Quantitative Ecology Lab[a]
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How resource abundance and stochasticity affect animals' spatial needs

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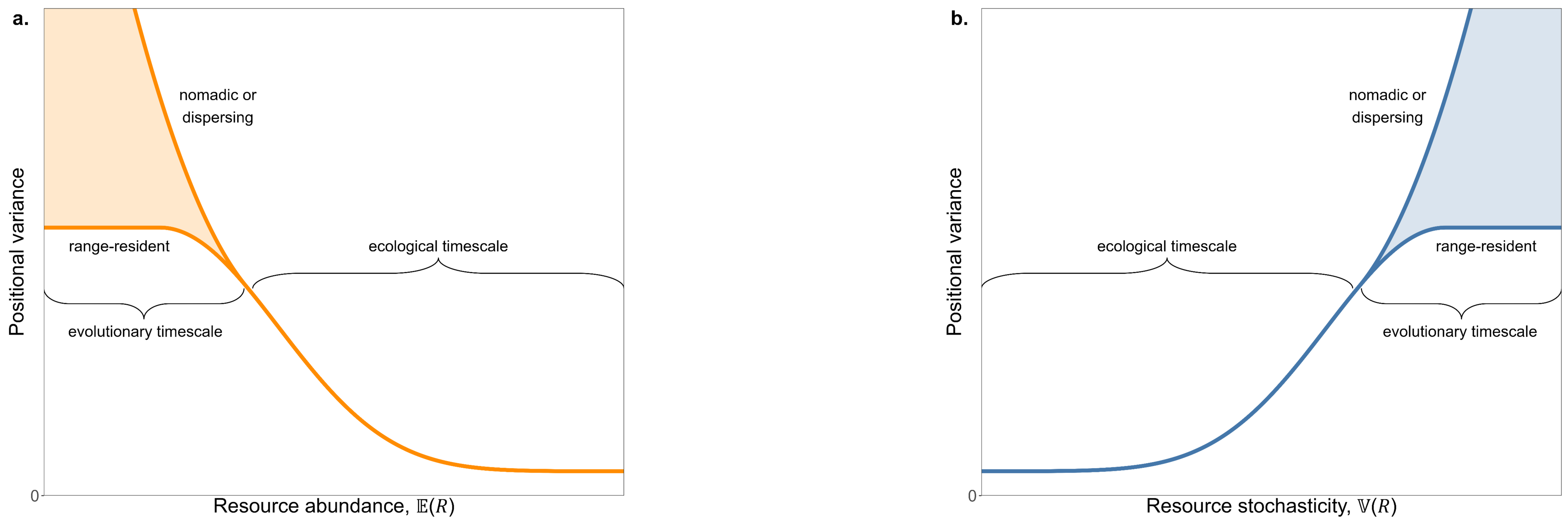
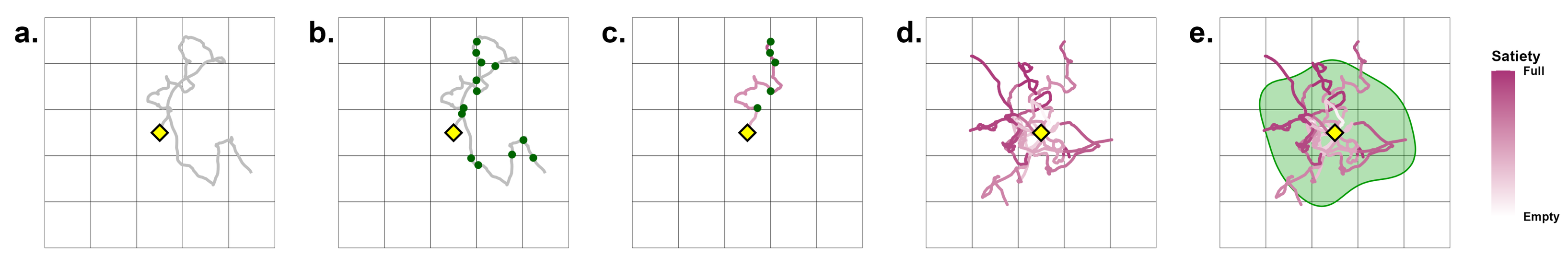
Hypotheses

Animals require more space when resources are scarce[1,2] (low resource abundance, $\mathbb{E}(R)$, see **a.**) than when resources are high. In contrast, **animals need less space when resources are predictable**[2] (low resource stochasticity, $\mathbb{V}(R)$, see **b.**) than when resources are stochastic. Long-term resource scarcity or stochasticity may favor evolutionary pressure for nomadic or dispersing behaviors and associated physiological traits.

