Received: 4 August 2024 | Revised: 19 August 2024 | Accepted: 21 August 2024

DOI: 10.1111/gcb.17497

RESPONSE

Global Change Biology WILEY

The influence of habitat alteration is widespread, but the impact of climate cannot continue to be discounted

Melanie Dickie[1,2,3] | Robert Serrouya[1,3] | Marcus Becker[1] | Craig DeMars[1,3] | Michael J. Noonan[2,4,5] | Robin Steenweg[6] | Stan Boutin[7] | Adam T. Ford[2,3]

[1]Alberta Biodiversity Monitoring Institute, University of Alberta, Edmonton, Alberta, Canada
[2]Department of Biology, University of British Columbia, Kelowna, British Columbia, Canada
[3]Wildlife Science Centre, Biodiversity Pathways, University of British Columbia, Kelowna, British Columbia, Canada
[4]Okanagan Institute for Biodiversity, Resilience, and Ecosystem Services, The University of British Columbia Okanagan, Kelowna, British Columbia, Canada
[5]Department of Computer Science, Math, Physics, and Statistics, The University of British Columbia Okanagan, Kelowna, British Columbia, Canada
[6]Canadian Wildlife Service—Pacific Region, Environment and Climate Change Canada, Kelowna, British Columbia, Canada
[7]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

Correspondence
Melanie Dickie, Alberta Biodiversity Monitoring Institute, University of Alberta, Edmonton, AB T6G 2E9, Canada.
Email: mvezina@ualberta.ca

Funding information
Regional Industry Caribou Collaboration

KEYWORDS
camera traps, climate change, data transformation, effect size, land-use, model inference

Recently, we (Dickie et al., 2024) contrasted the effects of climatic factors and habitat alteration on the density of white-tailed deer, a species implicated in declines of woodland caribou (Latham et al., 2011). Barnas et al. (2024) provided a critique of our study, but misrepresented our overall findings, claiming we reported negligible effects of habitat change on deer. Although we reported stronger climate effects, we repeatedly highlighted that habitat alteration had positive effects on deer density (Appendix S1). Barnas et al. (2024) also suggested a number of putative shortcomings to our study, but we submit that their conclusions are either unfounded or identical to that of Dickie et al. (2024).

Barnas et al. (2024) argue that our method for transforming predictor variables affects model inferences. It does not. Model predictions are identical whether the data are minimum-maximum scaled, or z-standardized as proposed by Barnas et al. (2024). These results are unsurprising given the two transformations yield perfectly correlated data (Figure 1). Barnas et al. (2024) then highlight that coefficients for the single-term predictors differ between the two transformations, with the z-standardization yielding similar effect sizes for climate and habitat alteration. Focusing on these coefficients for inference is misguided when interaction effects are included, because these coefficients are conditional (i.e., estimates when other interaction variables = 0). Estimated slopes for predictors are not invariant; the magnitude, and possibly direction, of slope coefficients change as other interaction variables change (Aiken et al., 1991; Mize, 2019; Spake et al., 2023). Interaction effects are more appropriately evaluated by plotting predicted responses over the range of the focal predictor at meaningful values of the modifying predictor(s) (Mize, 2019; Spake et al., 2023; Figure 1).

Barnas et al. (2024) then suggested our model was overfit, resulting in low precision. To support their claim, Barnas et al. (2024) used an information-theoretic approach and found that a reduced model was supported over our full model. Although information-theoretic approaches are favored for prediction, they are not optimal for causal inference (Bolker, 2024), which was our objective. Our full model reflected our study design, which empirically sampled gradients of climate, habitat alteration, and habitat productivity—factors known *a priori* to influence deer density. Barnas et al. (2024) also suggested

This article is a Response to the Letter by Barnas et al, https://doi.org/10.1111/gcb.17498, which was related to the paper of Dickie et al, https://doi.org/10.1111/gcb.17286.

