

How resource abundance and unpredictability affect animal movement



Stefano Mezzini – M.Sc. Biol.



THE UNIVERSITY OF BRITISH COLUMBIA
Biology
Irving K. Barber Faculty of Science
Okanagan Campus

Why do animals move?

- Food/nutrients
- Water
- New den/nest
- Mate/group
- And many other reasons...

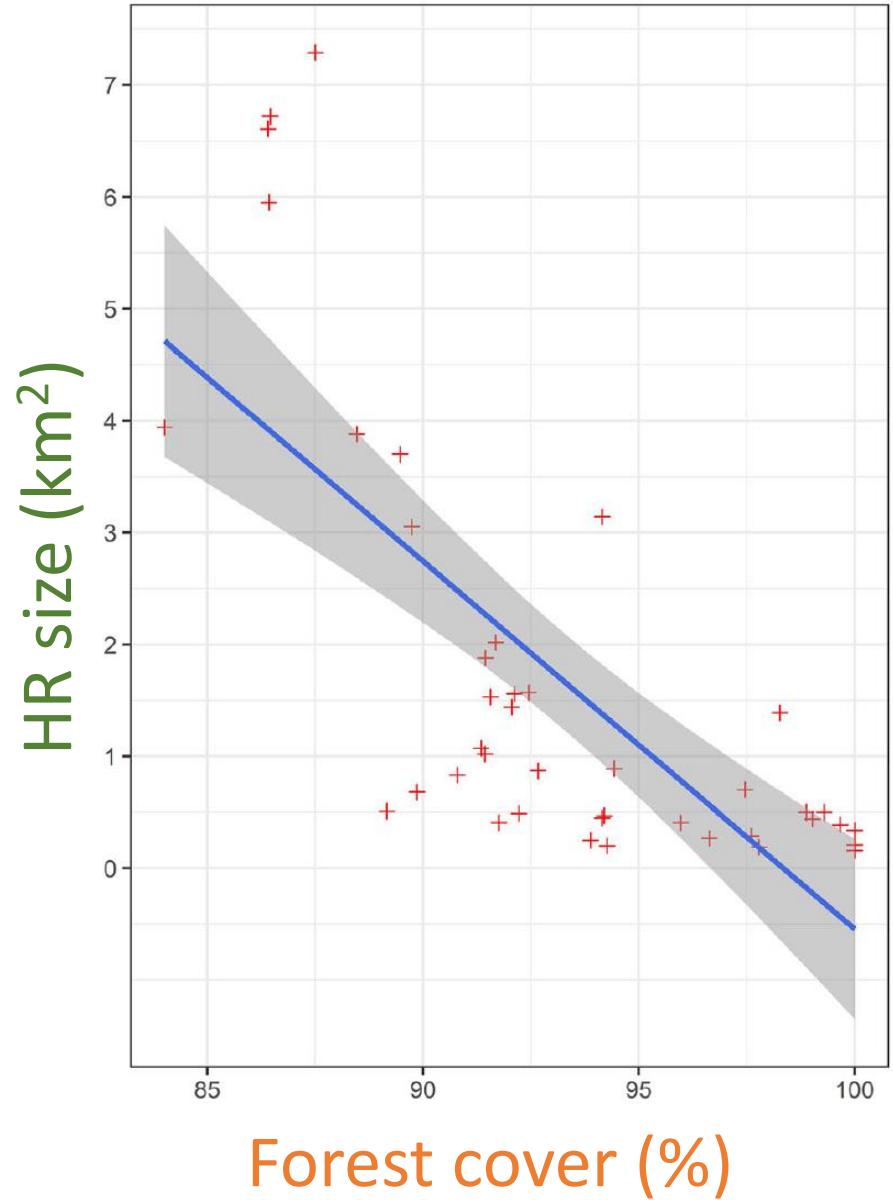
Mother elephant with offspring,
photo by Floodmfx, CC0, via Wikimedia Commons



Use **home range size** as a proxy for all needs

Resource abundance and HR

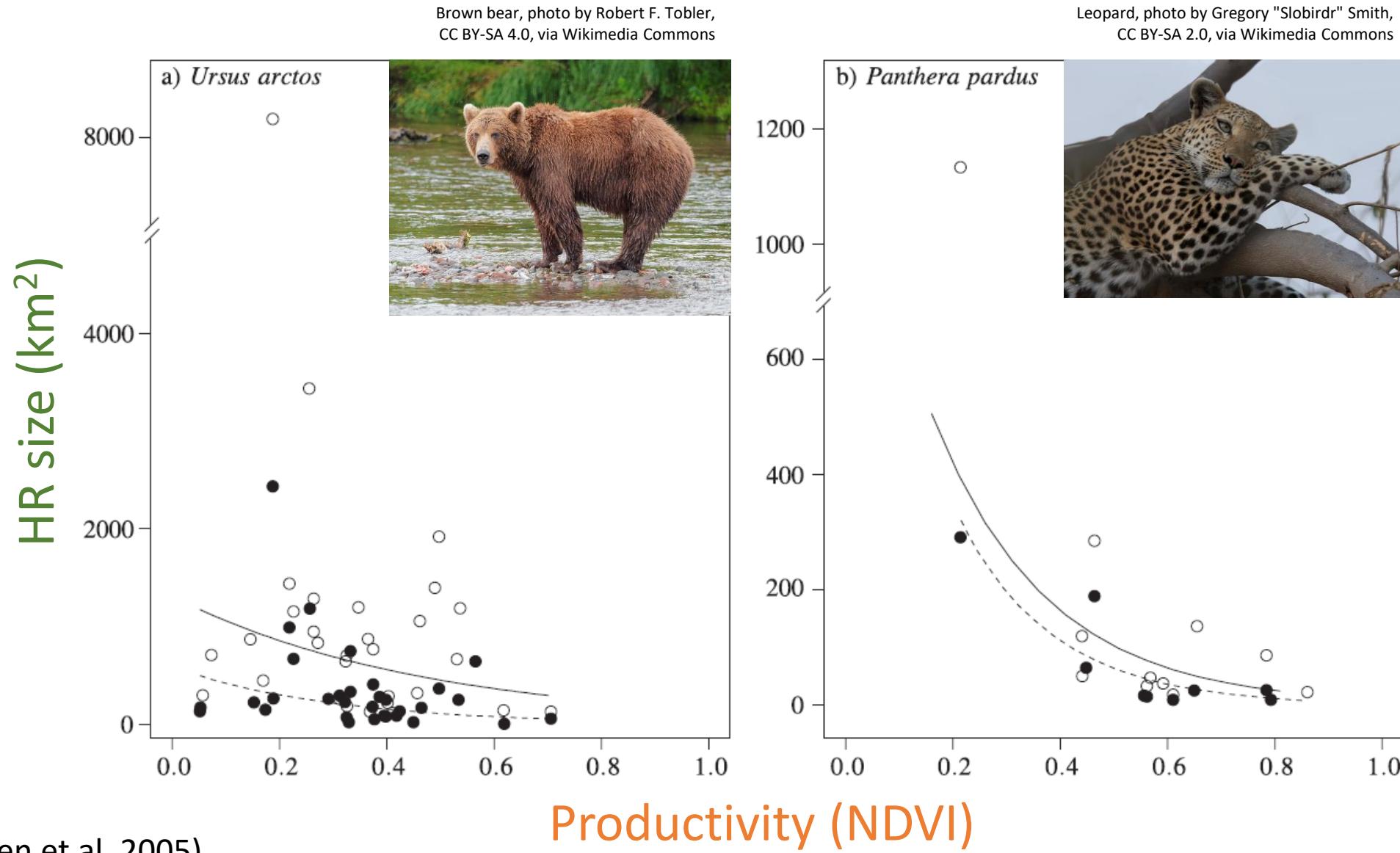
Resource abundance and HR: examples in literature



Red panda,
photo by Brunswyk, CC BY-SA 3.0,
via Wikimedia Commons

(Bista et al. 2022)

