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Moving beyond semantics: Advancing restoration with food web approaches

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> "Sciences generate jargon. This specialized terminology is necessary to express complex and novel ideas clearly and succinctly, but terminology often becomes a linguistic barrier around the science, protecting its practitioners from too close a scrutiny by the public or other scientists and providing the camaraderie offered by a common, but private, language."
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> -R. H. Peters, "*A Critique for Ecology*"

Peters' (1991) incisive assessment of weaknesses characterizing the field of ecology continues to frame many of the challenges faced by practitioners today. A theme of Peters' book is that ambiguities in semantics limit progress in the field and constrain the utility of ecology as a predictive science. He writes in another chapter, "As a result, ecological classifications, ecological characteristics and ecological relationships may refer to phenomena that vary with each change in focus, scale, or author, and ecologists are often not sure they are talking about the same thing." A term in ecology may mean many things to people and, conversely, many different terms refer to the same conceptual idea or construct. Such semantical considerations were forefront as this Virtual Special Issue (VSI) was compiled: "Restoration Initiatives Viewed Through a Lens of Food Web Structure and Dynamics."

From one perspective, singular definitions of "restoration" and "food webs" do not matter. If a researcher conducts any aspect of "food web" ecology, and it is useful in any aspect of "restoration," then all the better, regardless of what connotation of food webs is being applied. On the other hand, words do matter. When they lack specificity, their usefulness is diminished. Some terms conflate so many meanings to become vacuous, or terms may be used widely in ways in which they were not originally intended. Take a word that is ubiquitous in public discourse —"literally." This word has come to mean the opposite of what was originally intended. As a trivial example, "That rainbow was so amazing I was literally blown away." The linguistic utility of a word is diminished when it denotes the opposite of its traditional meaning. Our language does call for a word that (literally) means literally, and thus there is a semantical dilemma.

In science, such drifts in meaning can distract from the underlying science that matters. As As an example from contemporary ecology, consider "ecosystem function," especially when its meaning is extended to ecosystem service provision (de Groot et al., 2010). Ecosystem function means numerous things from diverse perspectives and thus frequently defaults to an assumed connotation of "how an ecosystem works." FFFIt is most commonly assumed to denote a process, *e.g.*, Bellwood et al. (2019) define function as movement or storage of energy or material. Yet ecosystem function is used in various ways by researchers, for example, biomass is a common metric even though it it is not a process (unless qualified by a time frame). Semantics, in cases such as this, lead to confusion about the direct application of terms when addressing environmental challenges. Similar confusion can be found for other terminology commonly used in environmental problem-solving, such as for communities (Stroud et al., 2015), species interactions (Nakazawa, 2020), and ecosystem health (O'Brien et al., 2016).

It follows that there is a fundamental need for specificity in language when *writing* about science, yet semantics also should not constrain how we approach *doing* science. We should blur semantics when doing so allows us to bridge across disciplinary boundaries, providing for insights that otherwise would not be obtainable. For example, predation risk is not a food web concept in a strict sense, as it (by definition, see Peacor et al., 2020) does not encompass direct trophic links. Yet, it does reflect the evolutionary and ecological aspects of trophic relationships that are important. Likewise, predation-risk conceptualizations may not be designed for assessing food webs in restoration projects *per se*, but they can be a useful construct to that end (Beschta et al., 2020; Brown et al., 2020). Such conceptual and practical bridges are especially important in restoration ecology, as it is a decentralized field that "links biological and ecological sciences, social sciences, engineering, economics, health sciences, traditional ecological knowledge, ethics, politics, climate change science, and more" (quoted from James Aronson, *pers. comm.*).