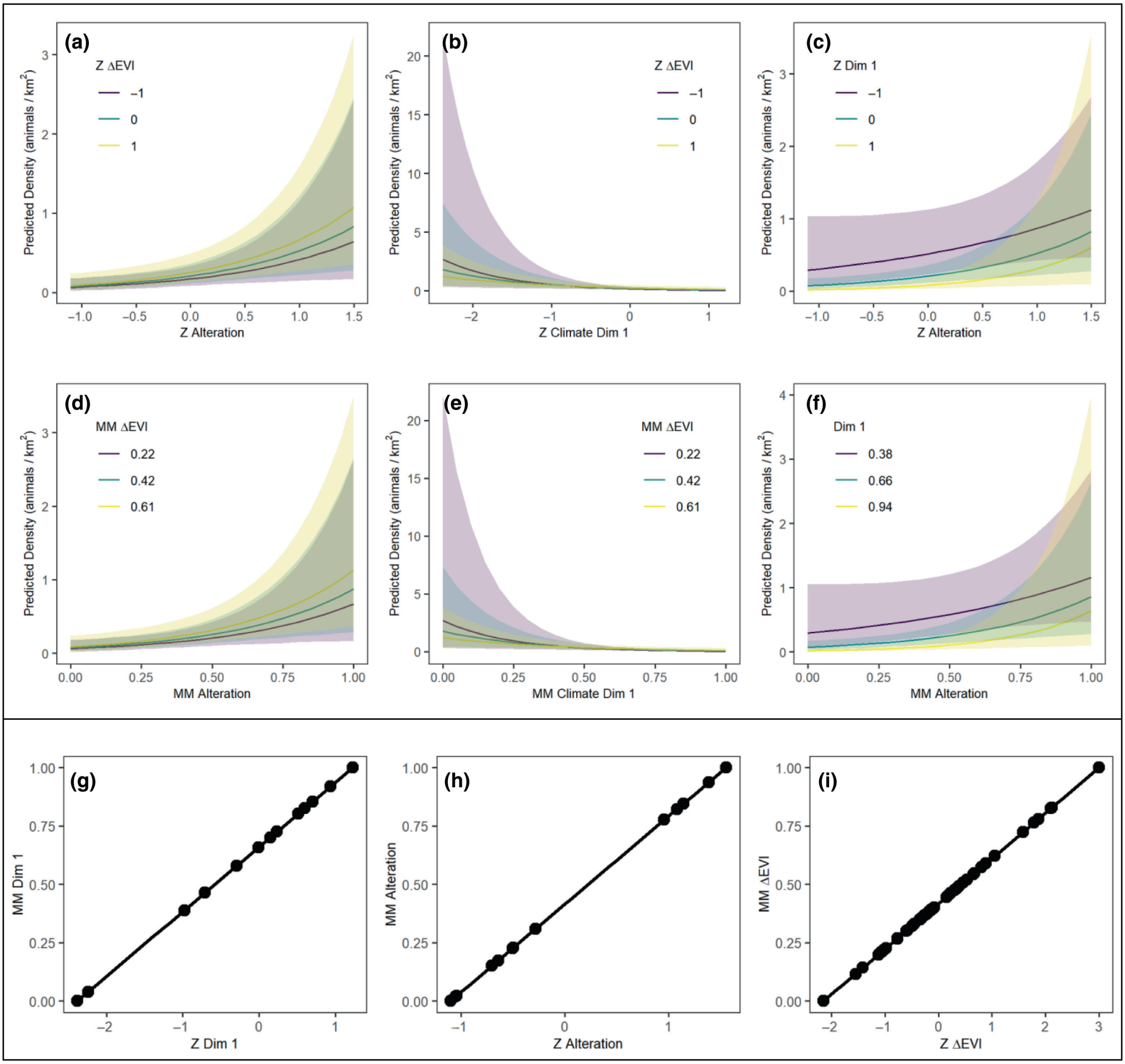

FIGURE 1 Comparison of z-standardization (Z) transformation (panels a–c) and minimum-maximum (MM) scaling (panels d–f) of predictor variables, and resulting impacts on model predictions. Predicted densities of white-tailed deer (animals/km^2) are shown as a function of percent habitat alteration at three levels of habitat productivity (change in the Enhanced Vegetation Index, ΔEVI; panels a, d), climate Dimension 1 (Dim 1), such that winter severity increases as Dim 1 increases, at three levels of habitat productivity (ΔEVI; panels b, e), and habitat alteration at three levels of Dim 1 (panels c, f). Note the y-axis varies across predictor variables, but is consistent across transformations, demonstrating that the estimates and precision are unchanged between the two transformations. The two methods for transforming data yield perfectly correlated and 1: 1 data ($R^2 = 1$ for all combinations; panels g–i), though MM preserves the shape of the raw data. Barnas et al. (2024) contend that our model has overly large standard errors, yet the two transformations yield the same relative precision. MM results in estimates and standard errors that are correspondingly large because they represent a change in the predictor variable from the minimum to the maximum value. In contrast, estimates and standard errors resulting from Z are correspondingly small because a one-unit change in the predictor variable represents only a change of one standard deviation of the predictor.

