Fall 2016 committee meeting for Peter Smits

Post-doc applications

Chapter 2: brachiopod survival

Chapter 3: mammal species pool

Finishing

Post-doc applications

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Chapter 3: mammal species pool

Finishing

What I've applied for

- project idea: models of both within- and across-species continuous trait evolution
- Miller Fellowship at Berkeley with Charles Marshall
- Killam Fellowship at UBC with Matt Pennell

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Revisions following rejection

- reviews considered text to be both too "paleontological" and technical
- new target is *American Naturalist*.
- conceptual figures (e.g. behaviour Wiebull distribution, model structure)
- text emphasis on fitness, selection interpretations

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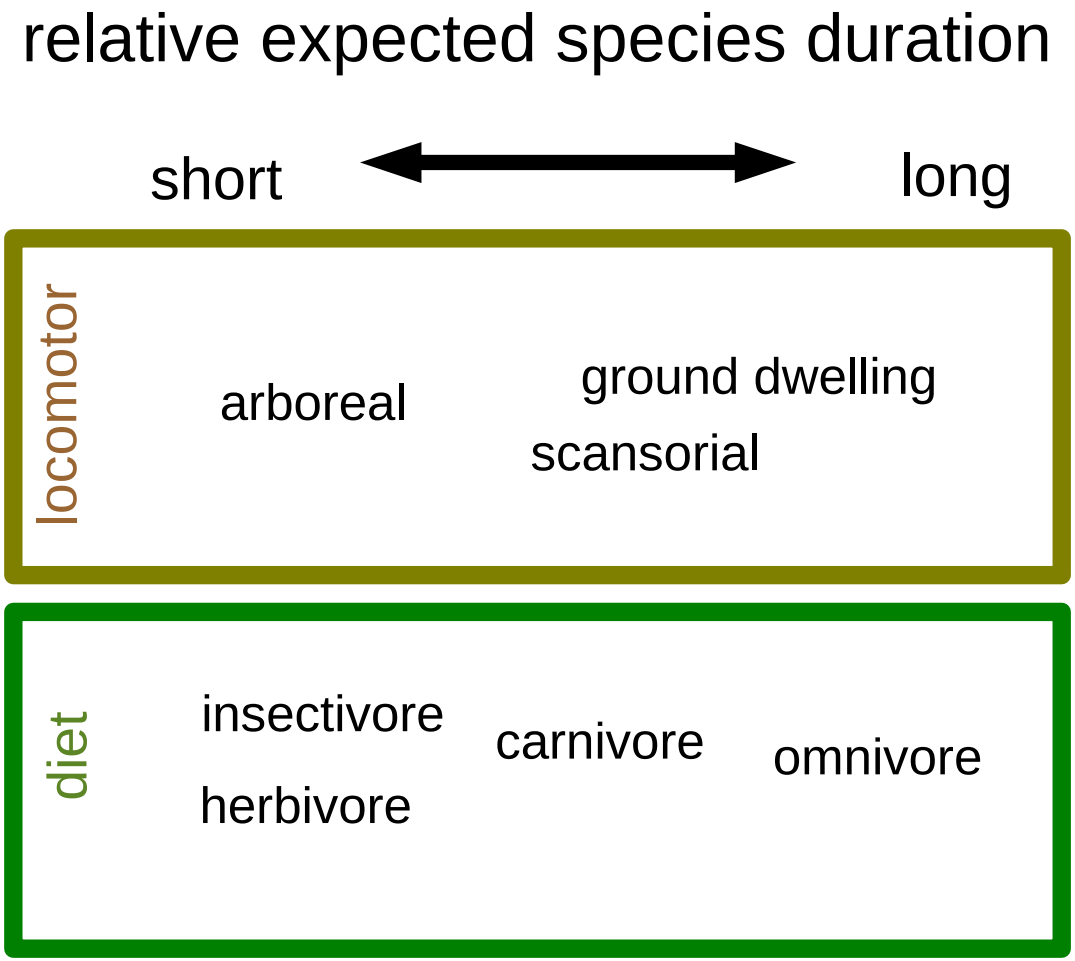
Question

When are certain ecologies/ecotypes enriched or depleted?

Differences in extinction risk



(Smits, 2015, *PNAS*)

