

Finding the major descriptors of species networks

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Abstract: TODO

Keywords: food web, structure, dimensionality reduction

¹ Blah blah blah Vermaat et al. (2009)

² “*It is incumbent on network ecologists to establish clearly the independence and uniqueness of the descriptive metrics used.*” - Lau et al. (2017)

Table 1: An informative caption about the different network properties. We use a combination of metrics from both the original Vermaat et al. (2009) paper as well as including those that have been identified by Thompson et al. (2012) and have been linked to emerging ecosystem properties such as stability

Label	Definition	“Function”	Reference (for maths), can make footnotes probs
Basal	Percentage of basal taxa, defined as species who have a vulnerability of zero		
Connectance	L/S^2 , where S is the number of species and L the number of links		
Cannibal	Percentage of species that are cannibals		
ChLen	Mean food chain length, averaged over all species (where a food chain is defined as a continuous path from a ‘basal’ to a ‘top’ species)		
ChSD	Standard deviation of ChLen		
ChNum	log number of food chains		
Clust	mean clustering coefficient (probability that two taxa linked to the same taxon are also linked)		TODO
GenSD	Normalized standard deviation of generality of a species standardized by L/S		Williams & Martinez (2008)

Label	Definition	“Function”	Reference (for maths), can make footnotes probs
Herbivore	Percentage of herbivores plus detritivores (taxa that feed only on basal taxa)		
Intermediate	Percentage of intermediate taxa (with both consumers and resources)		
LinkSD	Normalized standard deviation of links (number of consumers plus resources per taxon)		
Loop	Percentage of taxa in loops (food chains in which a taxon occurs twice)		
L/S	links per species		
MaxSim	Mean of the maximum trophic similarity of each taxon to other taxa, the number of predators and prey shared by a pair of species divided by their total number of predators and prey		TODO
Omnivory	Percentage of omnivores (taxa that feed on ≥ 2 taxa with different trophic levels)		
Path	characteristic path length, the mean shortest food chain length between species pairs		
Richness	Number of nodes in the network		
TL	Prey-weighted trophic level averaged across taxa		Williams & Martinez (2004)

Label	Definition	“Function”	Reference (for maths), can make footnotes probs
Top	Percentage of top taxa (taxa without consumers)		
VulSD	Normalized standard deviation of vulnerability of a species standardized by L/S		
Links	The number of links in the network		
Diameter	Diameter can also be measured as the average of the distances between each pair of nodes in the network		Delmas et al. (2019)
ρ	Spectral radius is a conceptual analog to nestedness (and more appropriate for unipartite networks). It is defined as the absolute value of the largest real part of the eigenvalues of the <i>undirected</i> adjacency matrix		Staniczenko et al. (2013)
Complexity	SVD complexity of a network, defined as the Pielou entropy of its singular values	Something about structural v behavioural complexity being captured	Strydom et al. (2021)
Centrality	Centrality is a measure of how ‘influential’ a species is, under various definitions of ‘influence’...	Centrality can help in quantifying the importance of species in a network	
S1	Number of linear chains		Stouffer et al. (2007) Milo et al. (2002)

Label	Definition	“Function”	Reference (for maths), can make footnotes probs
S2	Number of omnivory motifs		Stouffer et al. (2007)
			Milo et al. (2002)
S4	Number of apparent competition motifs		Stouffer et al. (2007)
			Milo et al. (2002)
S5	Number of direct competition motifs		Stouffer et al. (2007)
			Milo et al. (2002)
Intervality	The degree to which the prey in a food web can be ordered so that all species can be placed along a single dimension		Stouffer et al. (2006)
Prey:predator	Ratio of prey (basal + intermediate) to predators (top + intermediate)	A measure of food web ‘shape’. Values <1 imply an inverted structure and might indicate instability	
Robustness	Minimum level of secondary extinction that occurs in response to a particular perturbation		Jonsson et al. (2015)

Table 2: Here is a table showing the correlation of the different network properties with the first three dimensions of the PCA

Property	PCA 1 (30%)	PCA 2 (21%)	PCA 3 (17%)
richness	0.29	0.82	0.35
links	0.63	0.68	0.1
connectance	0.5	-0.5	-0.61
diameter	0.55	0.47	0.35
complexity	-0.48	-0.08	0.46
distance	0.02	0.34	-0.11