Resource abundance and HR: examples in literature



Resource abundance and HR : an abundance of evidence

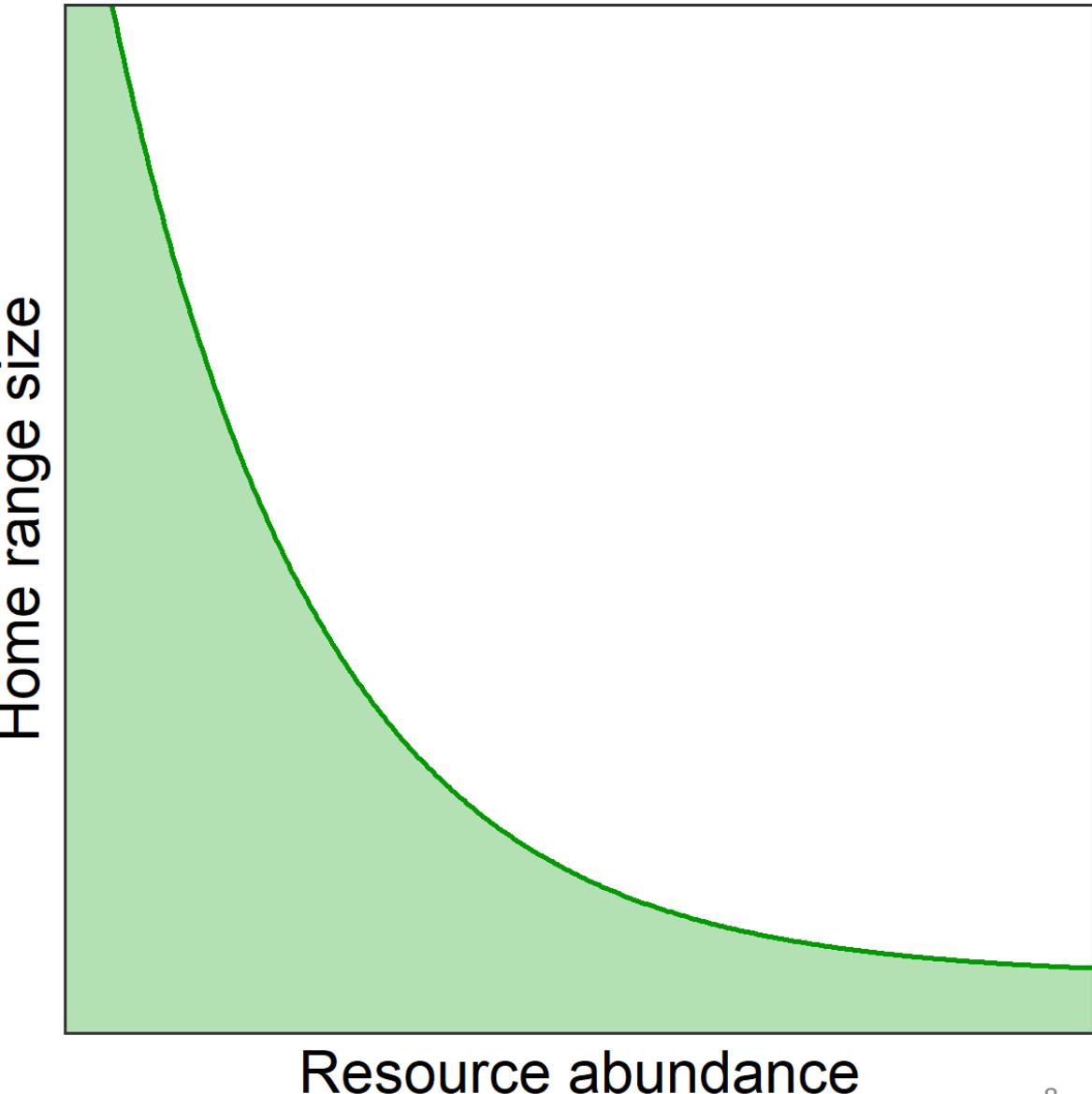
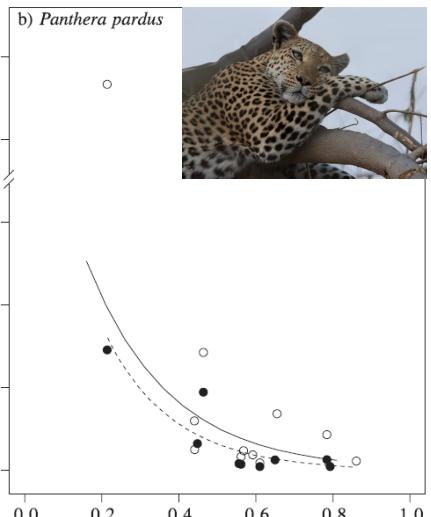
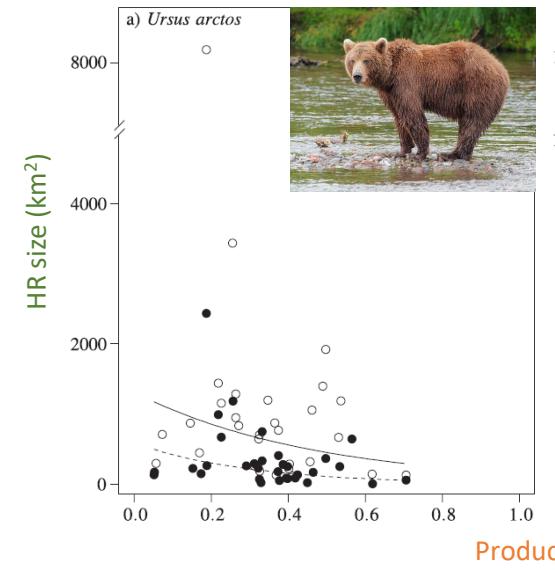
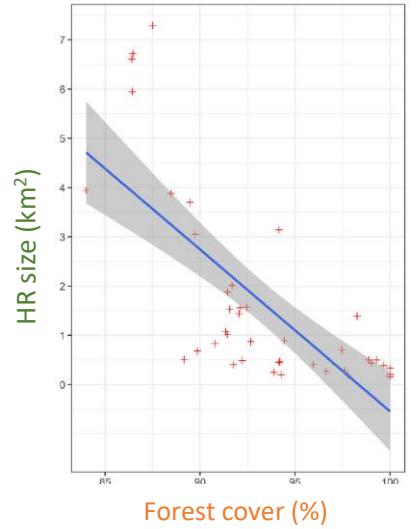
1. Bista, D., G. S. Baxter, N. J. Hudson, S. T. Lama, and P. J. Murray. 2022. Effect of disturbances and habitat fragmentation on an arboreal habitat specialist mammal using GPS telemetry: A case of the red panda. *Landscape Ecology* 37:795–809.
2. Geremia, C., J. A. Merkle, D. R. Eacker, R. L. Wallen, P. J. White, M. Hebblewhite, and M. J. Kauffman. 2019. Migrating bison engineer the green wave. *Proceedings of the National Academy of Sciences* 116:25707–25713.
3. Herfindal, I., J. D. C. Linnell, J. Odden, E. B. Nilsen, and R. Andersen. 2005. Prey density, environmental productivity and home-range size in the Eurasian lynx (*Lynx lynx*). *Journal of Zoology* 265:63–71.
4. Lucherini, M., and S. Lovari. 1996. Habitat richness affects home range size in the red fox *Vulpes vulpes*. *Behavioural Processes* 36:103–105.
5. Nilsen, E. B., I. Herfindal, and J. D. C. Linnell. 2005. Can intra-specific variation in carnivore home-range size be explained using remote-sensing estimates of environmental productivity? *Écoscience* 12:68–75.
6. Relyea, R. A., R. K. Lawrence, and S. Demarais. 2000. Home Range of Desert Mule Deer: Testing the Body-Size and Habitat-Productivity Hypotheses. *The Journal of Wildlife Management* 64:146.
7. Rickbeil, G. J. M., J. A. Merkle, G. Anderson, M. P. Atwood, J. P. Beckmann, E. K. Cole, A. B. Courtemanch, et al. 2019. Plasticity in elk migration timing is a response to changing environmental conditions. *Global Change Biology* 25:2368–2381.
8. Williams-Guillen, K., C. McCann, J. C. Martinez Sanchez, and F. Koontz. 2006. Resource availability and habitat use by mantled howling monkeys in a Nicaraguan coffee plantation: Can agroforests serve as core habitat for a forest mammal? *Animal Conservation* 9:331–338.

...

Resource abundance and HR : common issues

- Results reported as **new findings**
- No **unifying hypotheses**

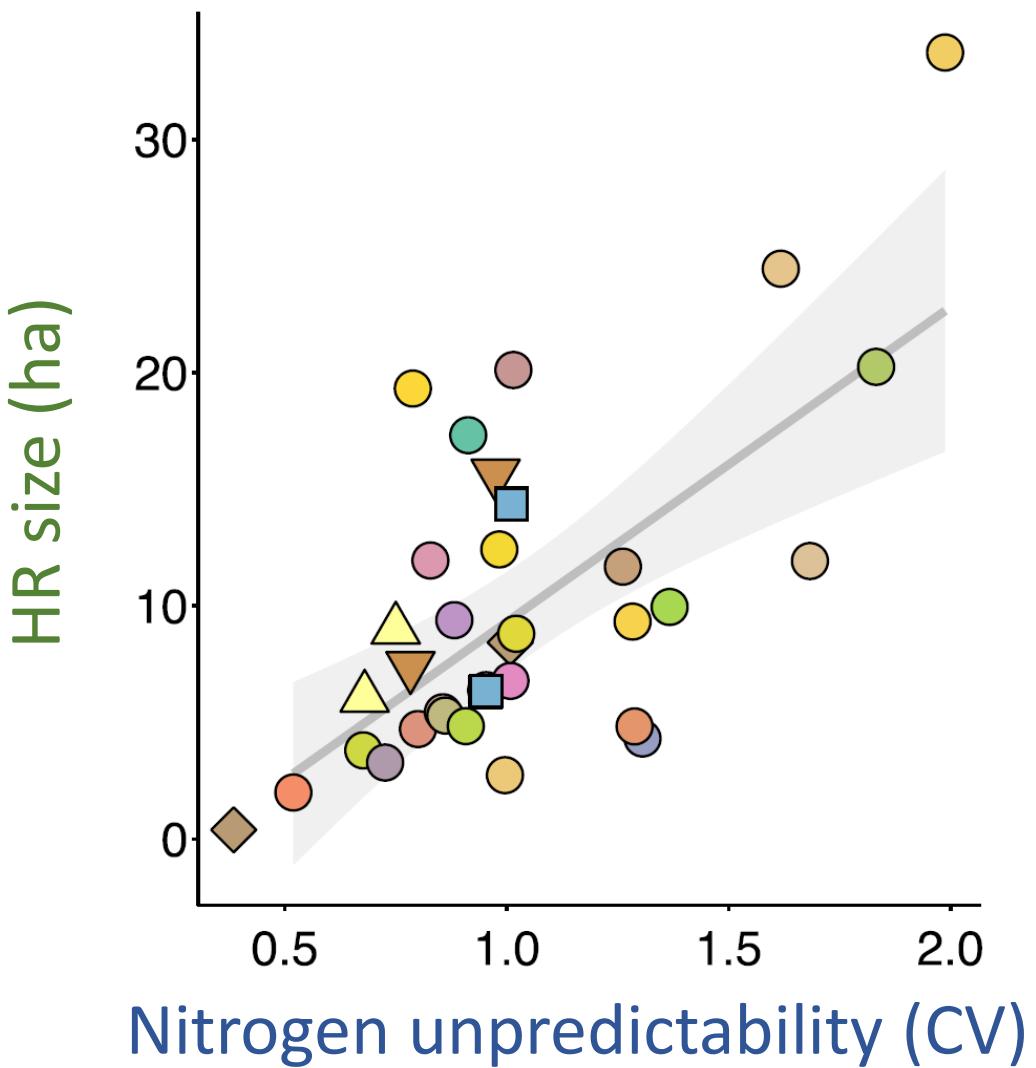
Resource abundance and HR: hypothesis



Resource abundance

Resource unpredictability and HR

Resource unpredictability and HR: examples in literature



(Rizzuto et al. 2021)



Showshoe hares, photos by Walter Siegmund (top) and D. Gordon and E. Robertson (bottom), CC BY-SA 3.0, via Wikimedia Commons

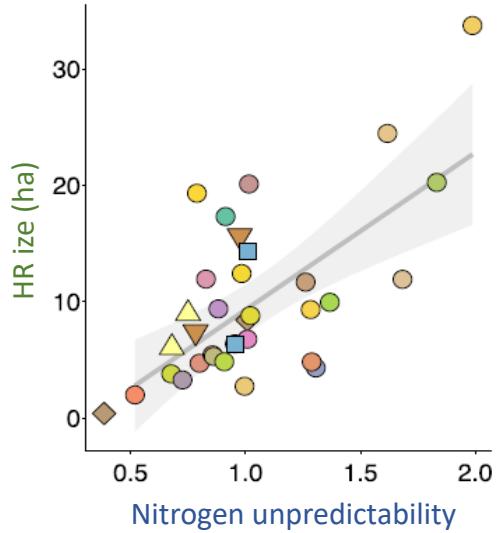
Resource unpredictability and HR : current evidence

1. Herfindal, I., J. D. C. Linnell, J. Odden, E. B. Nilsen, and R. Andersen. 2005. Prey density, environmental productivity and home-range size in the Eurasian lynx (*Lynx lynx*). *Journal of Zoology* 265:63–71.
2. Nilsen, E. B., I. Herfindal, and J. D. C. Linnell. 2005. Can intra-specific variation in carnivore home-range size be explained using remote-sensing estimates of environmental productivity? *Écoscience* 12:68–75.
3. Rizzuto M., Leroux S.J., Vander Wal E., Richmond I.C., Heckford T.R., Balluffi-Fry J., et al. (2021). Forage stoichiometry predicts the home range size of a small terrestrial herbivore. *Oecologia* 197, 327–338.