Species pool concept

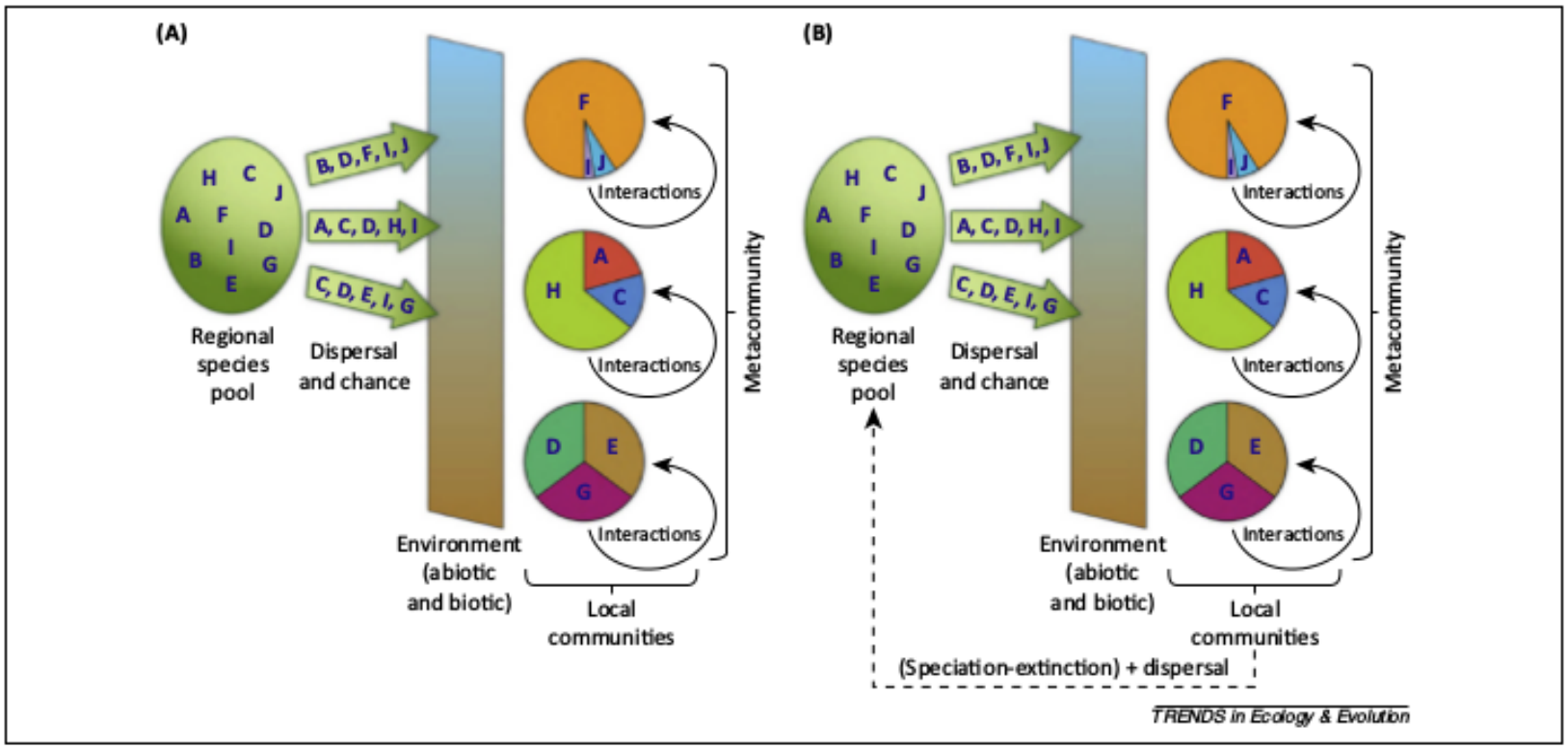
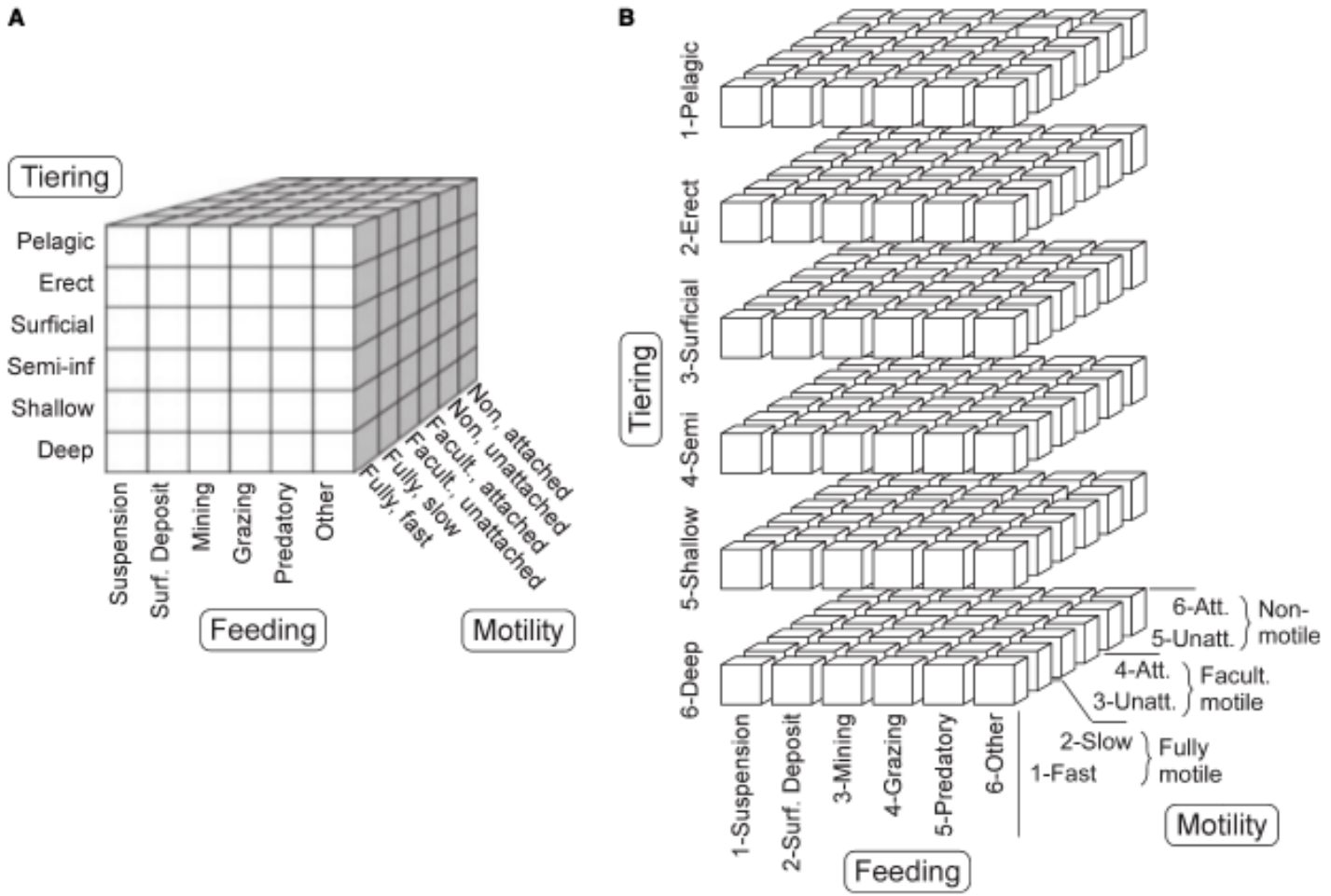