Table 2: Here is a table showing the correlation of the different network properties with the first three dimensions of the PCA

Property	PCA 1 (30%)	PCA 2 (21%)	PCA 3 (17%)
basal	-0.46	0.45	-0.69
top	-0.56	0.17	0.28
intermediate	0.67	-0.47	0.44
predpreyRatio	-0.24	0.42	-0.73
herbivory	-0.5	0.24	-0.06
omnivory	0.77	-0.27	0.23
cannibal	0.73	0.12	-0.29
l_S	0.83	0.5	-0.13
GenSD	-0.37	0.67	-0.32
VulSD	-0.4	0.52	0.38
TL	0.5	-0.41	0.71
ChLen	0.48	-0.54	0.53
ChSD	0.32	0.1	0.46
ChNum	-0.19	0.74	0.48
path	0.28	0.34	0.41
LinkSD	-0.25	0.68	0.4
S1	0.92	0.02	0.01
S2	0.85	0.01	-0.35
S4	0.62	0.53	-0.19
S5	0.67	0.49	-0.42
	0.56	-0.3	-0.55
centrality	-0.23	-0.63	-0.35
loops	0.81	0.29	-0.05
robustness	0.07	0.16	-0.51

⁴ Source: [Article Notebook](#)

⁵ [Figure 1 about here.]

⁶ [Figure 2 about here.]

7 References

- 8 Delmas, E., Besson, M., Brice, M.-H., Burkle, L. A., Riva, G. V. D., Fortin, M.-J., Gravel, D., Guimarães,
9 P. R., Hembry, D. H., Newman, E. A., Olesen, J. M., Pires, M. M., Yeakel, J. D., & Poisot, T. (2019).
10 Analysing ecological networks of species interactions. *Biological Reviews*, 94(1), 16–36. <https://doi.org/10.1111/brv.12433>
- 12 Jonsson, T., Berg, S., Pimenov, A., Palmer, C., & Emmerson, M. (2015). The reliability of R50 as a
13 measure of vulnerability of food webs to sequential species deletions. *Oikos*, 124(4), 446–457. <https://doi.org/10.1111/oik.01588>
- 15 Lau, M. K., Borrett, S. R., Baiser, B., Gotelli, N. J., & Ellison, A. M. (2017). Ecological network metrics:
16 Opportunities for synthesis. *Ecosphere*, 8(8), e01900. <https://doi.org/10.1002/ecs2.1900>
- 17 Milo, R., Shen-Orr, S., Itzkovitz, S., Kashtan, N., Chklovskii, D., & Alon, U. (2002). Network Motifs: Simple
18 Building Blocks of Complex Networks. *Science*, 298(5594), 824–827. <https://doi.org/10.1126/science.298.5594.824>
- 20 Staniczenko, P. P. A., Kopp, J. C., & Allesina, S. (2013). The ghost of nestedness in ecological networks.
21 *Nature Communications*, 4(1), 1391. <https://doi.org/10.1038/ncomms2422>
- 22 Stouffer, D. B., Camacho, J., & Amaral, L. A. N. (2006). A robust measure of food web intervality. *Proceedings
23 of the National Academy of Sciences*, 103(50), 19015–19020. <https://doi.org/10.1073/pnas.0603844103>
- 24 Stouffer, D. B., Camacho, J., Jiang, W., & Nunes Amaral, L. A. (2007). Evidence for the existence of a robust
25 pattern of prey selection in food webs. *Proceedings of the Royal Society B: Biological Sciences*, 274(1621),
26 1931–1940. <https://doi.org/10.1098/rspb.2007.0571>
- 27 Strydom, T., Dalla Riva, G. V., & Poisot, T. (2021). SVD Entropy Reveals the High Complexity of Ecological
28 Networks. *Frontiers in Ecology and Evolution*, 9. <https://doi.org/10.3389/fevo.2021.623141>
- 29 Thompson, R. M., Brose, U., Dunne, J., Hall, R. O., Hladyz, S., Kitching, R. L., Martinez, N. D., Rantala,
30 H., Romanuk, T. N., Stouffer, D. B., & Tylianakis, J. M. (2012). Food webs: Reconciling the structure
31 and function of biodiversity. *Trends in Ecology & Evolution*, 27(12), 689–697. <https://doi.org/10.1016/j.tree.2012.08.005>
- 33 Vermaat, J. E., Dunne, J. A., & Gilbert, A. J. (2009). Major dimensions in food-web structure properties.
34 *Ecology*, 90(1), 278–282. <https://doi.org/10.1890/07-0978.1>
- 35 Williams, R. J., & Martinez, N. D. (2004). Limits to Trophic Levels and Omnivory in Complex Food Webs:
36 Theory and Data. *The American Naturalist*, 163(3), 458–468. <https://doi.org/10.1086/381964>
- 37 Williams, R. J., & Martinez, N. D. (2008). Success and its limits among structural models of complex food
38 webs. *The Journal of Animal Ecology*, 77(3), 512–519. <https://doi.org/10.1111/j.1365-2656.2008.01362.x>