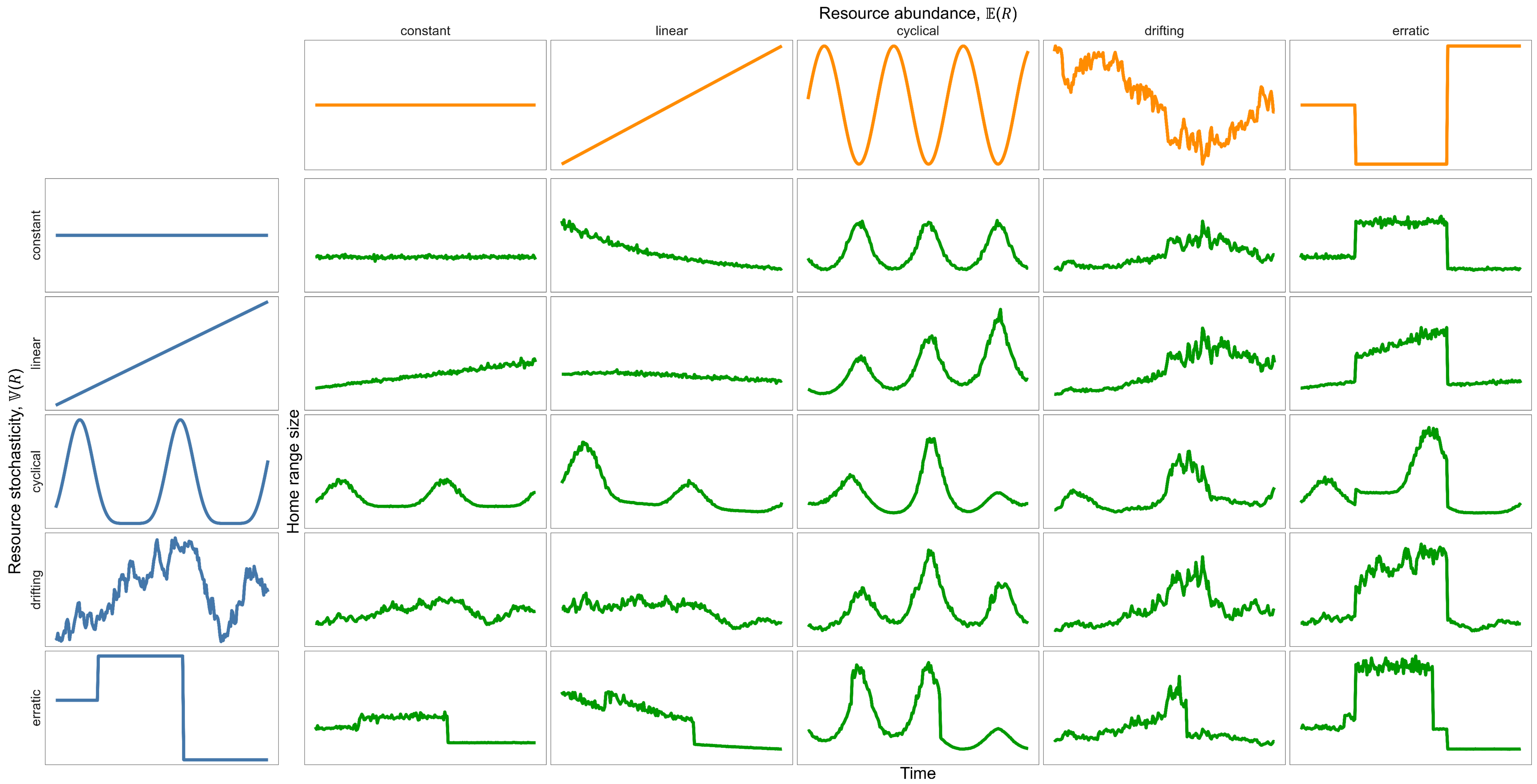


Simulations

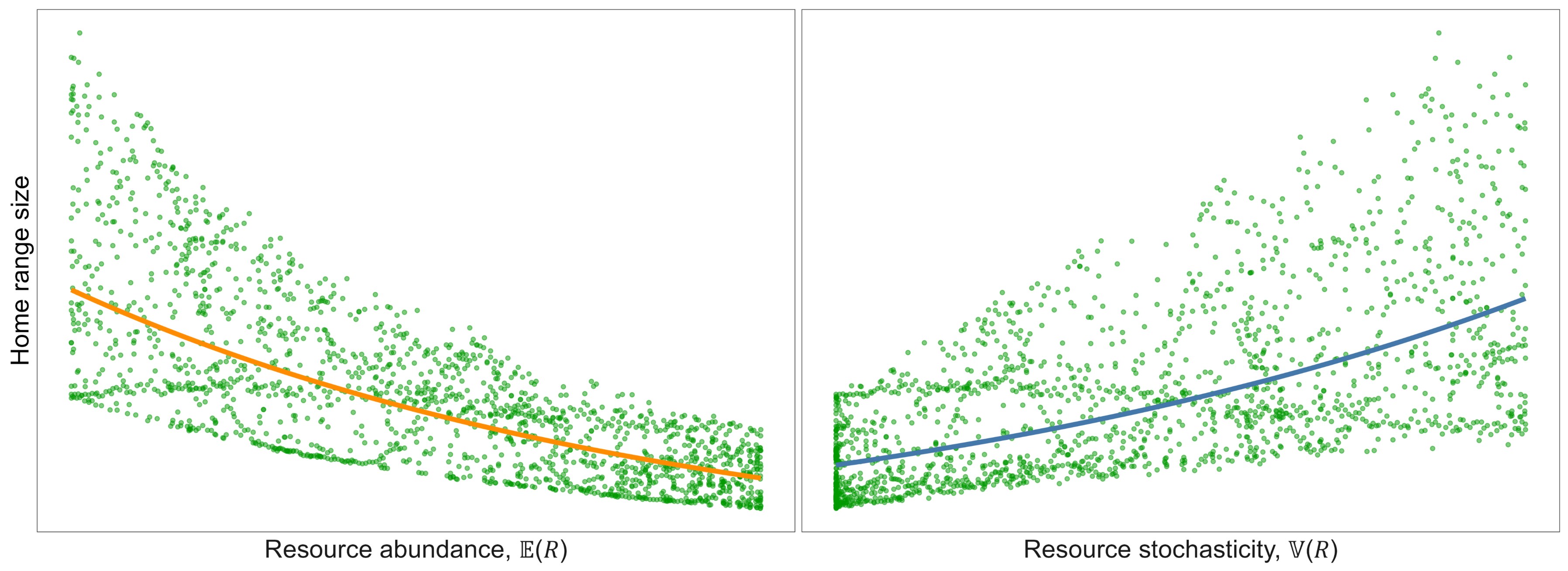


a. Movement tracks were generated via the `ctmm` package[3] for R using an Integrated Ornstein-Uhlenbeck (IOU) movement model, a spatially unrestricted, continuous-velocity process. **b.** The animal encountered food (dots) whenever it moved to a new cell. **c.** Tracks were truncated once the animal reached satiety. **d., e.** A total of 2^{10}=1024 independent tracks (13 in these figures) were then used to estimate the animal's spatial needs via Autocorrelated Kernel Density Estimation[3] (AKDE).

Simulated spatial needs decrease nonlinearly with $\mathbb{E}(R)$ and increase nonlinearly with $\mathbb{V}(R)$. Additionally, changes in $\mathbb{E}(R)$ have a greater effect on home range size in stochastic times, and the variance in home range size is greater when $\mathbb{E}(R)$ is low. In contrast, changes in $\mathbb{V}(R)$ have a greater impact in resource-poor times, and the variance in home range size is greater when $\mathbb{V}(R)$ is high.