Figure 1. Two models of community assembly. **(A)** Local communities comprise a subset of species from the regional species pool that have passed through environmental filters. There is no feedback from the metacommunity (collection of local communities) to the regional species pool. Adapted from [5]. **(B)** Local communities are assembled as in (A), but speciation adds new species to the pool, extinction removes others, and dispersal allows the persistence of species that might otherwise go extinct.

(Mittelbach and Schemske, 2015, *TREE*)

Eco-cube and ecotypes



TEXT-FIG. 1. Ecospace as defined by the three axes of tiering, motility level and feeding strategy. A, the ecospace cube with categories on each axis labelled. B, the ecospace cube 'exploded', showing 216 'bins' or modes of life specified by the combination of the categories on each ecospace axis.

(Bambach *et al.*, *2007*, Palaeontology)

The fourth-corner problem

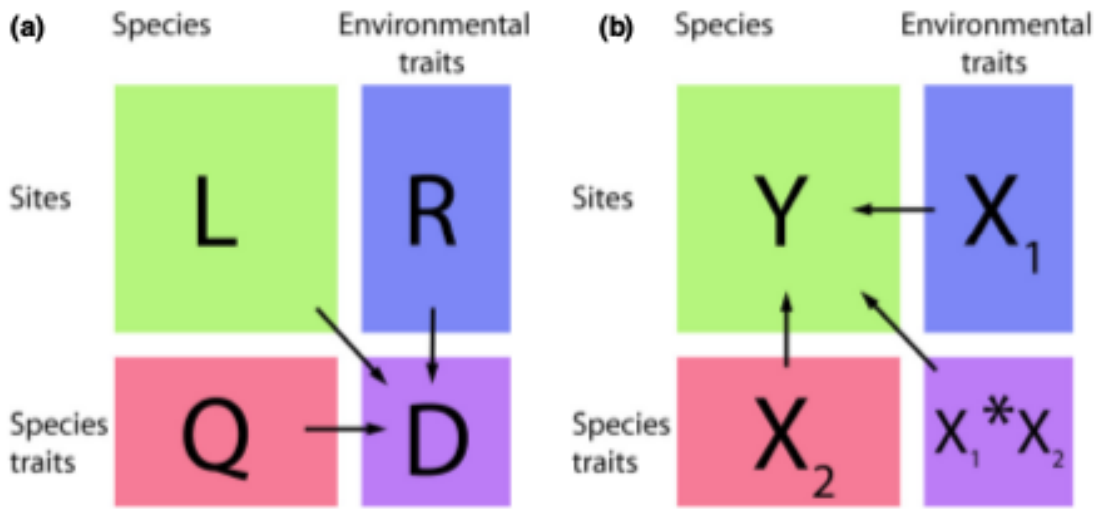


Fig. 1. Graphical representation of the fourth-corner problem and its solution. (a) The problem as posed by Legendre, Galzin & Harmelin-Vivien (1997), where the goal is to combine abundance (**L**), trait (**Q**) and environment (**R**) data in some way, to determine a matrix describing the trait–environment relationship (**D**). (b) The proposed model-based solution to the fourth-corner problem, where the goal is to predict abundance (**Y**) as a function of predictor variables for environment ($\mathbf{X_1}$), species traits ($\mathbf{X_2}$) and their interaction ($\mathbf{X_1}$*$\mathbf{X_2}$). The matrix of coefficients for the interaction between $\mathbf{X_1}$ and $\mathbf{X_2}$ is the fourth corner.

(Brown *et al.*, *2014*, Methods Ecol. Evol.)