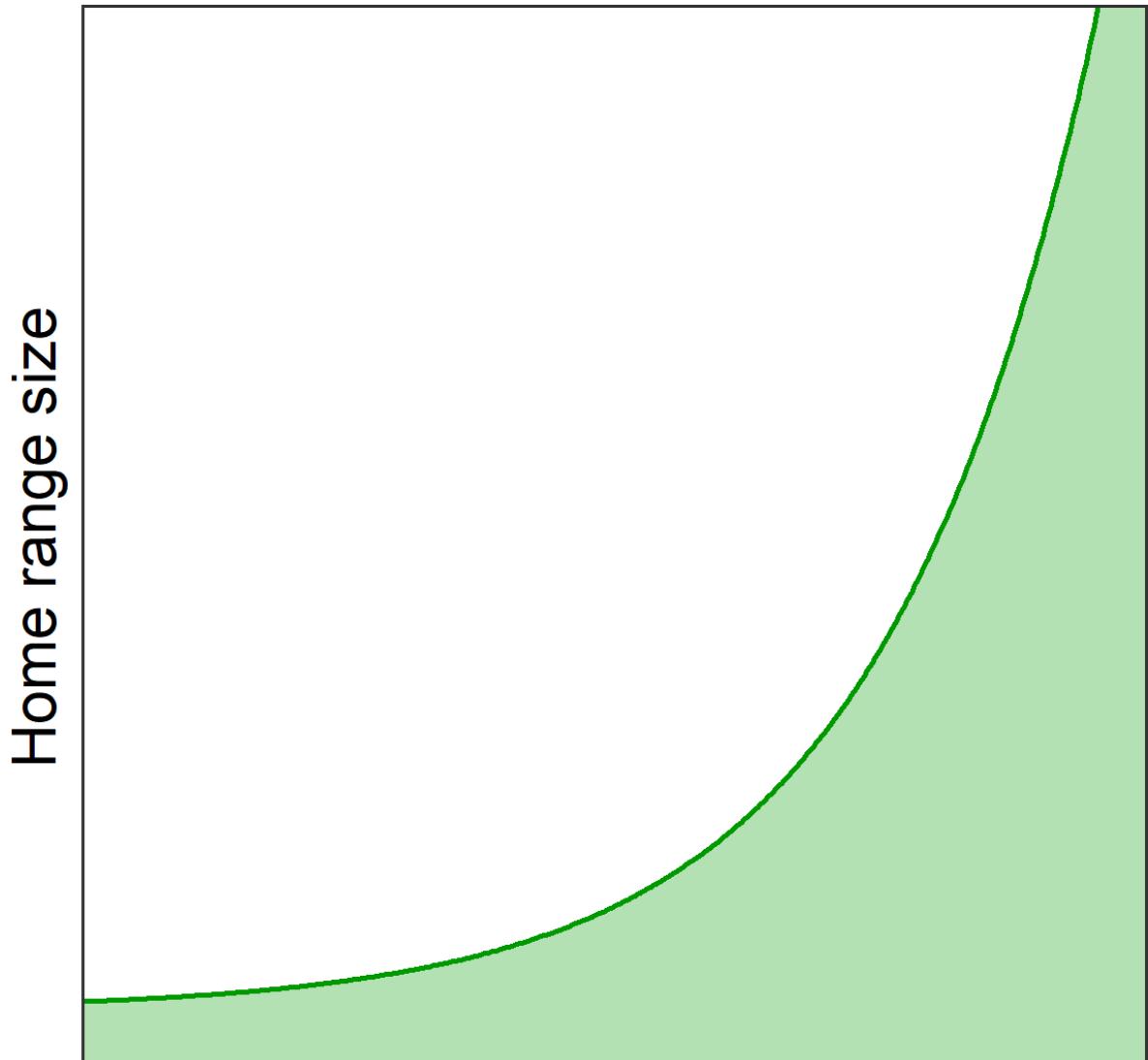
Resource unpredictability and HR: common issues

- Results reported as **new findings**
- No **unifying hypotheses**

Resource unpredictability and HR: a unifying framework

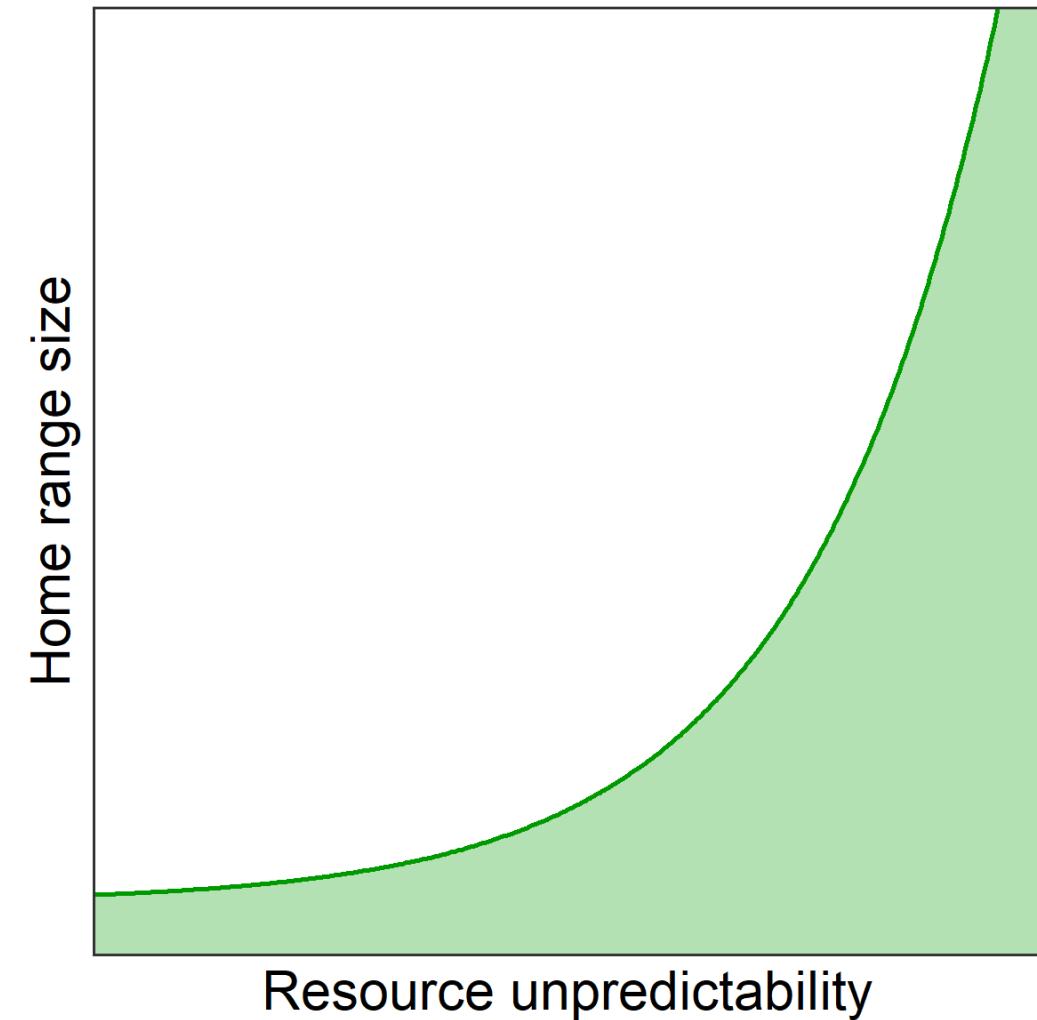
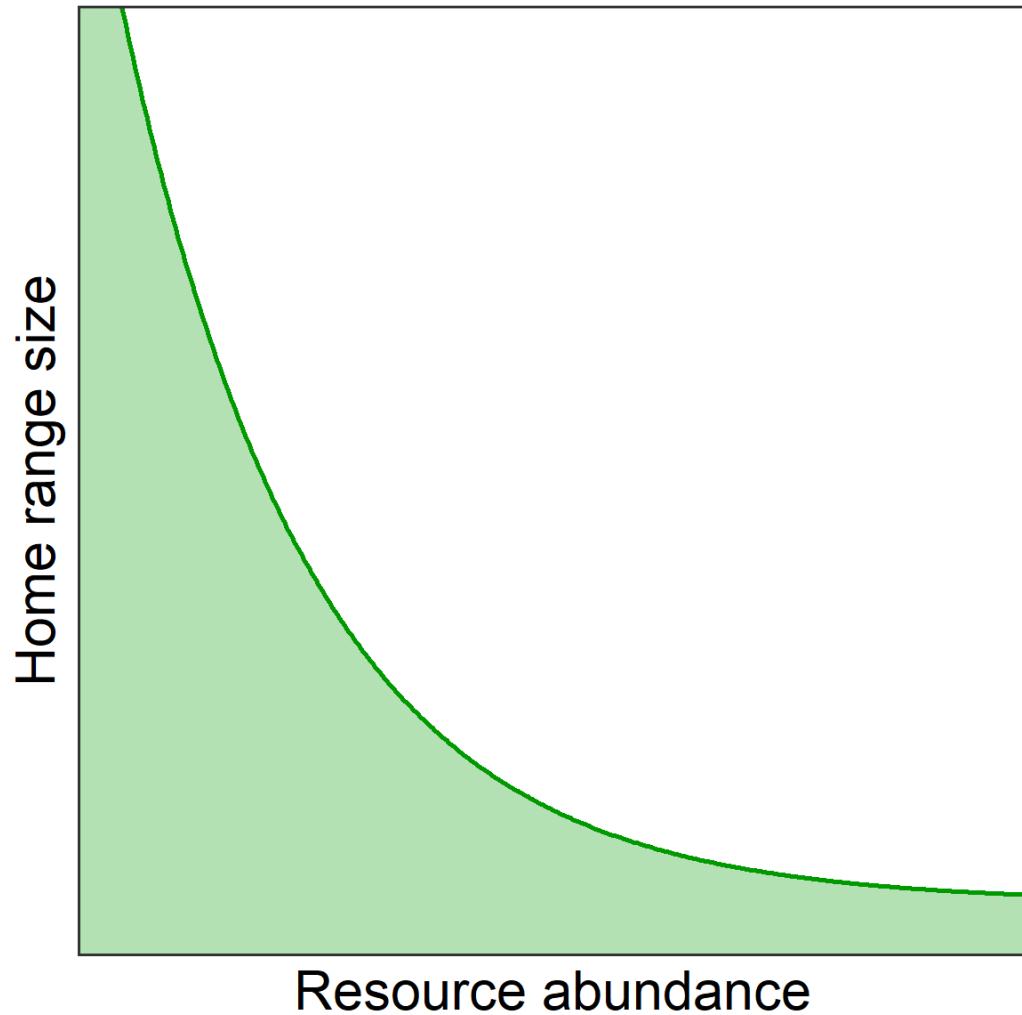