Food webs and associated trophic approaches are increasingly applied to directly inform restoration projects, as is summarized by Loch et al. (2020). Authors in this VSI were given the latitude to consider restoration and food webs as they chose (and that is why no specific definitions are given in this essay), provided that they (1) described why/how the project was carried out in a restoration context and (2) operationalized the aspects of food web structure/dynamics employed. This resulted in diverse contributions with food web conceptual frameworks, methodologies, and measurable entities that can be applied to

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inform ecological restoration theory and practice. The papers relate to aspects of population, community, and ecosystem ecology and reveal key insights into applied ecology topics such as fishery management (Bieg and McCann, 2020), dam removals (McCaffery et al., 2020), species re-introductions (Bamber et al., 2020), and coastal zone management (Brown et al., 2020; Plumlee et al., 2020).

The key theme that emerged from the compilation was how food web tools and perspectives provide foresight and focus to improve goal-setting for restoration planning, and a means for adequate monitoring and evaluation. Perhaps Whitney et al. (2020) best illustrates this when providing comprehensive watershed assessments that can be used for river restoration planning. Using a dynamic food web model that integrated physical and ecological conditions of rivers, they showed that some river sites had large increases in modeled fish biomass with restoration, whereas other locations were almost entirely unresponsive—as the structure of the local food webs varied, so too did restoration outcomes. Also in the VSI, traditional food web approaches, such as using stable isotopes (Plumlee et al., 2020) and functional trait-based tools (Ostertag et al., 2020), were applied in novel ways to inform restoration planning.

Other articles highlight emerging tools. Foster et al. (2020) used DNA metabarcoding to assess community dynamics of arthropods. They showed that this tool can be used to examine species composition across trophic levels and infer food web structure, which then can be a useful guide for planning restoration efforts. Moore et al. (2020) assessed oyster restoration using parasite diversity—an understudied, yet a fundamental, component of food webs. They demonstrated that parasite responses to restoration can occur quickly and are sensitive to site-specific environmental characteristics, thus providing an alternative tool to assess restoration. Mazón (2020) also utilize parasites, raising larvae in the lab to back-assess patterns of parasite diversity of forest plots at different stages of restoration. Brown et al. (2020) used remotely-operated vehicles to reveal insights into species interactions, drawing on behavioral ecology to potentially inform marine restoration projects.

Several papers in the VSI call for broader application of underutilized food web approaches in restoration. For example, Layman and Rypel (2020) point out how secondary production, an integrative metric that necessarily encompasses trophic interactions, is underutilized in restoration studies. A literature search revealed a strong aquatic bias applying secondary production, suggesting scope of application remains for terrestrial systems. Secondary production may simplify the assessment of restoration as it is a composite metric representing many aspects of ecosystem structure and function, thereby obviating the need to quantify various population-, community-, and ecosystem-level metrics individually. Ladd and Shantz (2020) show that trophic relationships in coral reef restorations provide key insights into coral reef restoration design. Rather than considering trophic interactions as specified response variables of restoration, researchers can better use trophic ecology to craft desired restoration outcomes.

There is great promise in using food web tools to inform ecological restoration. When we allude to restoration and food webs, we should be explicit about how we are applying both these concepts in practice. Yet, we should not allow historical or traditional connotations of these terms to constrain interdisciplinary approaches in applied ecology. We need precise language when we write about restoration, yet semantics should not constrain how we carry it out. Some of the most pressing global environmental problems necessitate creative approaches and perspectives—semantics should not constrain these efforts.

Declaration of Competing Interest

There are no conflicts of interest concerning our article.

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References

Bamber, J.A., Shuttleworth, C.M., Hayward, M.W., Everest, D.J., 2020. Reinstating trophic cascades as an applied conservation tool to protect forest ecosystems from invasive grey squirrels (*Sciurus carolinensis*). Food Webs 25, e00164.

Bellwood, D.R., Streit, R.P., Brandl, S.J., Tebbett, S.B., 2019. The meaning of the term 'function' in ecology: a coral reef perspective. Funct. Ecol. 33, 948–961.

Beschta, R.L., Ripple, W.J., Kauffman, J.B., Painter, L.E., 2020. Bison limit ecosystem recovery in northern Yellowstone. Food Webs 23, e00142.