Covariates of interest

individual-level
(species i at time unit t)

- log-odds of occurrence probability at time t
- effect of locomotor type
  - arboreal, digitigrade, plantigrade, unguligrade, fossorial, scansorial
- effect of dietary type
  - carnivore, herbivore, insectivore, omnivore
- effect body size
  (rescaled log body mass)

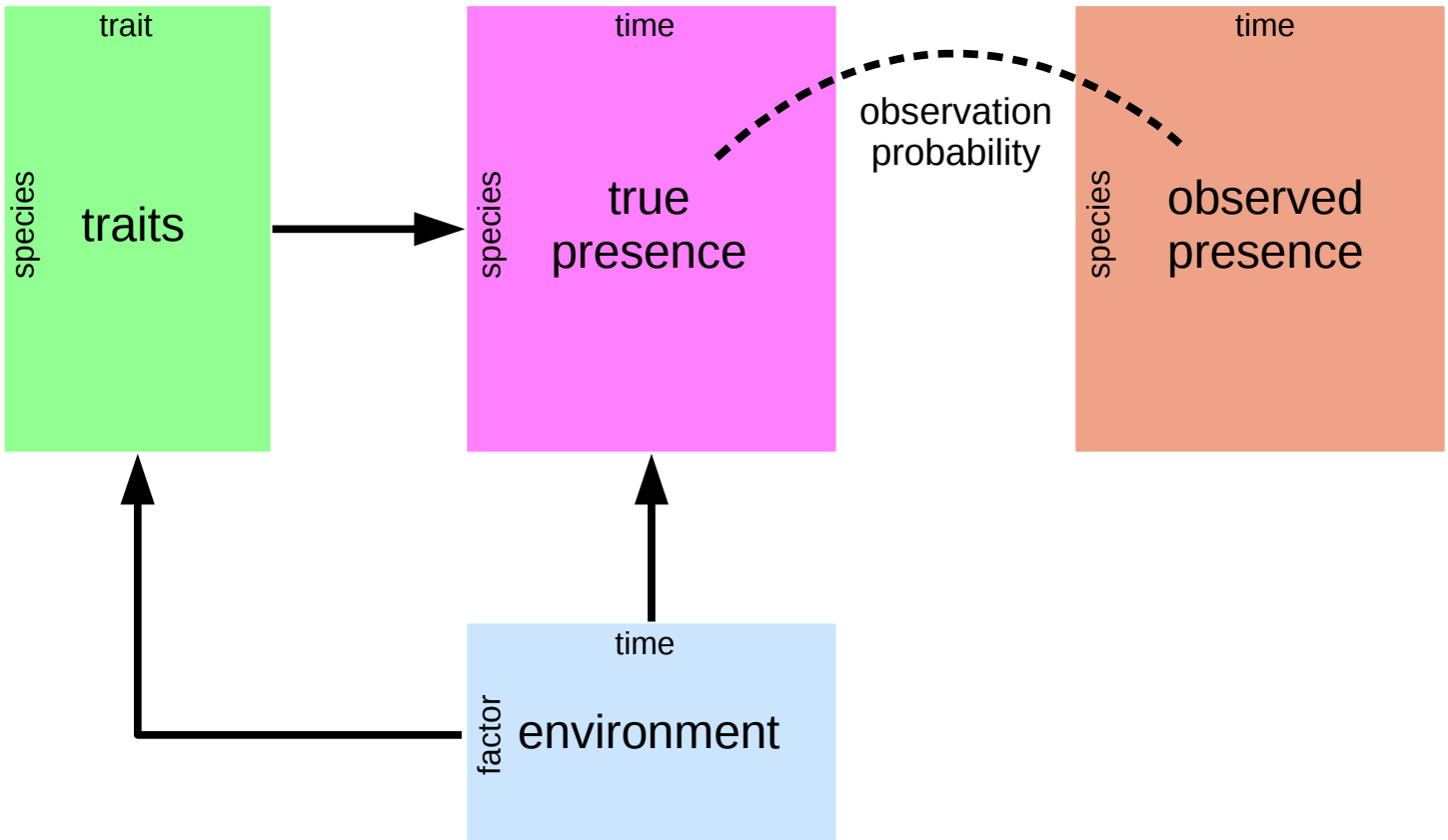
group-level (2 My time unit t)

- overall mean of log-odds of occurrence probability
- temperature record based on Mg/Ca estimates
  - mean and interquartile range of rescaled value
- plant community phase following Graham 2011

Model of taxon occurrence

- response is p/a of genus in NA at time t
  - Bernoulli variable
  - probability is (observation prob) times ("true" presence)
- observation probability is effect of sampling/fossil record
  - basic model does not model sampling
- the latent discrete "true" presence modeled as a multi-level logistic regression
  - individual- and group-level