Showshoe hares, photos by D. Gordon and E. Robertson (bottom), CC BY-SA 3.0, via Wikimedia Commons

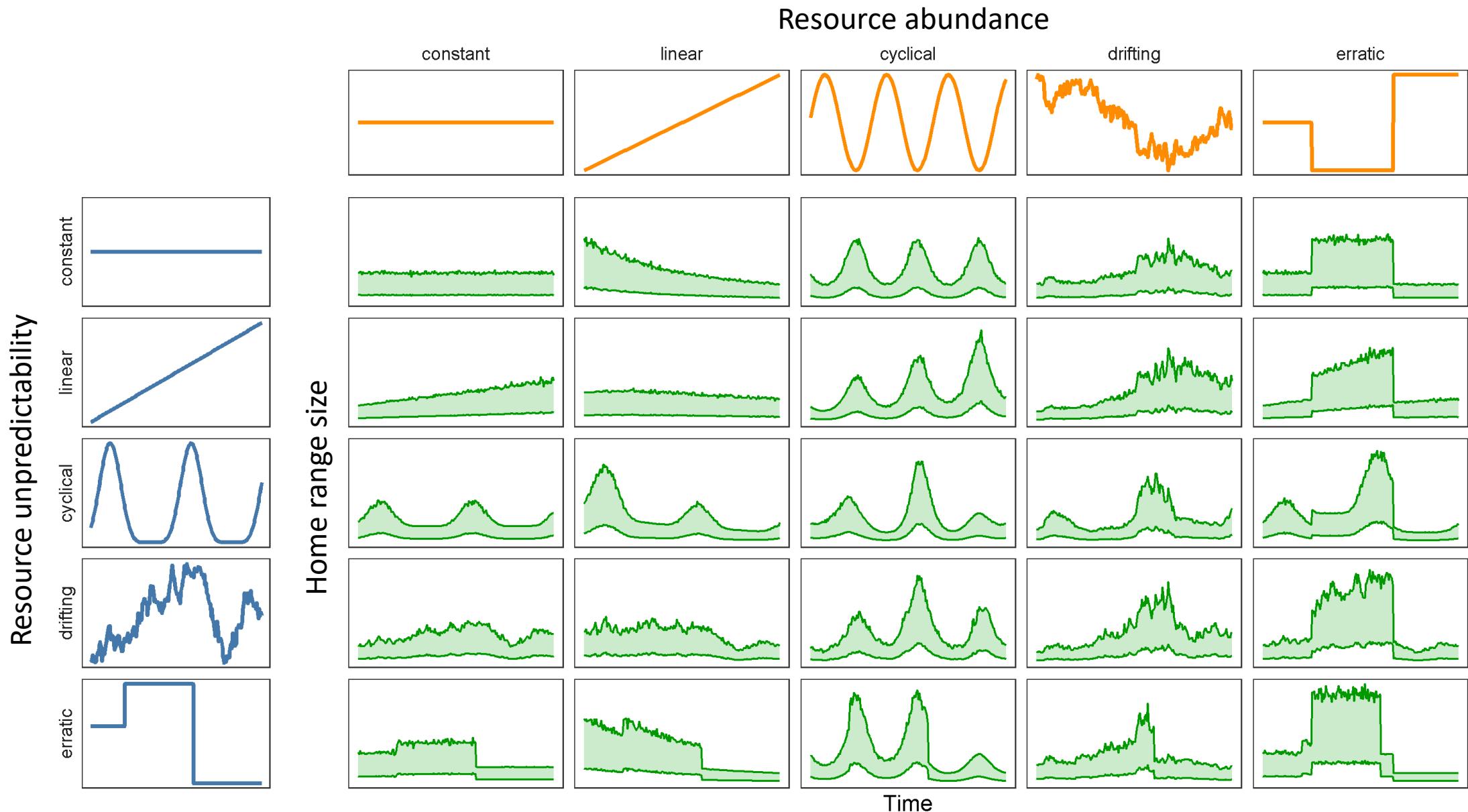


Resource unpredictability

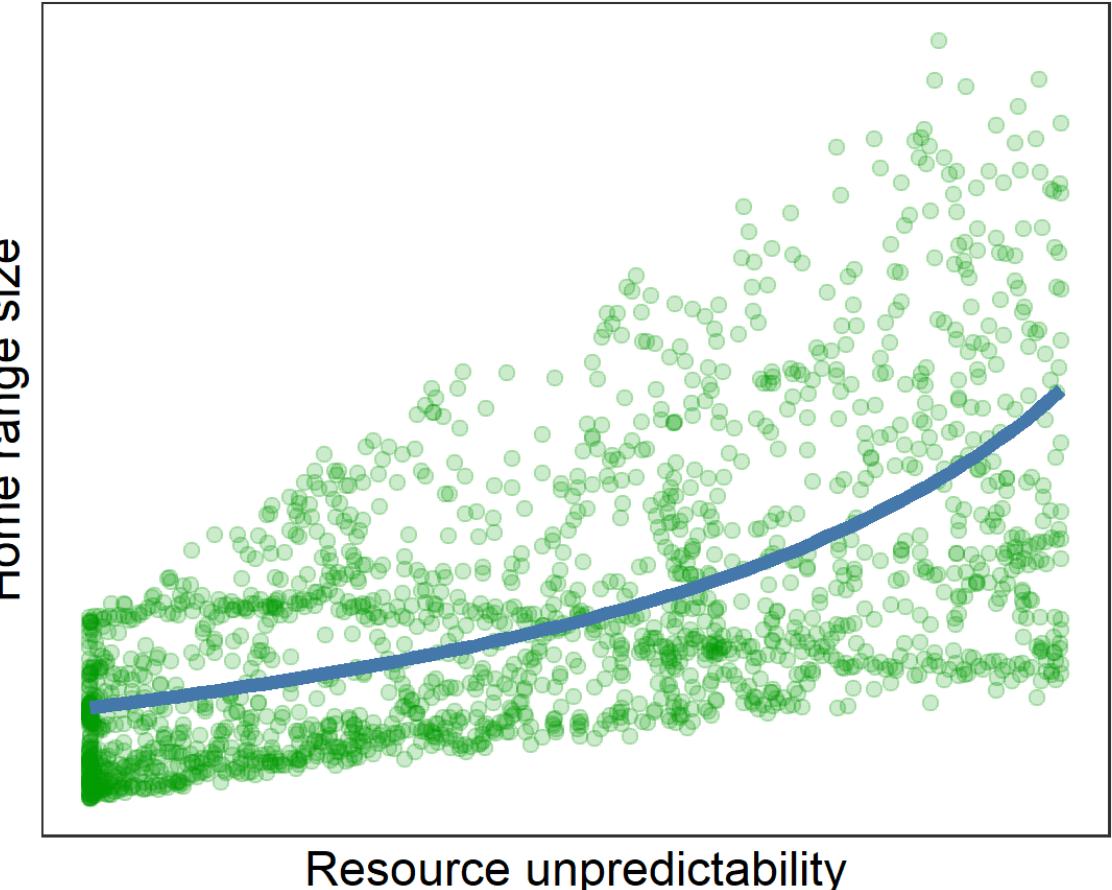
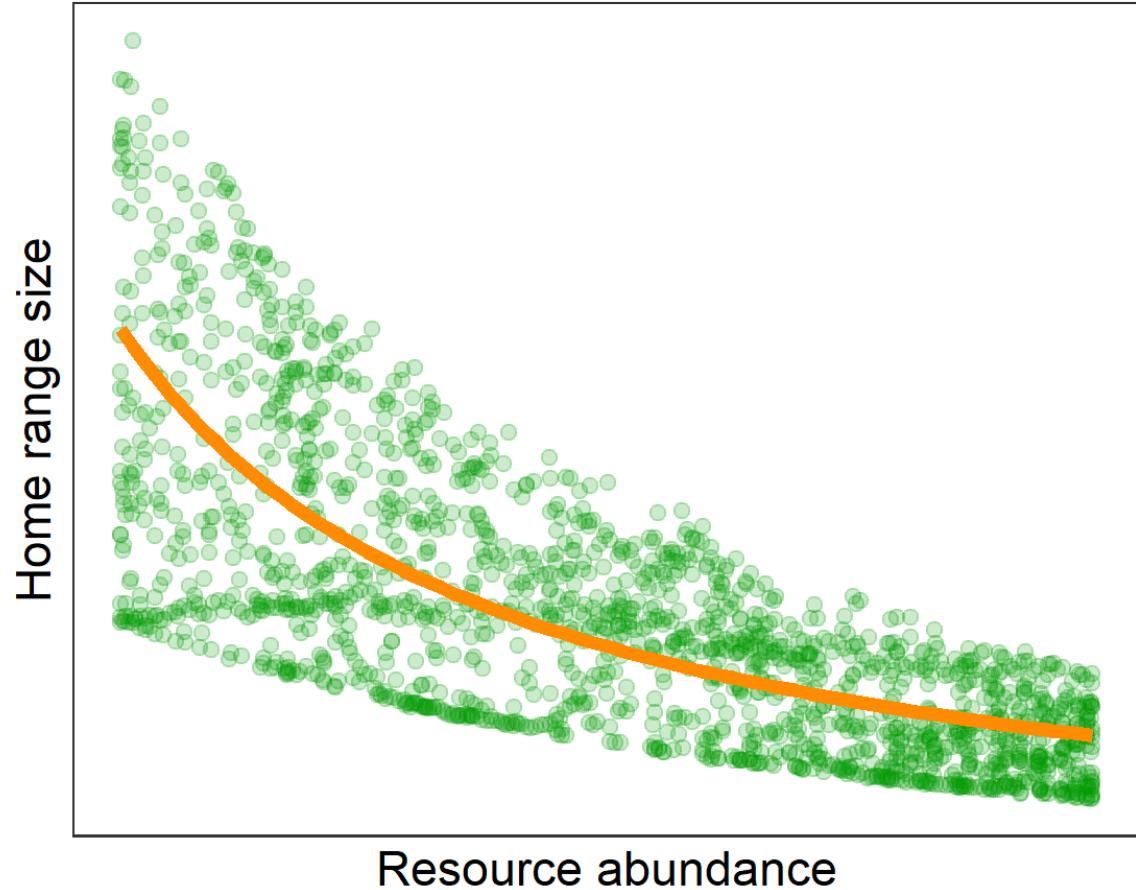
New generalized hypotheses