that our approach of using a single density estimate for each camera cluster contributed to an overfit model. As noted in Dickie et al. (2024), whether we specified each camera as the sample unit or used the collapsed data, our results did not fundamentally change. These outcomes suggest that our inferences are not sensitive to overfitting.

Finally, we submit that even when considering Barnas et al.'s (2024) reduced model, management implications for woodland caribou remain unchanged, despite Barnas et al.'s (2024) unspecified claims to the contrary. Using their reduced model and setting habitat alteration to the minimum observed value, climate is still predicted to support white-tailed deer densities that are incompatible with self-sustaining caribou populations (Appendix S1). As such, habitat protection and restoration alone are unlikely to halt the northward expansion of deer into caribou range, compelling managers to consider the effects of climate change, which are only predicted to increase in coming decades.

AUTHOR CONTRIBUTIONS

Melanie Dickie: Conceptualization; formal analysis; investigation; methodology; writing – original draft; writing – review and editing. **Robert Serrouya:** Conceptualization; formal analysis; supervision; validation; visualization; writing – review and editing. **Marcus Becker:** Writing – review and editing. **Craig DeMars:** Conceptualization; formal analysis; investigation; writing – original draft; writing – review and editing. **Michael J. Noonan:** Formal analysis; writing – review and editing. **Robin Steenweg:** Writing – review and editing. **Stan Boutin:** Writing – review and editing. **Adam T. Ford:** Conceptualization; formal analysis; investigation; supervision; writing – original draft; writing – review and editing.

CONFLICT OF INTEREST STATEMENT

All authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

There are no new data associated with this response.

ORCID

Melanie Dickie https://orcid.org/0000-0003-2177-2352
Michael J. Noonan https://orcid.org/0000-0003-4512-0535

REFERENCES

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Sage Publications.

Barnas, A., Burton, A. C., Kathleen, C., Cote, S. D., Festa-Bianchet, M., Fryxell, J., St. Laurent, M.-H., & Fisher, J. T. (2024). The influence of habitat alteration on density of invading white-tailed deer should not be discounted. *Global Change Biology*, e17498.

Bolker, B. M. (2024). Multimodel approaches are not the best way to understand multifactorial systems. *Entropy*, *26*, 506. https://doi.org/10.3390/e26060506

Dickie, M., Serrouya, R., Becker, M., DeMars, C., Noonan, M. J., Steenweg, R., Boutin, S., & Ford, A. T. (2024). Habitat alteration or climate: What drives the densities of an invading ungulate? *Global Change Biology*, *30*(4), e17286. https://doi.org/10.1111/gcb.17286

Latham, A. D. M., Latham, M. C., McCutchen, N. A., & Boutin, S. (2011). Invading white-tailed deer change wolf–caribou dynamics in northeastern Alberta. *The Journal of Wildlife Management*, *75*, 204–212.

Mize, T. (2019). Best practices for estimating, interpreting, and presenting nonlinear interaction effects. *Sociological Science*, *6*, 81–117. https://doi.org/10.15195/v6.a4

Spake, R., Bowler, D. E., Callaghan, C. T., Blowes, S. A., Doncaster, C. P., Antão, L. H., Nakagawa, S., McElreath, R., & Chase, J. M. (2023). Understanding 'it depends' in ecology: A guide to hypothesising, visualising and interpreting statistical interactions. *Biological Reviews*, *98*(4), 983–1002. https://doi.org/10.1111/brv.12939

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Dickie, M., Serrouya, R., Becker, M., DeMars, C., Noonan, M. J., Steenweg, R., Boutin, S., & Ford, A. T. (2024). The influence of habitat alteration is widespread, but the impact of climate cannot continue to be discounted. *Global Change Biology*, *30*, e17497. https://doi.org/10.1111/gcb.17497