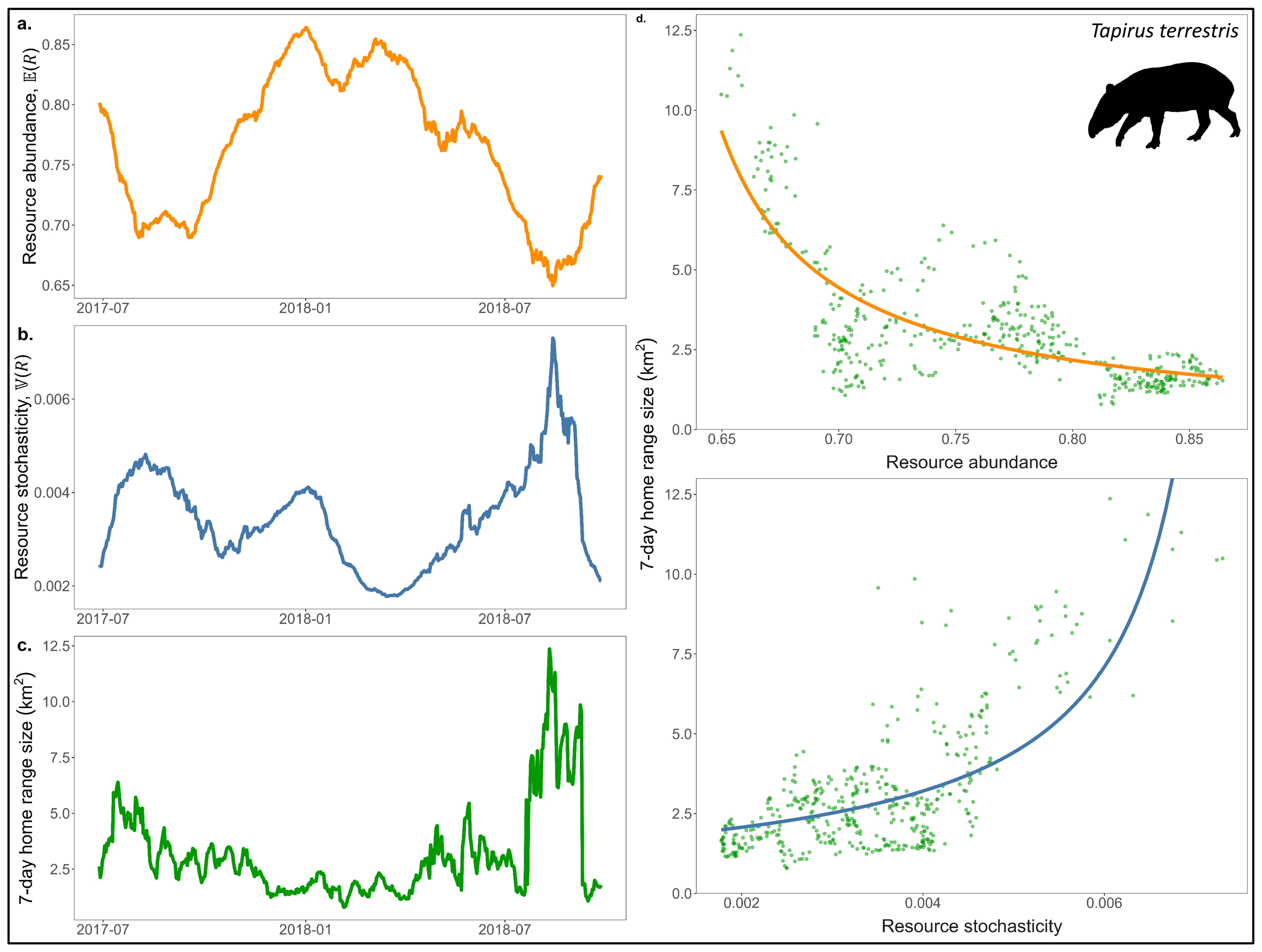


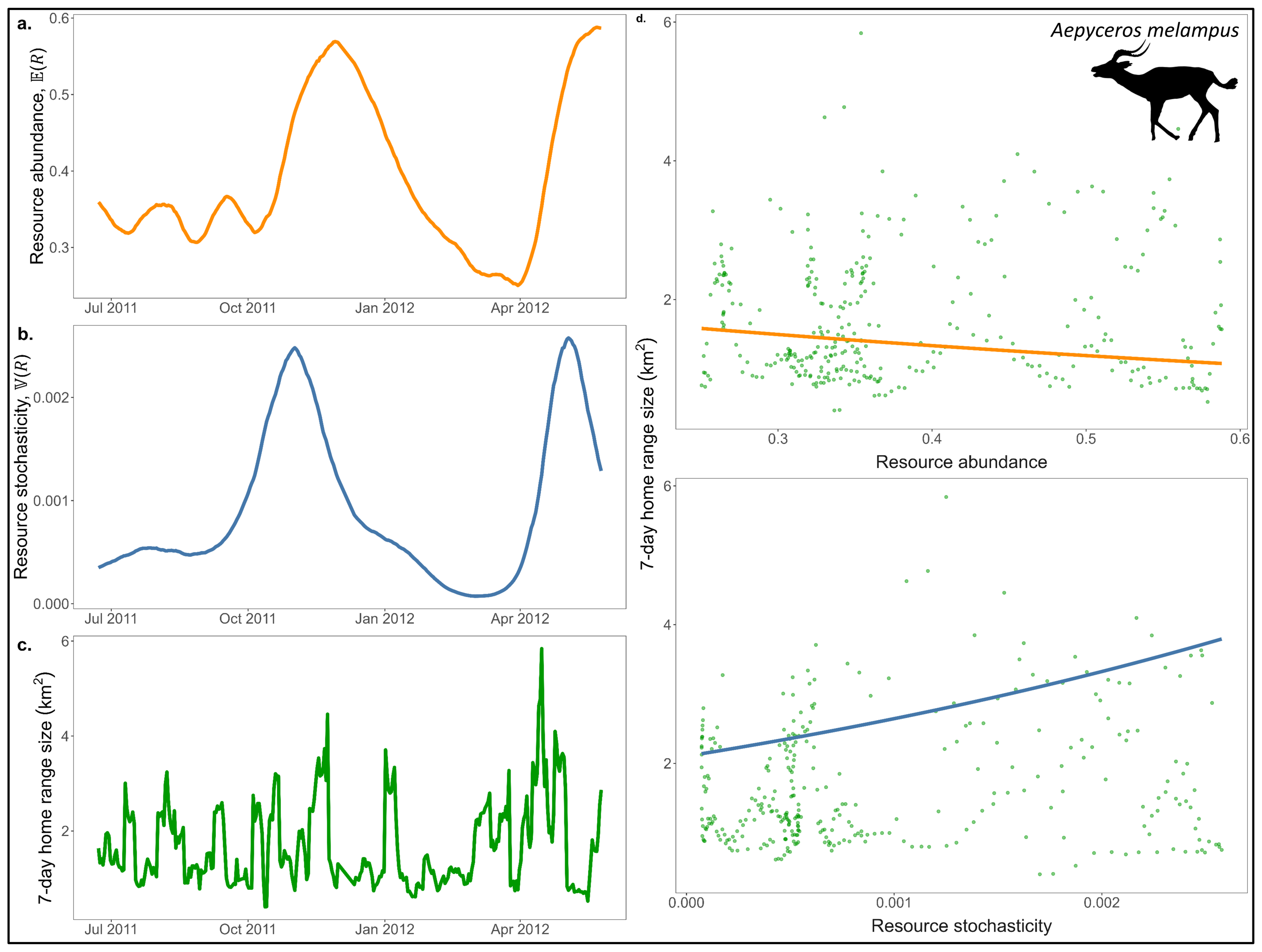
Simulated animals' spatial needs decrease nonlinearly as resources become more abundant, and they increase nonlinearly as resources become more stochastic. Note that as the mean HR increases, the variance in HR also increases (more than expected by a Gamma distribution with a constant mean-variance relationship). Therefore, animal behavior is likely to be less predictable in areas of low resources or high stochasticity.