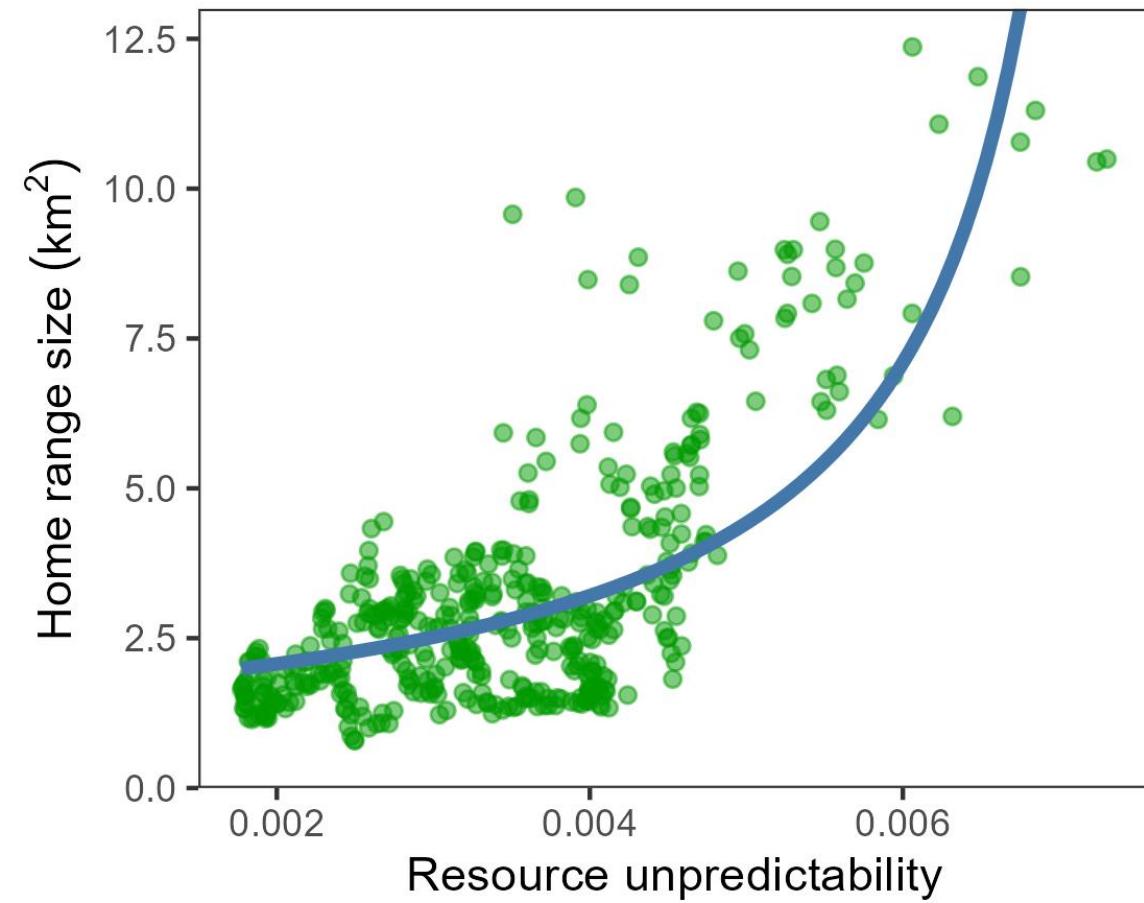
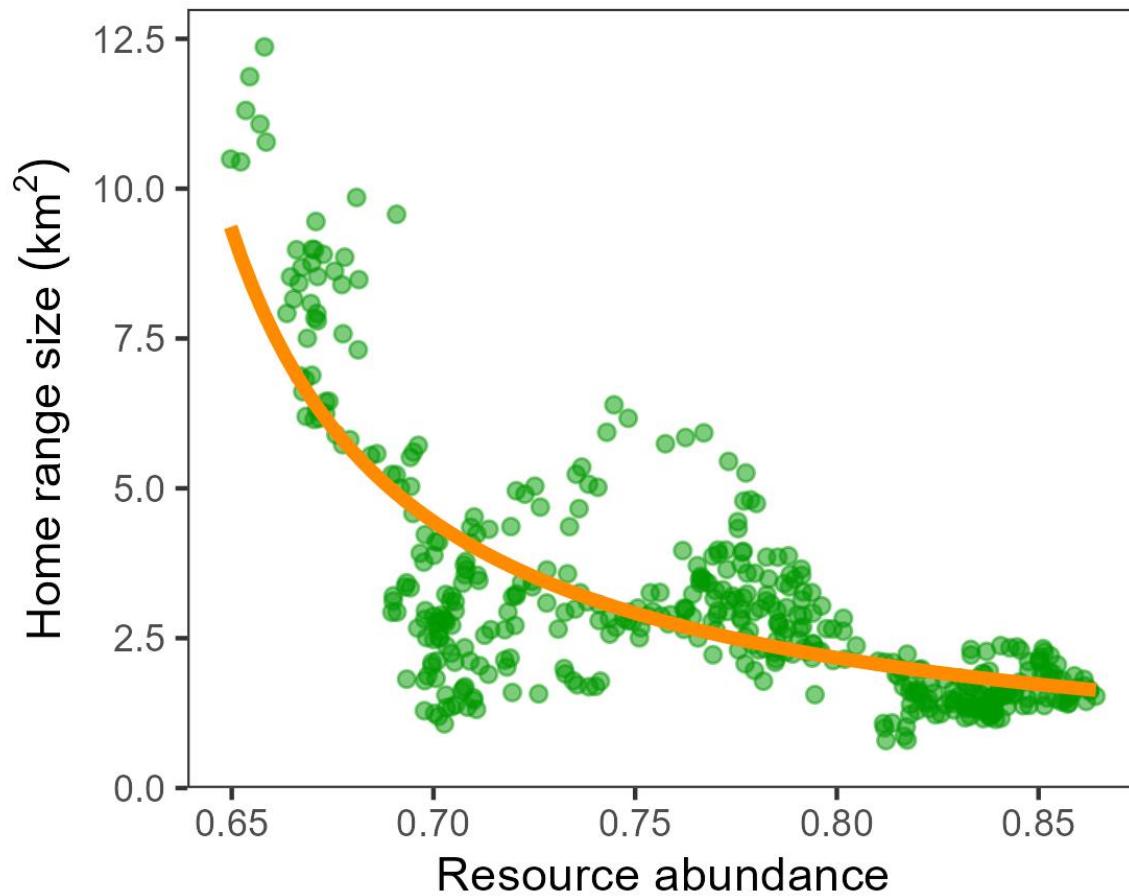
Simulating the relationships



