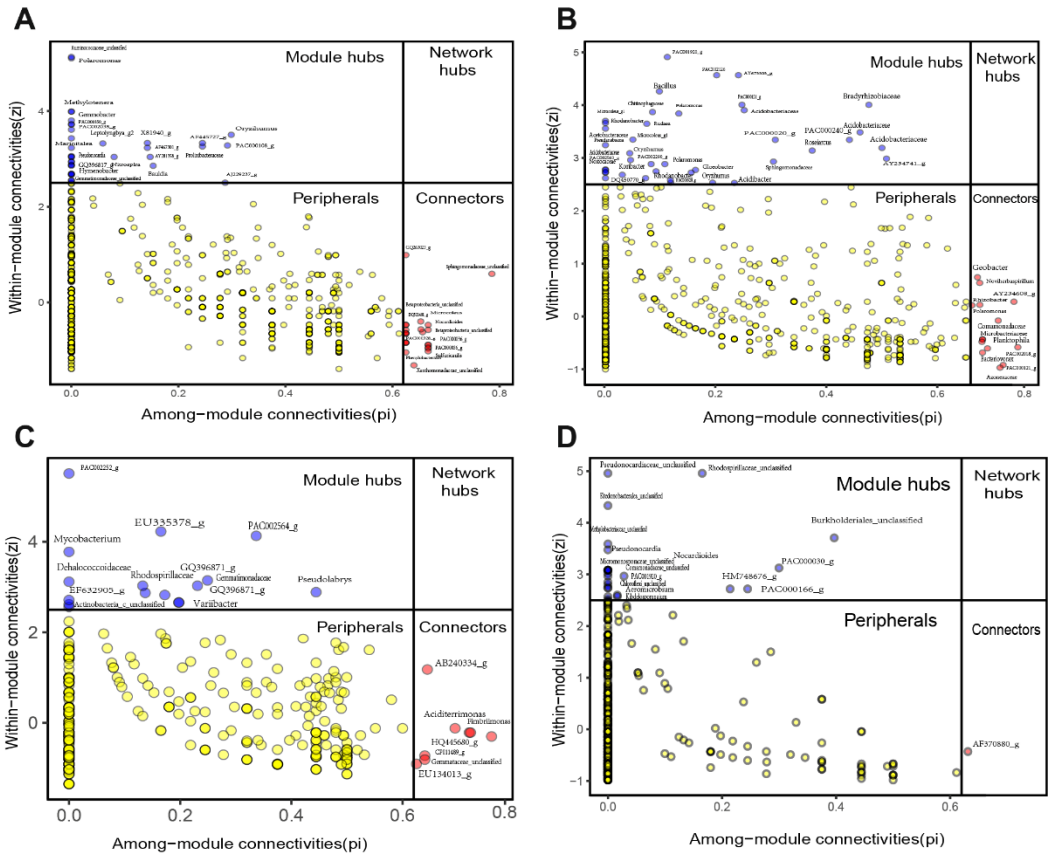


Fig S7. Identification of potential keystone taxa across 4 successional seires. Z-P plots showing the classification of nodes to identify putative keystone taxa of ecological network. Each node represents an otu. The threshold values of Zi and Pi for categorizing OTUs were 2.5 and 0.62, respectively. (A) Austre Lovenbreen glacier chronosequence; (B) Damma glacier chronosequence; (C) Franz josef glacier chronosequence; (D) Wilderness park sand dune chronosequence.