Bieg, C., McCann, K.S., 2020. Fisheries restoration potential: optimizing fisheries profits while maintaining food web structure. Food Webs 25, e00168.

Brown, C.M., Paxton, A.B., Taylor, J.C., Van Hoeck, R.V., Fatzinger, M.H., Silliman, B.R., 2020. Short-term changes in reef fish community metrics correlate with variability in large shark occurrence. Food Webs 24, e00147.

de Groot, R., Fisher, B., Christie, M., Aronson, J., Braat, L., Haines-Young, R., Gowdy, J., Maltby, E., Neuville, A., Polasky, S., Portela, R., Ring, I., 2010. Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In: Kumar, P. (Ed.), TEEB Foundations: The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, London and Washington DC, pp. 9–40.

Foster, J.G., Ploughe, L.W., Akin-Fajiye, M., Singha, J.P., Bottos, E., Van Hamme, J., Fraser, L.H., 2020. Exploring trophic effects of spotted knapweed (Centaurea stoebe L.) on arthropod diversity using DNA metabarcoding. Food Webs 24 e00157.

Ladd, M.C., Shantz, A.A., 2020. Trophic interactions in coral reef restoration: a review Food Webs. 24, e00149.

Layman, C.A., Rypel, A.L., 2020. Secondary Production Is an Underutilized Metric to Assess Restoration Initiatives (Food Webs).

Loch, J.M.H., Walters, L.J., Cook, G.S., 2020. Recovering trophic structure through habitat restoration: a review. Food Webs 25, e00162.

Mazón, M., Jiménez, M.D.C., Reátegui, J., Donos, D.A., 2020. Tritrophic Web Structure in Montane Andean Forests Undergoing Ecological Restoration (Food Webs).

McCaffery, R., Jenkins, K.J., Cendejas-Zarelli, S., Happe, P.J., Sager-Fradkin, K.A., 2020. Small mammals and ungulates respond to and interact with revegetation processes following dam removal. Food Webs 25, e00159.

Moore, C.S., Gittman, R.K., Puckett, B.J., Wellman, E.H., Blakesee, A.M.H., 2020. If you build it, they will come: restoration timing and design influence free-living and parasite diversity in a restored tidal marsh. Food Webs 25, e00167.

Nakazawa, T., 2020. Species interaction: revisiting its terminology and concept. Ecol. Res. 8.

O'Brien, A., Townsend, K., Hale, R., Sharley, D., Pettigrove, V., 2016. How is ecosystem health defined and measured? A critical review of freshwater and estuarine studies. Ecol. Indic. 69, 722–729.

Ostertag, R., Sebastián-González, E., Peck, R., Hall, T., Kim, J., DiManno, N., Rayome, D., Cordell, S., Banko, P., Uowolo, A., 2020. Linking Plant and Animal Functional Diversity with an Experimental Community Restoration in a Hawaiian Lowland Wet Forest (Food Webs).

Peacor, S.D., Barton, B.T., Kimbro, D.L., Sih, A., Sheriff, M.J., 2020. A framework and standardized terminology to facilitate the study of predation-risk effects. Ecology, e03152 In Press.

Peters, R.H., 1991. A Critique for Ecology. Cambridge University Press, Cambridge.

Plumlee, J.D., Yeager, L.A., Fodrie, F.J., 2020. Role of saltmarsh production in subsidizing adjacent seagrass food webs: implications for landscape-scale restoration. Food Webs 24, e00158.

Stroud, J.T., Bush, M.R., Ladd, M.C., Nowicki, R.J., Shantz, A.A., Sweatman, J., 2015. Is a community still a community? Reviewing definitions of key terms in community ecology. Ecol. Evol. 5, 4757–4765.

Whitney, E.J., Bellmore, J.R., Benjamin, J.R., Jordan, C.E., Dunham, J.B., Newsom, M., Nahorniak, M., 2020. Beyond sticks and stones: integrating physical and ecological conditions into watershed restoration assessments using a food web modeling approach. Food Webs 25, e00160.