

Applying a method before its proof of concept: A cautionary tale using inferred food webs

It is well known that biotic and abiotic factors directly influence species' presences and absences as well as their corresponding interactions (Guimarães, 2020). We are thus unsurprised by the sentiment reflected in the findings of Botella et al. (2024), namely, that land-use intensity alters food web structure. However, we respectfully challenge (1) the appropriateness of their novel inferred network methodology to test their hypotheses; and (2) the Authors' interpretation of their results to support their conclusions. Like many before us, we also advocate for establishing appropriate benchmarks to distinguish statistically significant relationships from those that are substantively significant.

Since collecting empirical species interaction data across space is extremely costly and difficult, less burdensome methods to build food webs using readily available data are potentially transformative for studying ecological communities (Morales-Castilla et al., 2015). These methods are perhaps particularly valuable when trying to ensure conservation actions lead to desired outcomes when only scant empirical information regarding prioritized communities are available (Brimacombe et al., 2021).

In their study, Botella et al. (2024) introduced a novel inferential food web method to investigate whether land-use intensity influences tetrapod ecological community structure across Europe. Their approach relies on an already constructed hypothetical food web called a *metaweb*, which contains all species under investigation and all reported species interactions that have occurred between them, collated from “expert knowledge, published information and field guides” (O'Connor et al., 2020). Simply put, the Authors built a total of 67,051 tetrapod local food webs across Europe—one food web for each 1 km × 1 km grid cell—by assuming tetrapod species interact if (i) both species were previously recorded present, for example via citizen science, at a 1-km² cell (but not necessarily co-occur in time); and (ii) the species also interact in the metaweb. Using the resulting webs—termed *local meta food webs*—the Authors then tested whether their structure is influenced by land-use intensity (i.e., low, medium, high), while accounting for both bioclimatic region (e.g., Atlantic, Mediterranean) and land-use type (e.g., forest, cropland).

Central to the issue of adopting the inferred approach presented in Botella et al. (2024) is if, and how, the resulting local meta food webs are useful for testing ecological hypotheses. Certainly, many inherent assumptions of the tetrapod local meta food webs are unlikely to be met by food webs in reality. For example, while

species interactions are known to be context dependent in nature—for example, species interactions reorganize across time and space (Bartley et al., 2019)—interactions in these tetrapod local meta food webs lack any spatial or temporal dimensions. As well, while empirically derived food webs are not clearly delineated in space (Strydom et al., 2022), these constructed tetrapod local meta food webs are confined to a 1-km² resolution. Moreover, it is a “truism” that species are required to co-occur for trophic interactions to exist (Blanchet et al., 2020), but these tetrapod local meta food webs assume interactions exist even if two species were observed to occur 10 years apart at the same location. Undoubtedly other concerns are left unsaid, yet collectively, the violation of these assumptions severely diminishes the efficacy of this inferred food web methodology, especially if there is no evidence that they can recreate empirical food webs.

Given the concerns above, it is perhaps unsurprising that Botella et al. (2024) found that land-use intensity only contributed, on average, to less than 1% of the total explained variation across each of their tetrapod local meta food web structural metrics (i.e., average $R^2_{\text{Intensity|Use,Climate}} = .007$; from Table 1 and Table S7.3 of Botella et al., 2024). What is surprising is that despite these extremely weak findings, the authors titled their article “Land-use intensity influences European tetrapod food webs” and concluded that “...the architecture of local meta food webs is significantly influenced by land use and management intensity.”

In summary, drawing useful insights on how land-use intensity affects food web structure needs to come from robust data sources and methodologies and be based on sufficient evidence. We do not mean to dissuade researchers from adopting new methods, even in light of their unimpressive performance. For instance, weather prediction would never be as good as it is now, if researchers had not continued to improve upon methods that were unremarkable (Dietze et al., 2018). Rather, we highlight that, first, we must seek meaningful ways to appropriately test these methodologies (Bodner et al., 2021), for example, by comparing inferred food webs with empirical food webs, and second, we must adopt appropriate benchmarks to both evaluate their performance and interpret their outcomes. Ultimately, novel methods are required to tackle complex issues relating to global change, but how we use these methods and derive conclusions from their results, warrant our careful consideration.

Tetrapod local meta food web structural metric description	$R^2_{Climate}$	$R^2_{Use Climate}$	$R^2_{Intensity Use,Climate}$	R^2_{All}
Ratio of species that are apex predators in local meta food web that are also apex predators in metaweb	.163	.034	.008	.198
Ratio of species that are basal in local meta food web that are also basal in metaweb	.032	.046	.007	.083
Ratio of species that are basal in local meta food web	.042	.032	.007	.078
Interaction density in local meta food web	.009	.019	.007	.034
Ratio of general omnivore species among non-basal and non-top species in local meta food web	.024	.008	.004	.037
Mean standard deviation of prey trophic levels of the non-basal and non-top species in local meta food web	.069	.025	.004	.097
Max length across shortest paths from basal to apex species in local meta food web	.015	.030	.007	.052
Mean length across shortest paths from basal to apex species in local meta food web	.018	.045	.009	.071
Standard deviation of lengths across shortest paths from basal to apex species in local meta food web	.019	.030	.007	.055
Modularity: A measure of species to form distinct groups (i.e., interact more) in local meta food web	.007	.012	.009	.027
Mean path distance across species pairs in the undirected transform of the local meta food web	.002	.008	.004	.014
Average	.036	.026	.007	.068

TABLE 1 Coefficient of determination (R^2) and coefficient of partial determination (R^2_{\dots}) of the multivariate linear regression for explaining each of the 11 tetrapod local meta food web metrics used by Botella et al. (2024). R^2_{\dots} reflects the additional variation explained by the explanatory variable on the left hand side of that is not explained by the variable(s) on the right hand side of . Explanatory variables were nested and included bioclimatic region, land-use type, and land-use type intensity (i.e., local meta food web structural metric ~ bioclimatic region/land-use type/intensity). $R^2_{Climate}$ and R^2_{All} reflect the proportion of variation explained using bioclimatic region and all nested explanatory variables, respectively. This is a reproduction of Table S7.3 from Botella et al. (2024).

AUTHOR CONTRIBUTIONS

Chris Brimacombe: Conceptualization; methodology; writing – original draft; writing – review and editing. **Korryn Bodner:** Methodology; writing – original draft; writing – review and editing. **Marie-Josée Fortin:** Funding acquisition; supervision; writing – review and editing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no data sets were generated or analyzed during the current study.

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