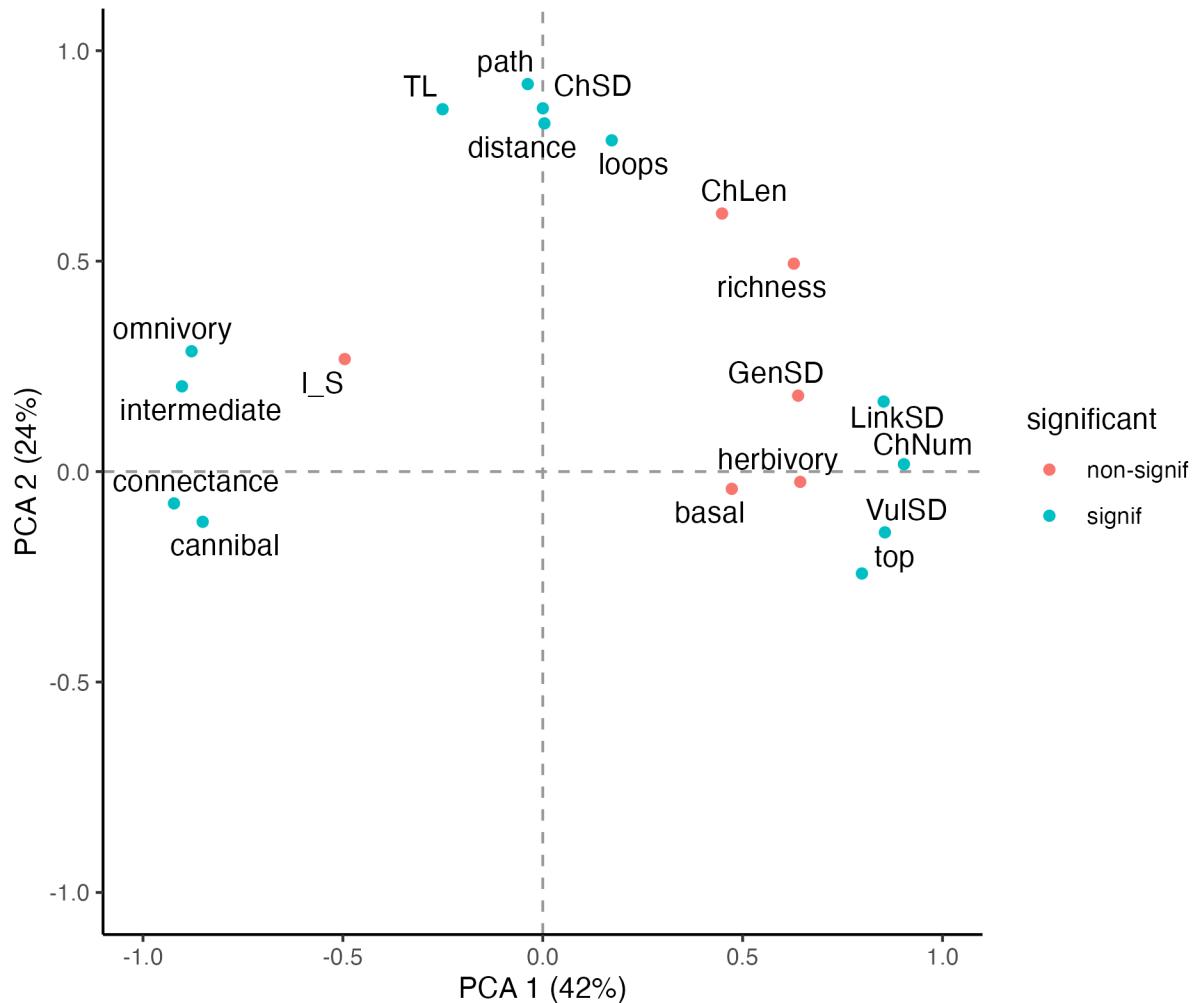


Figure 1: VERMAAT networks only

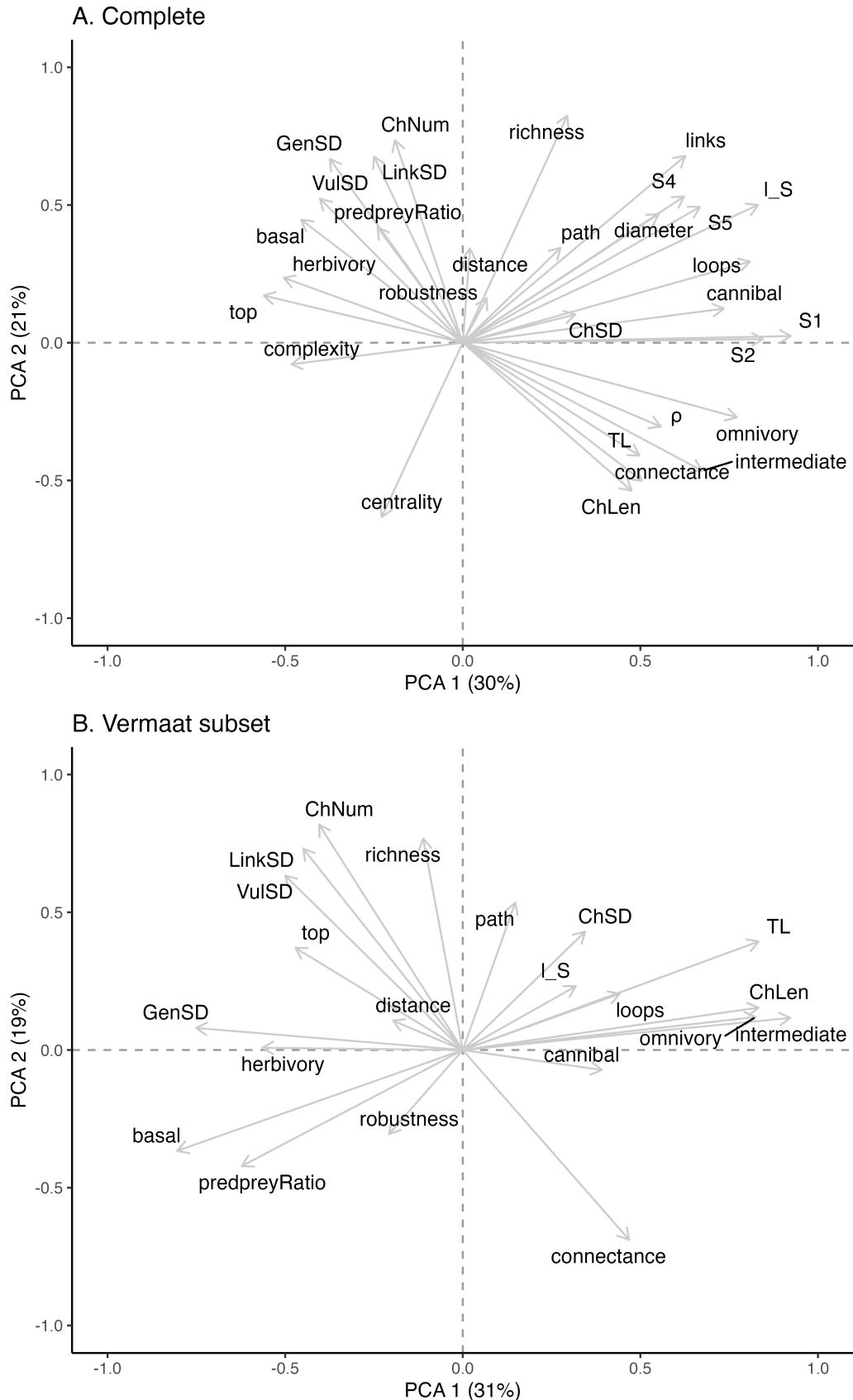


Figure 2: All networks. Vermaat subset = using only the structural measures from Vermaat