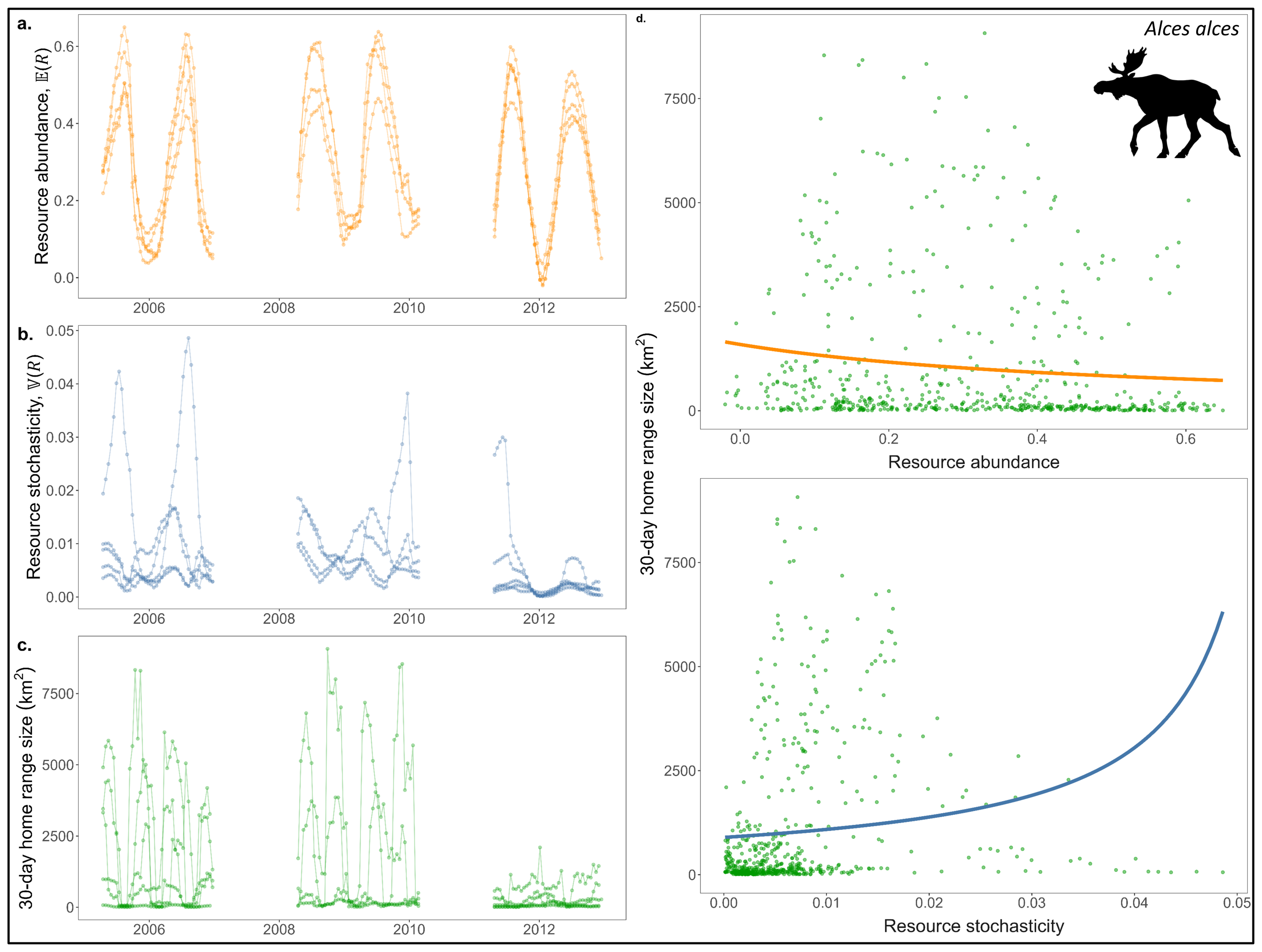


Empirical examples

As predicted by the simulations, **mammals' spatial needs decrease nonlinearly with $\mathbb{E}(R)$ and increase nonlinearly with $\mathbb{V}(R)$.** However, since $\mathbb{E}(R)$ and $\mathbb{V}(R)$ are often correlated and spatiotemporally autocorrelated, models should be reasonably constrained as well as free of outlier periods and animals.







The manuscript and sensitivity analyses are available on GitHub at the following URL and QR code:
https://github.com/QuantitativeEcologyLab/hr-resource-stoch/tree/main/writing

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2. Nilsen, E. B., Herfindal, I. & Linnell, J. D. C. Can intra-specific variation in carnivore home-range size be explained using remote-sensing estimates of environmental productivity? Écoscience 12, 68–75 (2005).
3. Calabrese, J. M., Fleming, C. H. & Gurarie, E. ctmm: an R package for analyzing animal relocation data as a continuous-time stochastic process. Methods Ecol Evol 7, 1124–1132 (2016).

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