Paleo-fourth corner model



Model and sampling statement definition

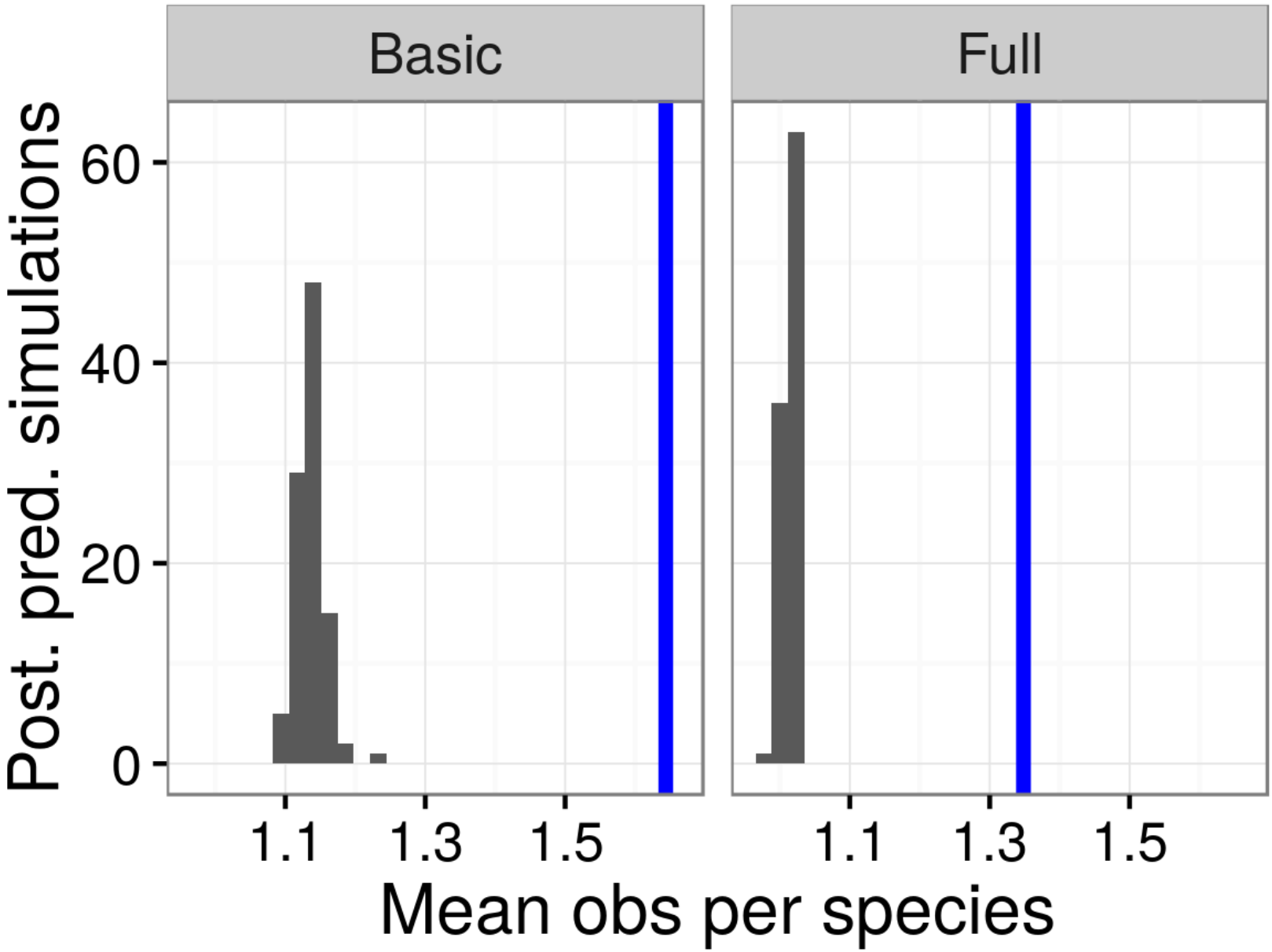
$$
\begin{aligned}
y_{i,t} &\sim \text{Bernoulli}(\rho_t z_{i,t}) \\
\text{logit}(\rho_t) &\sim \mathcal{N}(\rho^{'}, \sigma_\rho) \\
z_{i,t} &\sim \text{Bernoulli}(\theta_{i,t}) \\
\text{logit}(\theta_{i,t}) &= z_{i,t-1}(X_i \beta_{t\_}) + (\prod_{k=1}^{t-1} 1 - z_{i,k})(X_i \beta_{t\_}) \\
\beta_t &\sim \text{MVN}(\mu, \Sigma)
\end{aligned}
$$

Note: Product term ensures taxon-loss is permanent. Implementation in Stan marginalizes over all possible (range-through) values of z instead of estimating the discrete parameters. I also use a noncentered parameterization of the hierarchical effects for better posterior sampling behavior. This presentation excludes final (hyper)priors.