Testing the hypotheses with simulated data

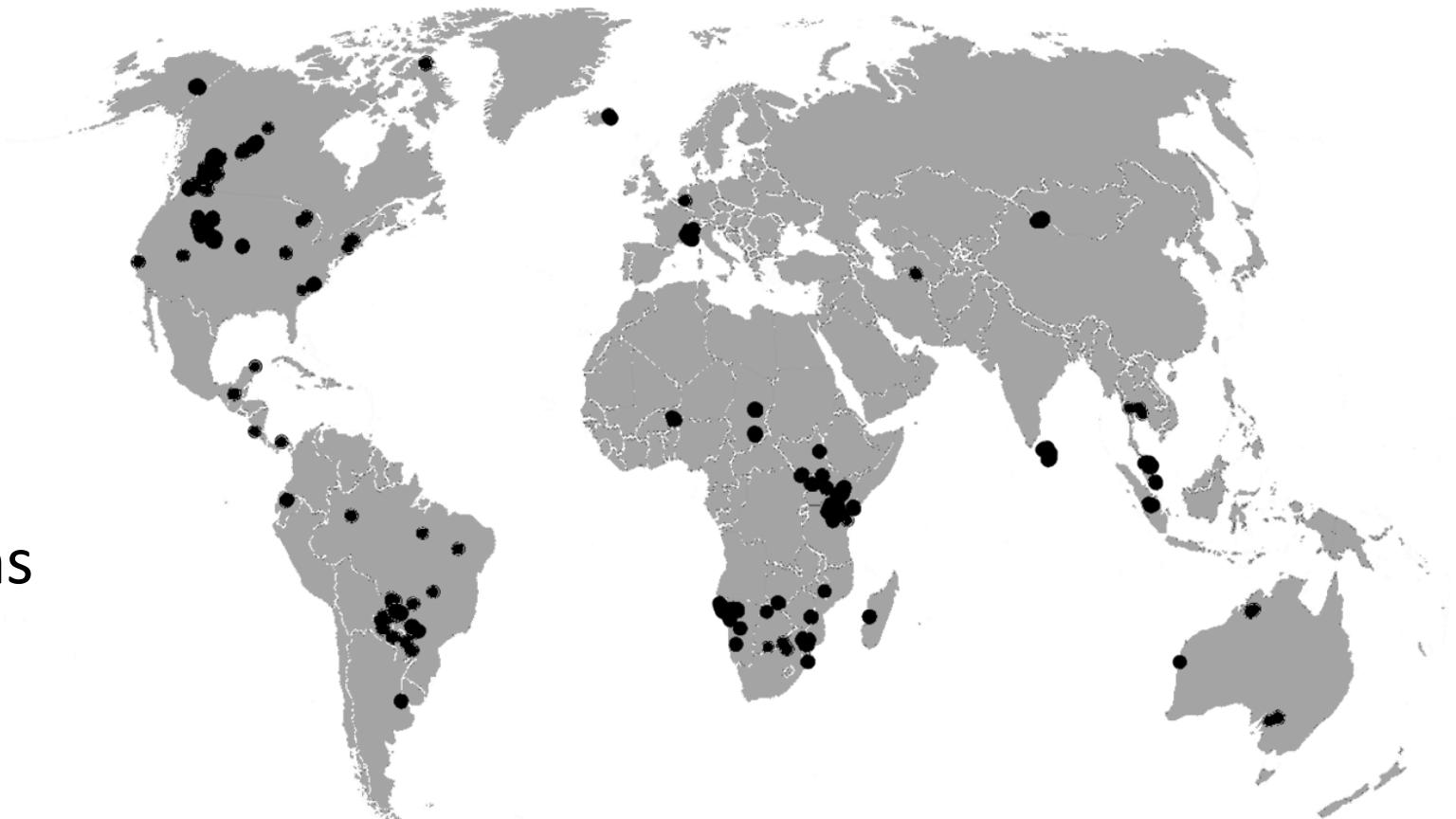


Testing the hypotheses with real data



Using a sample size greater than $n = 1$

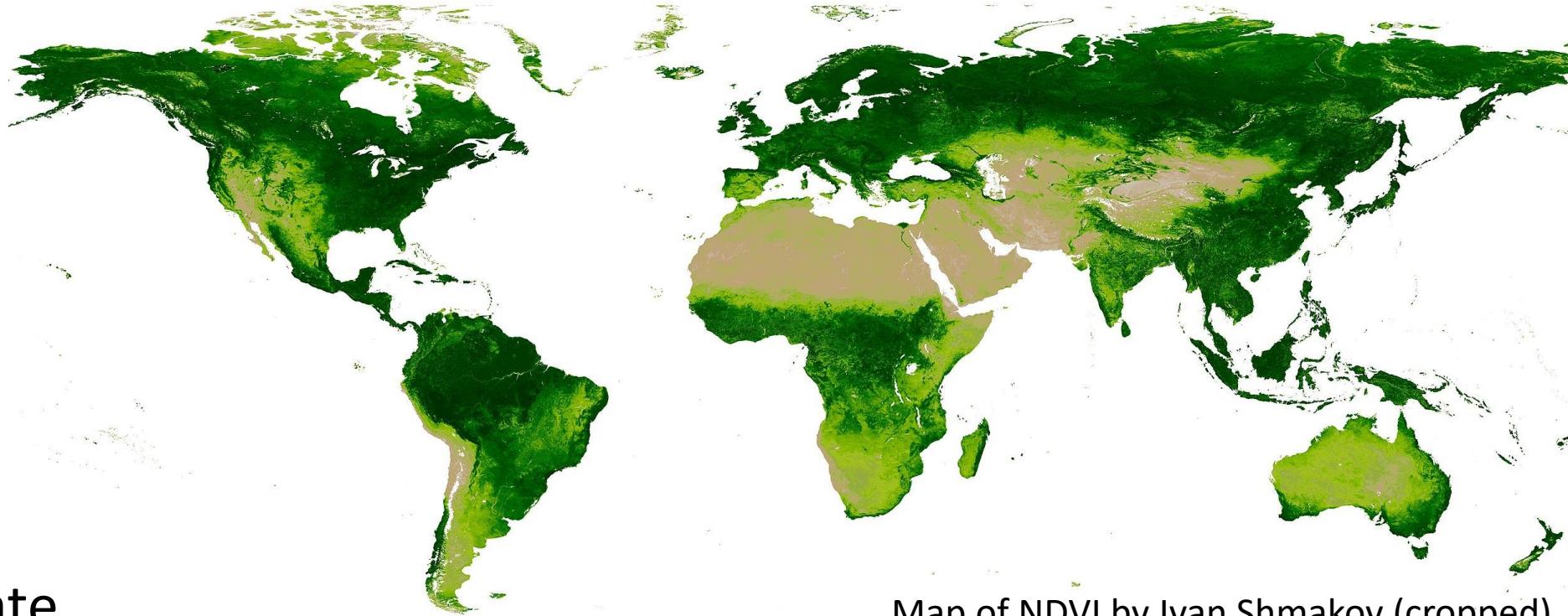
- Repeat analysis for:
 - 3,000+ animals
 - 85+ species
- Estimate **behaviors**:
 - Between populations
 - Between species
- Test for **common behavior**



Estimating abundance and unpredictability

NDVI:

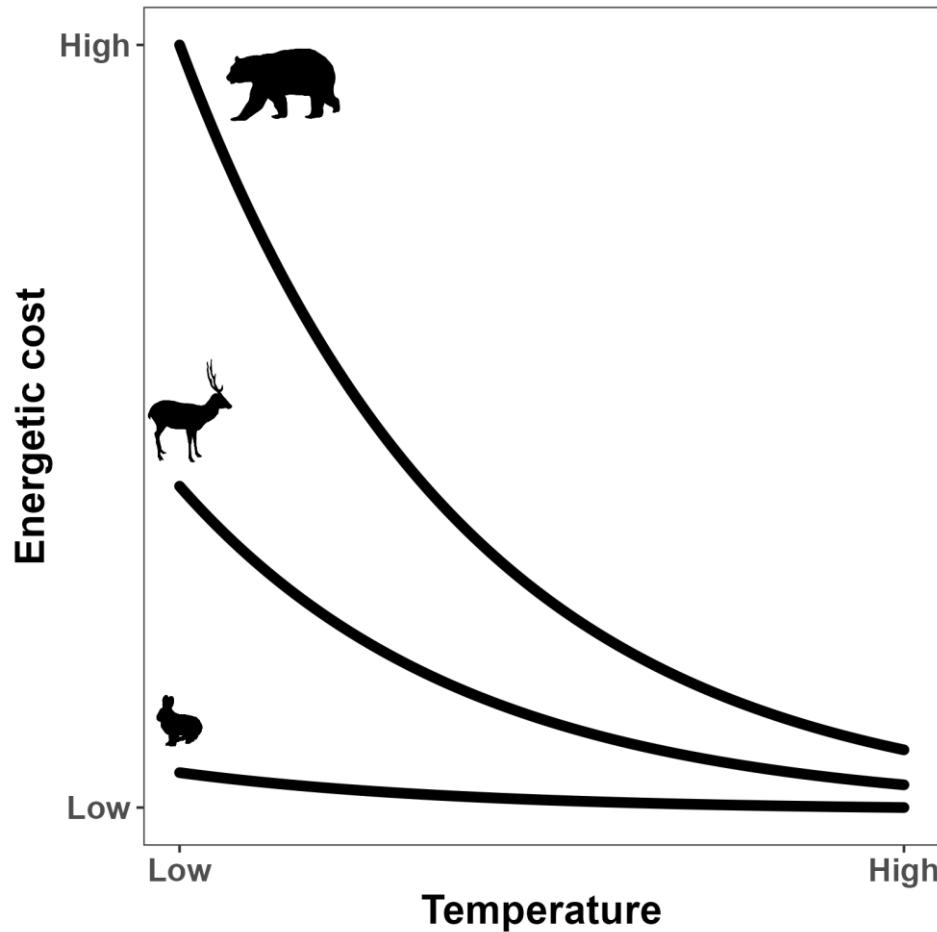
- Productivity
- Seasonality
- Weather, climate
- Extreme events (burns, floods)
- Does not measure prey
- Competitors



Map of NDVI by Ivan Shmakov (cropped)

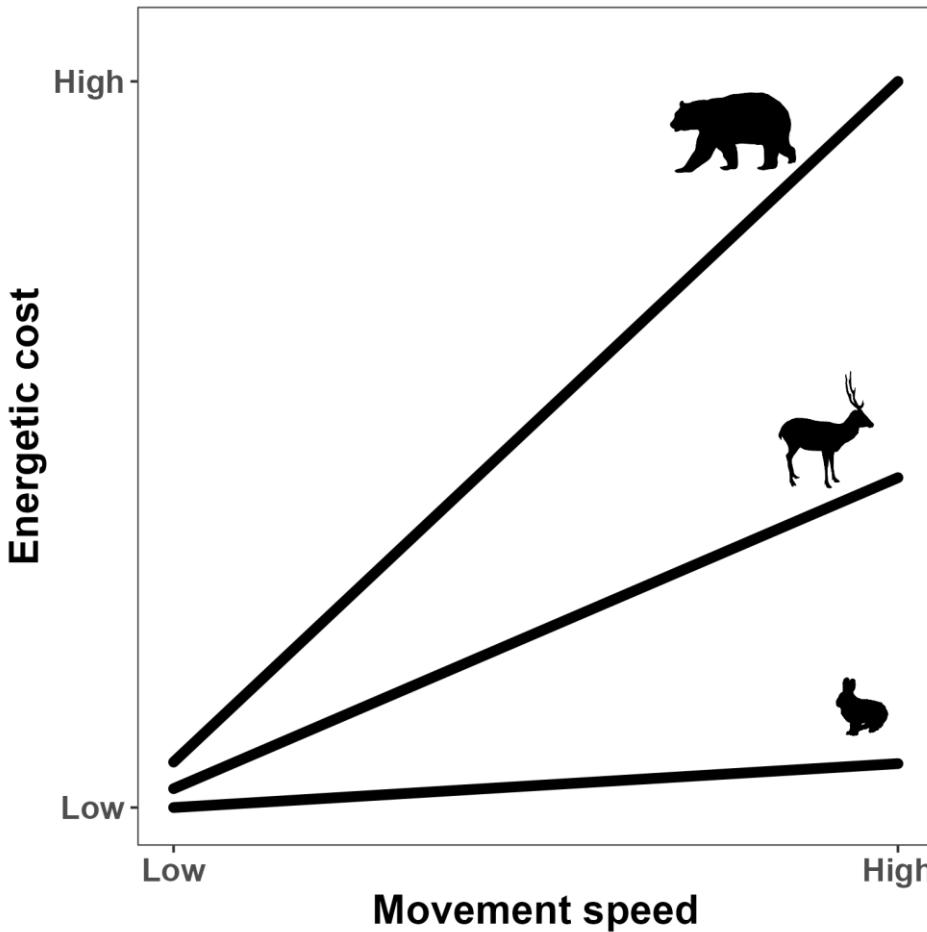
Energetic costs depends on temperature

$$I = I_0 M^{3/4} e^{-cT}$$



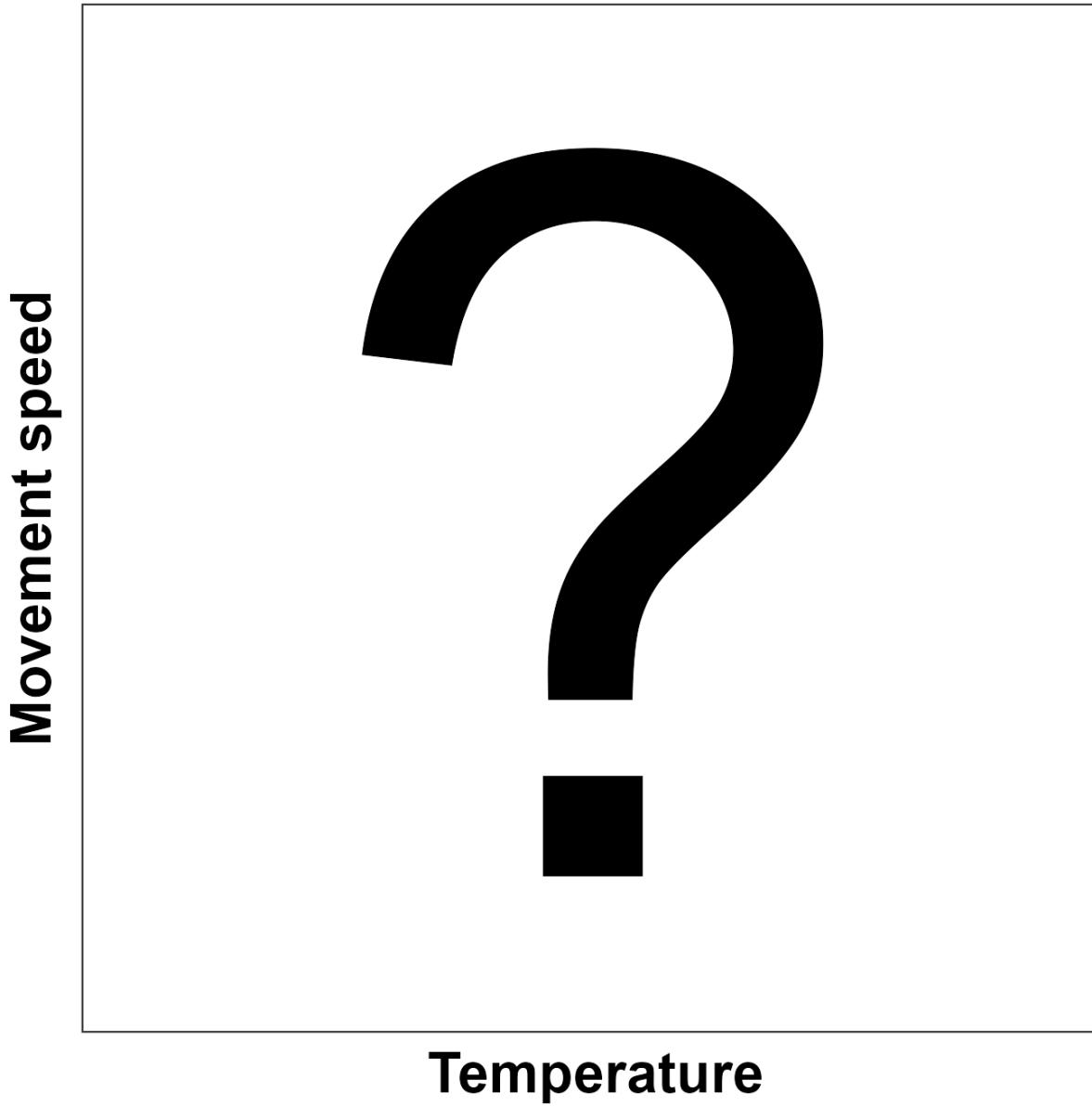
(Brown et al. 2004)

