THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Forestry

Dear Dr. Surridge:

Please consider our paper, "Woody plant phenological responses are strongly associated with key functional traits" for publication as a research article in *Nature Plants*.

Climate change is impacting species phenologies—timing of life history events—altering ecosystem services and community composition[1–3]. But predicting these changes is challenging, as it requires an understanding of phenological drivers at a proximate scale—cues like temperature and daylength—and the ultimate scale at which long-term environmental pressures can produce species differences[4,5]. Variation in cues may also produce gradients in species growth strategies and traits, with some species exhibiting traits associated with acquisitive growth that are favourable under abiotically stressful spring conditions, while late season species exhibit more conservative traits that confer a greater tolerance to competition. The extension of existing trait frameworks to include phenology is intuitive, but it has often been excluded from trait studies as it is highly variable across temporal and spatial ranges. The relationships between phenology and broader trait syndromes are thus largely unknown, despite it being a critical trait to forecast future community dynamics.

Here we combined data of experimental budburst phenology and plant traits, with cutting-edge Bayesian approaches, jointly modelling budburst cues in relation to other key traits. Our dataset represents one of the most comprehensive datasets of trait syndrome available, making it an important first step to identify general trends that scale across populations and species. Further, by using a joint modelling approach, we are the first to identify broader trait relationships to phenological cues based on species-level trait variation, while also accounting for the high degree of uncertainty that arises when combining datasets of diverse communities.

Our findings demonstrate how traits and phenologies are inextricably linked to varying strategies for growth, as we found earlier species to exhibit acquisitive traits—like short heights, and denser, lower nitrogen leaves—while later-active species were taller with low nitrogen leaves. This indicates that spring leafout phenology does fit within the functional trait framework of acquisitive to conservative growth strategies.

By including phenology in the existing trait framework, we can tease apart the underlying mechanisms shaping species phenology and traits across communities. These relationships provide novel insights that can be used to better predict how communities may shift in their growth strategies alongside changing phenology with climate change. Our work highlights the complexity of interactions shaping plant phenotypes, and represents a more holistic approach that can better forecast future changes in community assembly and productivity.

All authors contributed to this work and approved this version for submission. The manuscript is XXX words with a ZZZ word summary, and X figures. It is not under consideration elsewhere. We hope you find it suitable for publication in *Nature Plants*, and look forward to hearing from you.

We recommend the following reviewers: Dr. Angela Moles, Dr. Daniel. C. Laughlin, Dr. Maria Sporbert, Dr. Lee E. Frelich.

Sincerely,

Deirdre Loughnan

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Forest & Conservation Sciences
University of British Columbia

References

[1] Cleland, E. E., Chuine, I., Menzel, A., Mooney, H. A., and Schwartz, M. D. Shifting plant phenology in response to global change. *Trends in Ecology and Evolution* **22**(7), 357–365 (2007).

[2] Beard, K. H., Kelsey, K. C., Leffler, A. J., and Welker, J. M. The Missing Angle : Ecosystem Consequences of Phenological Mismatch. *Trends in Ecology and Evolution* **34**(10), 885–888 (2019).

[3] Gu, H., Qiao, Y., Xi, Z., Rossi, S., Smith, N. G., Liu, J., and Chen, L. Warming-induced increase in carbon uptake is linked to earlier spring phenology in temperate and boreal forests. *Nature Communications* **13**(3698), 1–8 (2022).

[4] Ovaskainen, O., Skorokhodova, S., Yakovleva, M., Sukhov, A., Kutenkov, A., Kutenkova, N., Shcherbakov, A., Meyke, E., and del Mar Delgado, M. Community-level phenological response to climate change. *PNAS* **110**(33), 13434–13439 (2013).

[5] Wolkovich, E. M. and Donahue, M. J. How phenological tracking shapes species and communities in non-stationary environments. *Biological Reviews* **96**, 2810–2827 (2021).