Last updated: December 16, 2020

Seed banks present a challenge for models of plant population demography. Individual seeds can not be tracked and it is likely that there is greater uncertainty associated with seed bank vital rates. Ecologists have turned to various methods to assess survival and germination from the seed bank, including experimental burials and seed addition experiments.

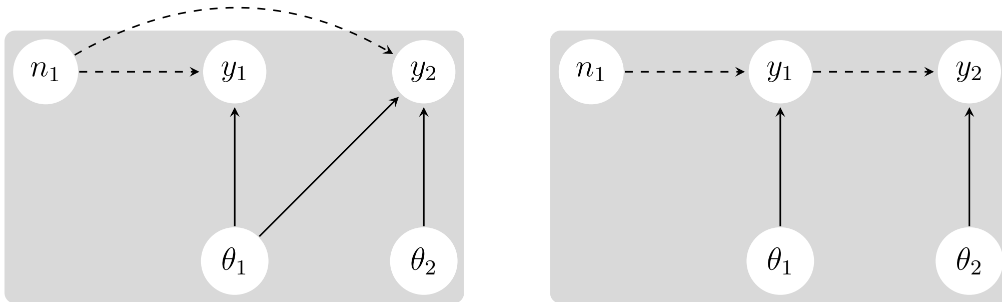
The models below represent the joint likelihood for data from the seed bag experiments. All data from seed bags and viability trials is in the form of binomial trials: we have counts of seeds at the start and end of an experimental window of time. All models for the parameters $\theta_1, \theta_2, \theta_3, \theta_4, \theta_5$ have the same structure for seeds in bag i in year j in population k. If the number of seeds starting the trial (trials) is n_{ijk} and the number of seeds at the end of the trial (successes) is y_{ijk}, we write a model that has a population-level mean and year-level means drawn from the population-level distribution. The probability of success for each bag is drawn from this year- and population-level distribution:

I compared convergence diagnostics (R-hat, effective sample size) for centered and non-centered parameterizations of the model. Here, I use the centered parameterization because this led to improved convergence. In each model, we obtain the population-level posterior distribution probability of success (the θs) by marginalizing across years and taking the inverse logit.

Table 1: Summary of models.

Model	Description
Exponential	...
Compound exponential	...
Weibull	...
Log logistic	...

Identifiability within years

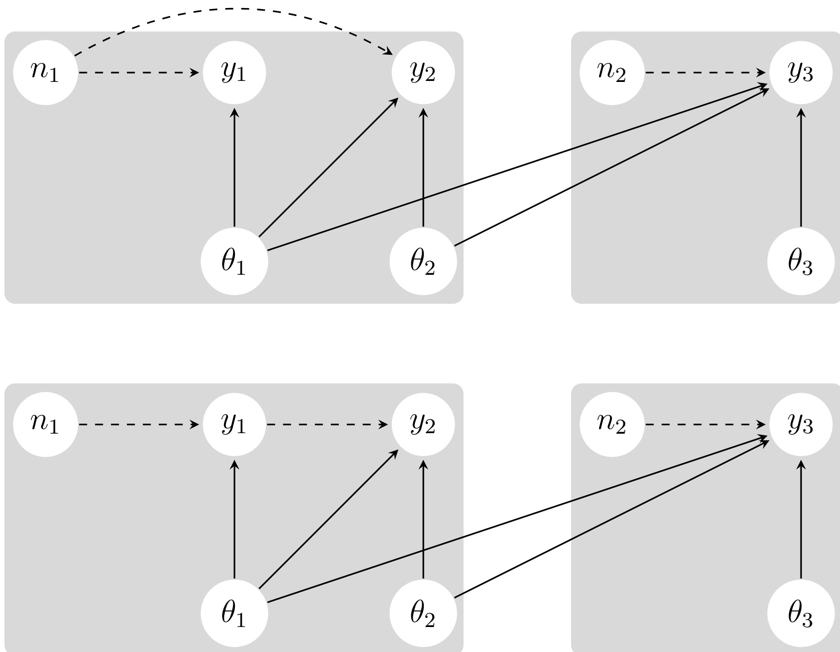


(a) Directed acyclic graphs for the hierarchical models for seed bag rates. Solid arrows depict the relationships among random variables, and dashed arrows depict the deterministic relationships.