Parameter estimation and inference

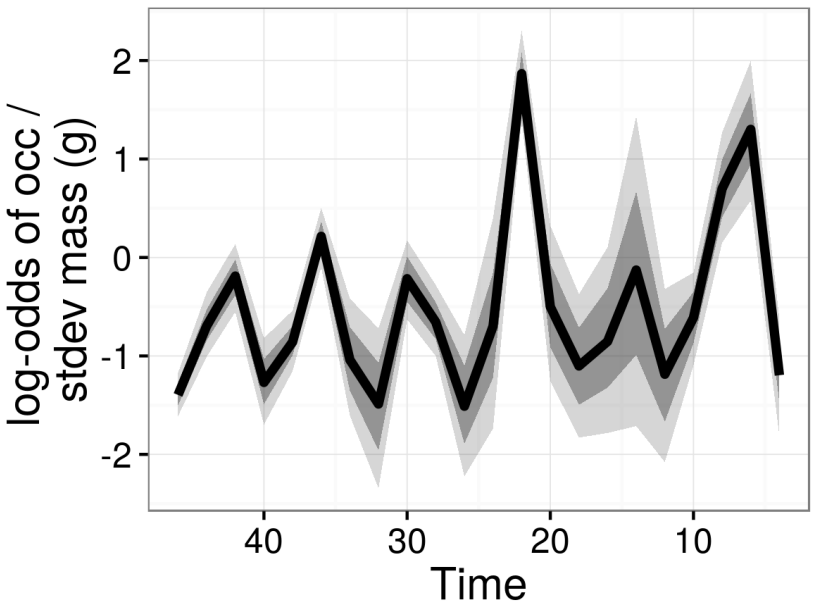
- full HMC/MCMC slow
- Automatic Differentiation Variational Inference (ADVI)
  - approximate Bayesian inference
  - assumes posterior is Gaussian, no correlation between parameters
  - true Bayesian posterior