$$E = 10.7 M^{-0.684} v + 6.03 M^{-0.697}$$

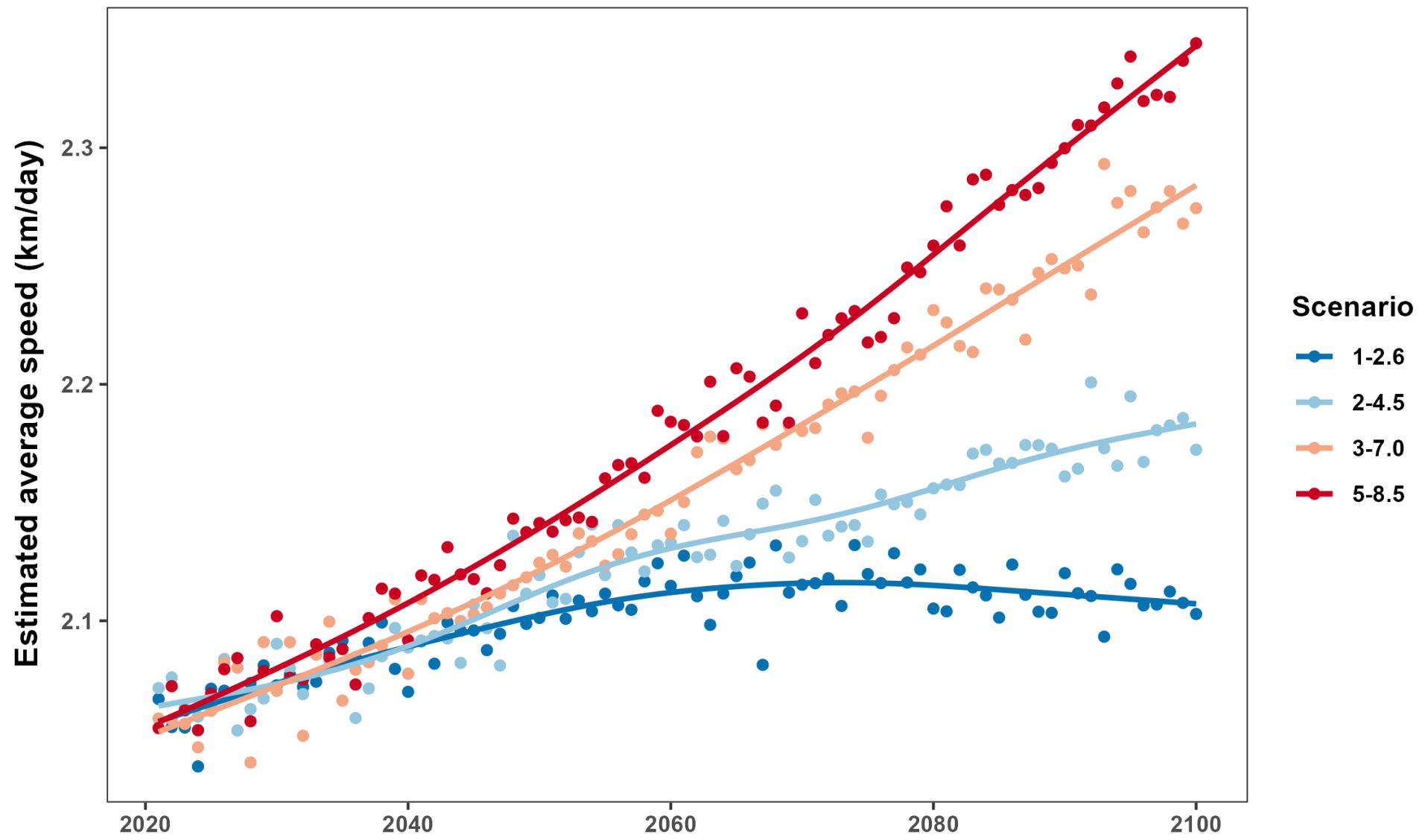


(Taylor et al. 1982)

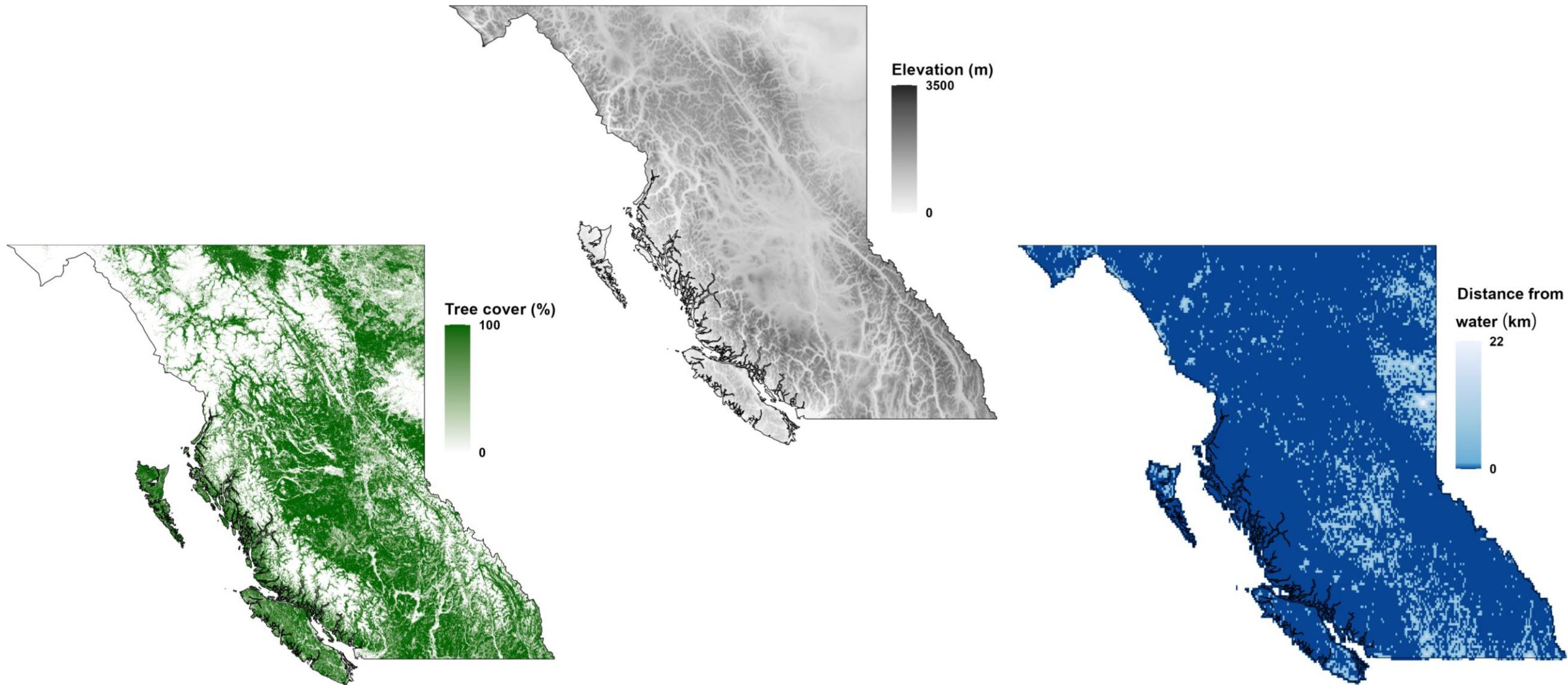
Does speed depend on temperature?



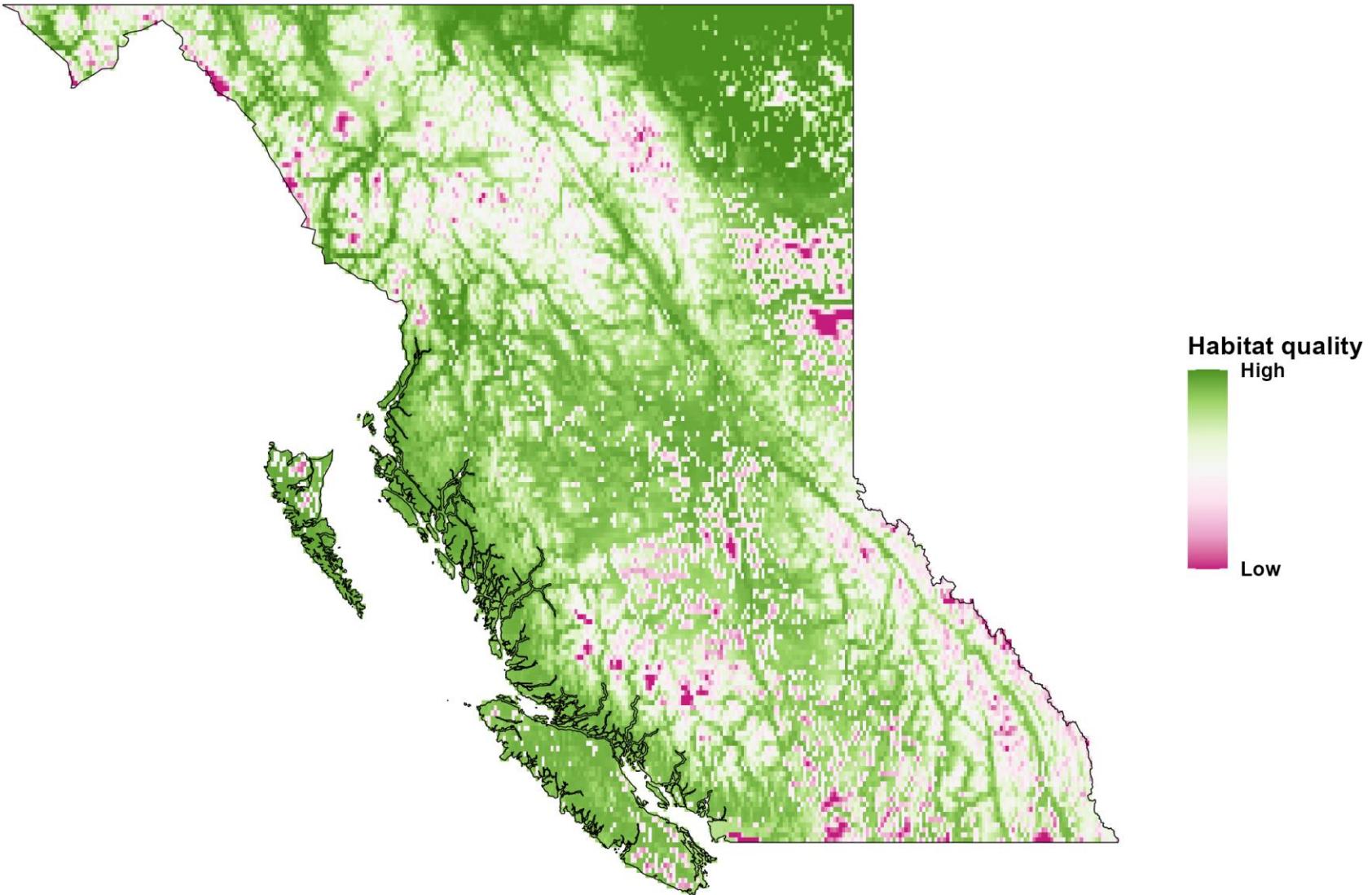
Predicting how bears will move in the future



