

19 June 2019

Dear Dr. Bronwyn Wake:

Please consider our manuscript ‘Trophic phenological mismatch: Disconnects between underlying theory and climate change responses’ as a Review Article in *Nature Climate Change*. As this article is unsolicited, we briefly outline our manuscript here.

Phenological mismatch—the consequences of shifts in the timing of species interactions—is an expanding area of research critical to predicting the consequences of climate change for communities and ecosystems. However, after decades of theoretical (1,2) and empirical studies (3,4), from single systems (5,6) and meta-analyses (7,8), there is little consensus. To date, most research has failed to identify repeatable patterns across systems. Previous reviews have focused on putting forward additional hypotheses about the context in which phenological mismatch will occur (9-11). Yet, we still have no general ability to predict the outcomes of shifts in phenological synchrony due to climate change.

This manuscript proposes this failure is due to a disconnect between the underlying ecological theory (i.e., match-mismatch hypothesis) and the phenological responses to climate change currently documented. We argue that there are two key theoretical areas that make it difficult to determine whether the match-mismatch hypothesis is widely supported in the context of climate change: studies often fail to rigorously test the hypothesis and/or test pre-climate change conditions. To put our argument in context, we systematically reviewed the phenological mismatch literature and examined 43 observational studies. In our discussion of these areas we:

1. Review the diverse array of potential mechanisms underlying the match-mismatch hypothesis.
2. Show how the type of data currently collected by researchers testing or applying the mismatch hypothesis in the context of climate change rarely provides a strong test of the hypothesis.
3. Show how baselines—which are rarely defined—are critical to mechanistic understanding and robust predictions.
4. Highlight how new approaches that emphasize the underlying theory can move the field forward.

**Novelty:** While the context in which phenological mismatch will occur has been reviewed extensively elsewhere, most recently by Visser and Gienapp (11), our manuscript is the first to highlight the data-theory discrepancy on the topic of phenological mismatch. By doing so, we believe our paper will help shape the future path of the field and help improve forecasts of the impacts of climate change on ecological communities—the ultimate goal of most of the phenological mismatch literature. It will also provide the framework for building the required depth in evidence across studies to determine general quantitative patterns and their underlying mechanisms, an approach not currently possible given the current state of the field.

This paper is authored by experts on phenological synchrony and phenological methods who bring a combined 20 years of experience in this area (8, 12-14).

I hope that you will find it suitable to submit to *Nature Climate Change*, and look forward to hearing from you.

Sincerely,

Heather Kharouba & Elizabeth Wolkovich

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