Posterior predictive performance

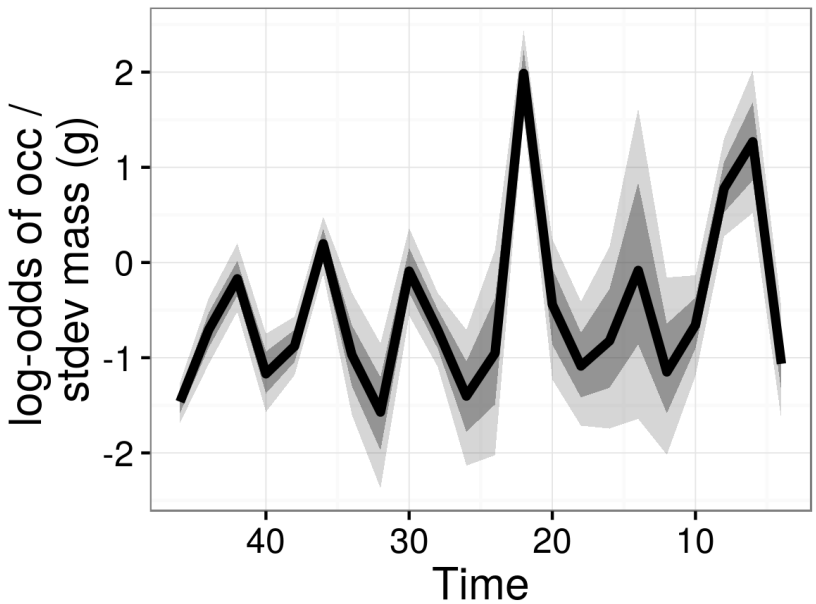


Effect of mass on log-odds of occurrence

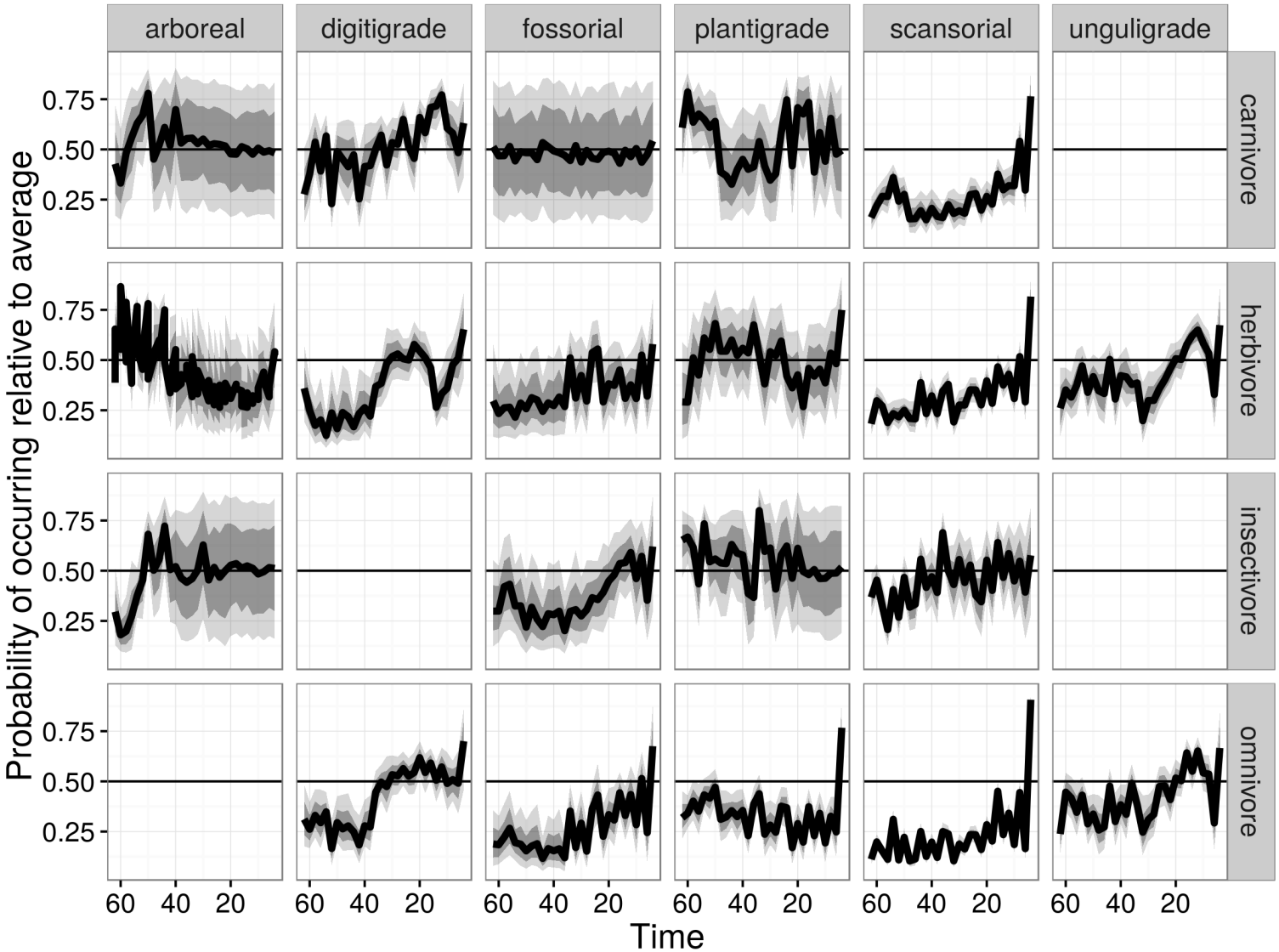
Basic model



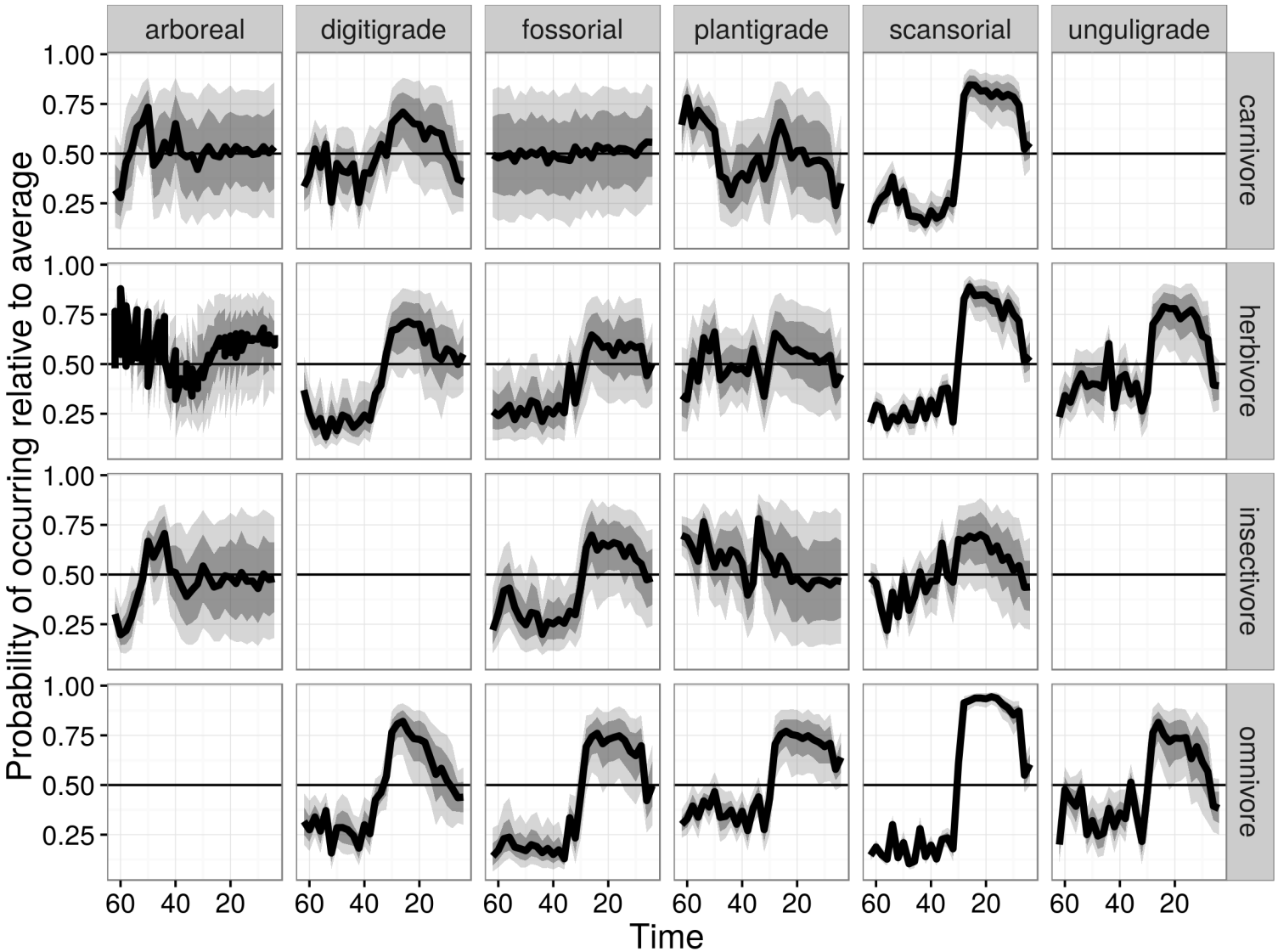
Full model



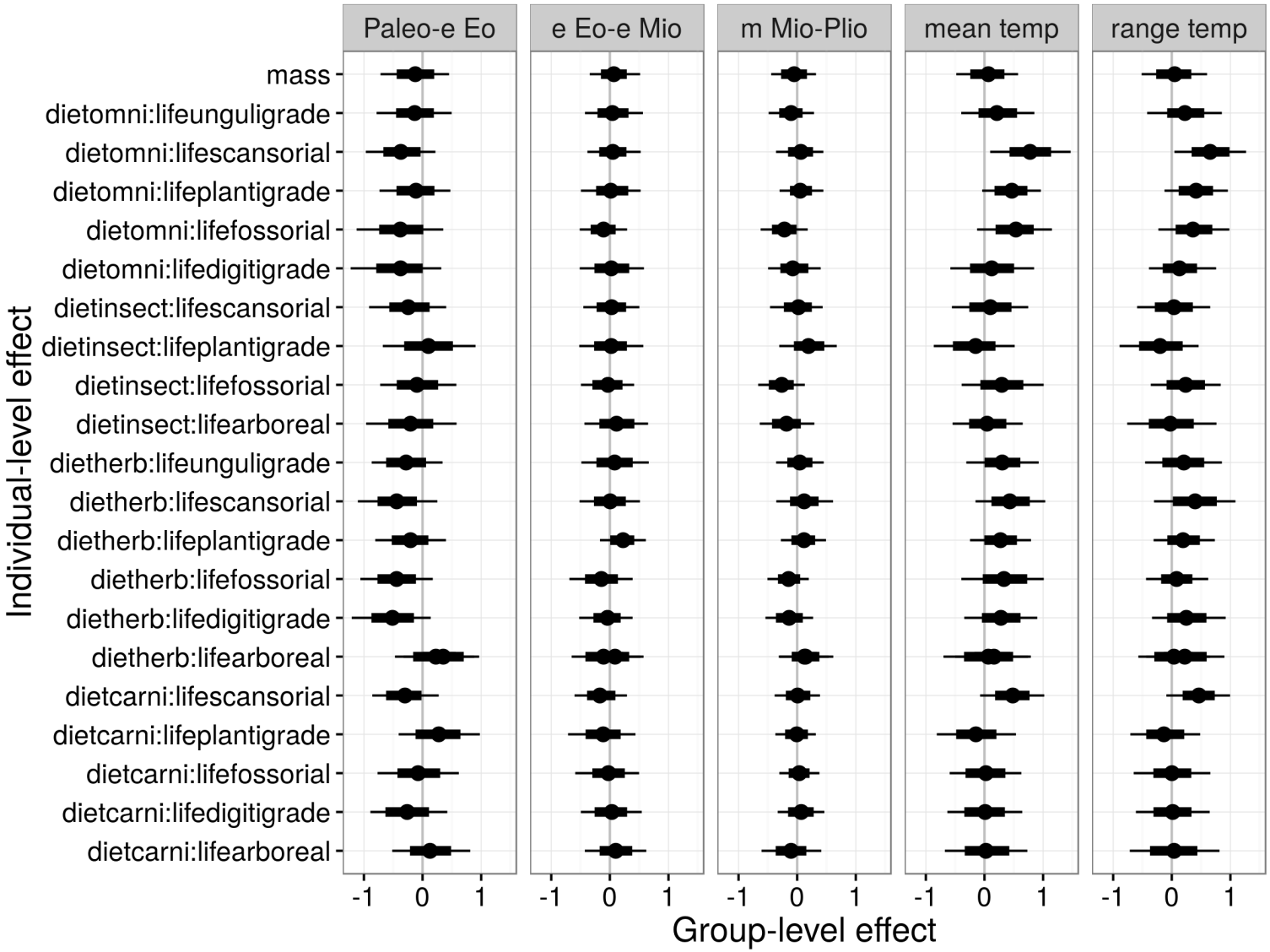
Probability occurrence is of ecotype (basic model)



Probability occurrence is of ecotype (full model)



Group-level effects (plant phase, climate)



Concerns and conclusions

- basic and full models have similar results until Neogene
- posterior predictive simulations disimilar to observed; poor model adequacy
  - previous work has *never* evaluated model adequacy
  - second-order Markov process?
  - full posterior inference?
- decreasing ability to discern arboreal taxa over time (absence/increased rarity)
- increase in scansorial taxa over time
- increase in herbivorous taxa over time
- plant phase has small, idiosyncratic effects

What's left with this project?

- full posterior inference
  - extremely slow b/c latent variables
  - *Folk Theory of Statistical Computing*?
- improve model structure
  - preservation as function of body size
  - second-order Markov process?
- write manuscript
  - no strong conclusions yet
  - journal target?

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Finishing

See “Timeline”

Options

- Finish in the Spring or finish in the Summer.
- Idea
  - Turn in, defend at end of Spring quarter.
  - Technically finish Summer quarter.
  - Unsure of details; need to contact Chair/Carolyn.