Bear habitat quality in 2005

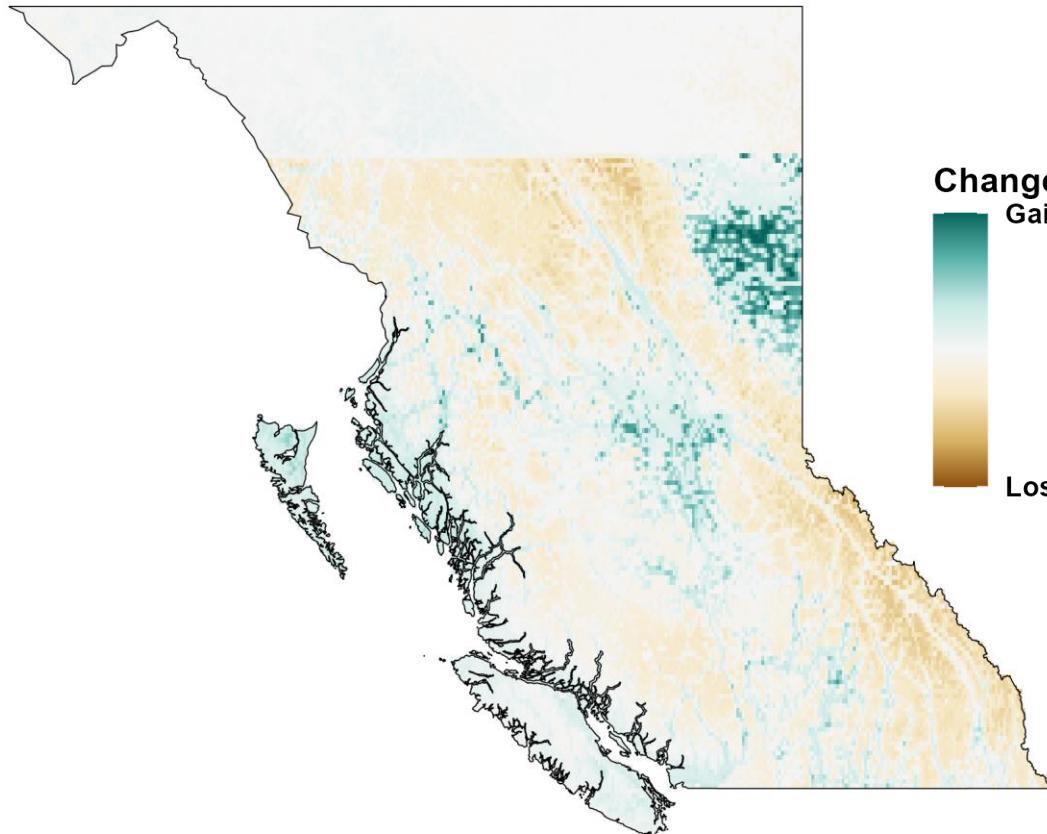


Bear habitat quality in 2005

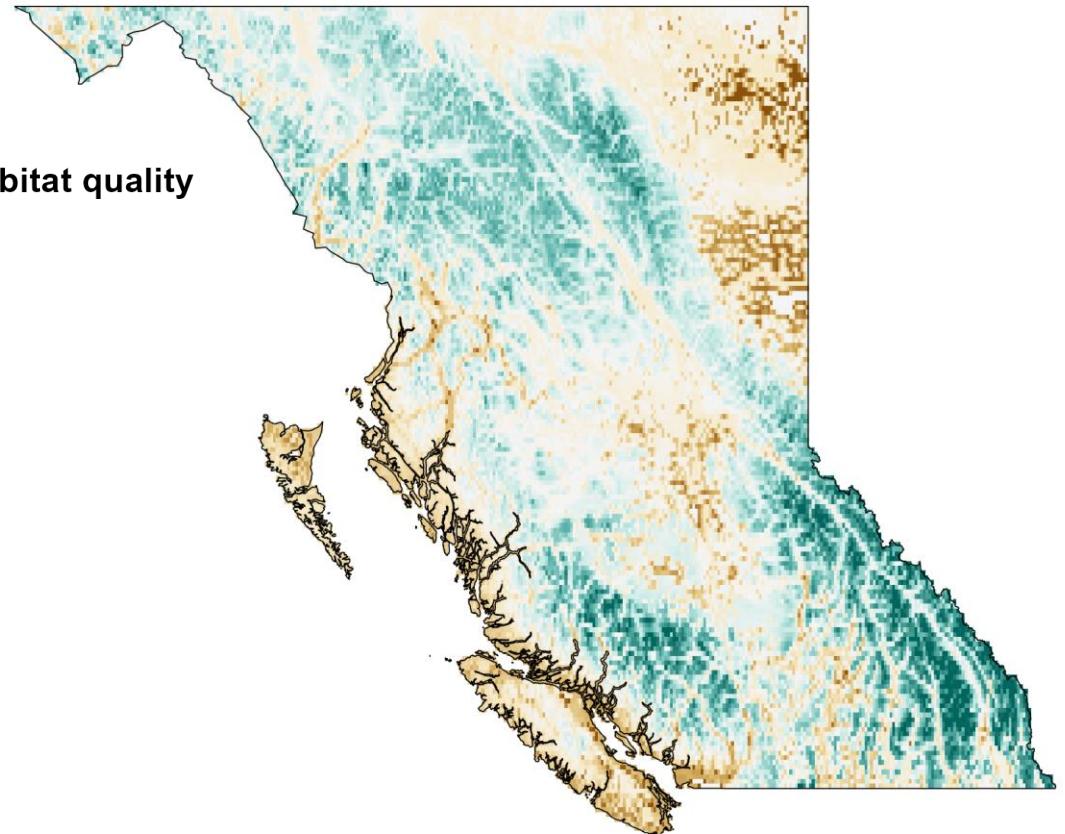


Bear habitat in 2100

SSP 1-2.6



SSP 5-8.5



Timeline

Preparatory

Open Science: Created and organized GitHub repository

Worte MSc Proposal

Write PhD Proposal

Chapter 1: Literature review and simulations

Literature review: surveyed the current knowledge

Developed simulation models with theoretical framework

Write chapter 1

Test simulation models with empirical data

Open science: update READMEs, ensure work is reproducible

Chapter 2: Animal movement in a changing climate

Collect historical climate data

Collect telemetry data

Model animal movement

Write Living Labs report

Open science: update READMEs, ensure work is reproducible

Write chapter 2

Chapter 3: A new global measure of stochasticity

Collect NDVI data

Model NDVI data

Write chapter 3

Open science: update READMEs, ensure work is reproducible

Chapter 4: Modeling animal movement

Clean, organize, and merge movement data

Model animal tracking data

Estimate stochasticity effects

Write chapter 4

Open science: update READMEs, ensure work is reproducible

Chapter 5: Summary

Write chapter 5

Jul 2021

Jan 2022

Jul 2022

Jan 2023

Jul 2023

Jan 2024

Jul 2024

Jan 2025

Jul 2025

Acknowledgements



THE UNIVERSITY OF BRITISH COLUMBIA

Biology

Irving K. Barber Faculty of Science
Okanagan Campus



Quantitative
Ecology Lab
UBC Okanagan



NSERC
CRSNG

Mitacs



References

- Bista, D., G. S. Baxter, N. J. Hudson, S. T. Lama, and P. J. Murray. 2022. Effect of disturbances and habitat fragmentation on an arboreal habitat specialist mammal using GPS telemetry: A case of the red panda. *Landscape Ecology* 37:795–809.
- Geremia, C., J. A. Merkle, D. R. Eacker, R. L. Wallen, P. J. White, M. Hebblewhite, and M. J. Kauffman. 2019. Migrating bison engineer the green wave. *Proceedings of the National Academy of Sciences* 116:25707–25713.
- Herfindal, I., J. D. C. Linnell, J. Odden, E. B. Nilsen, and R. Andersen. 2005. Prey density, environmental productivity and home-range size in the Eurasian lynx (*Lynx lynx*). *Journal of Zoology* 265:63–71.
- Lucherini, M., and S. Lovari. 1996. Habitat richness affects home range size in the red fox *Vulpes vulpes*. *Behavioural Processes* 36:103–105.
- Nilsen, E. B., I. Herfindal, and J. D. C. Linnell. 2005. Can intra-specific variation in carnivore home-range size be explained using remote-sensing estimates of environmental productivity? *Écoscience* 12:68–75.
- Relyea, R. A., R. K. Lawrence, and S. Demarais. 2000. Home Range of Desert Mule Deer: Testing the Body-Size and Habitat-Productivity Hypotheses. *The Journal of Wildlife Management* 64:146.
- Rickbeil, G. J. M., J. A. Merkle, G. Anderson, M. P. Atwood, J. P. Beckmann, E. K. Cole, A. B. Courtemanch, et al. 2019. Plasticity in elk migration timing is a response to changing environmental conditions. *Global Change Biology* 25:2368–2381.
- Rizzuto M., Leroux S.J., Vander Wal E., Richmond I.C., Heckford T.R., Balluffi-Fry J., et al. (2021). Forage stoichiometry predicts the home range size of a small terrestrial herbivore. *Oecologia* 197, 327–338.
- Williams-Guillen, K., C. McCann, J. C. Martinez Sanchez, and F. Koontz. 2006. Resource availability and habitat use by mantled howling monkeys in a Nicaraguan coffee plantation: Can agroforests serve as core habitat for a forest mammal? *Animal Conservation* 9:331–338.