$$
\begin{aligned}
[\theta_1, \theta_2 | \boldsymbol{y_1}, \boldsymbol{y_2}] \propto\ & \text{binomial}(y_1 | n_1, \text{logit}^{-1}(\alpha_1)) \\
& \times \text{binomial}(y_2 | n_1, \text{logit}^{-1}(\alpha_1) \times \text{logit}^{-1}(\alpha_2)) \\
& \times \text{normal}(\alpha_1 | \mu_1, \sigma_1) \text{normal}(\alpha_2 | \mu_2, \sigma_2) \\
& \times \text{normal}(\mu_1 | 0, 1000) \text{half-normal}(\sigma_1 | 0, 1) \\
& \times \text{normal}(\mu_2 | 0, 1000) \text{half-normal}(\sigma_2 | 0, 1).
\end{aligned} \tag{1}
$$

$$
\begin{aligned}
[\theta_1, \theta_2 | \boldsymbol{y_1}, \boldsymbol{y_2}] \propto\ & \text{binomial}(y_1 | n_1, \text{logit}^{-1}(\alpha_1)) \\
& \times \text{binomial}(y_2 | y_1, \text{logit}^{-1}(\alpha_2)) \\
& \times \text{normal}(\alpha_1 | \mu_1, \sigma_1) \text{normal}(\alpha_2 | \mu_2, \sigma_2) \\
& \times \text{normal}(\mu_1 | 0, 1000) \text{half-normal}(\sigma_1 | 0, 1) \\
& \times \text{normal}(\mu_2 | 0, 1000) \text{half-normal}(\sigma_2 | 0, 1).
\end{aligned} \tag{2}
$$

Identifiability across years

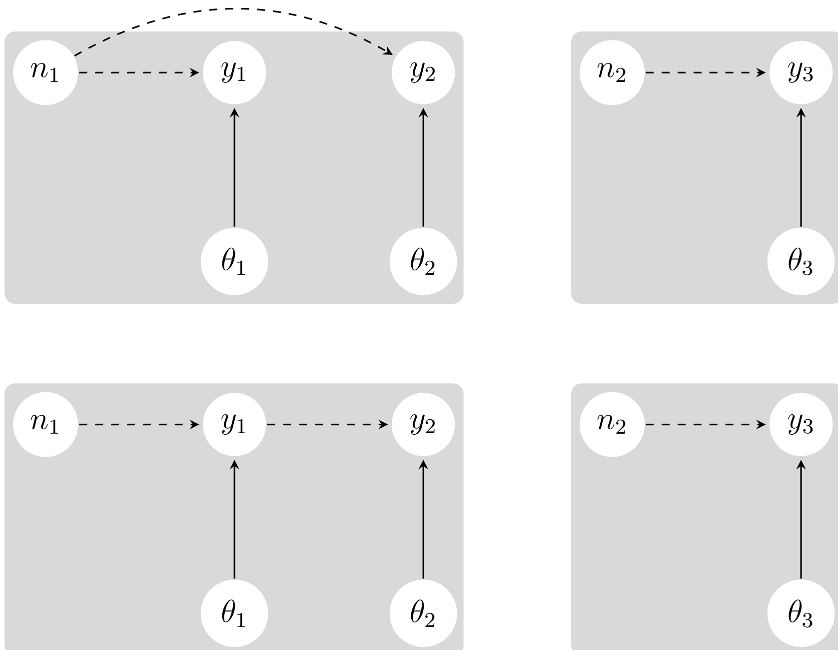


(a) Directed acyclic graphs for the hierarchical models for seed bag rates. Solid arrows depict the relationships among random variables, and dashed arrows depict the deterministic relationships.

$$
\begin{aligned}
[\theta_1, \theta_2 | \boldsymbol{y_1}, \boldsymbol{y_2}] \propto\ & \text{binomial}(y_1 | n_1, \text{logit}^{-1}(\alpha_1)) \\
& \times \text{binomial}(y_2 | n_1, \text{logit}^{-1}(\alpha_1) \times \text{logit}^{-1}(\alpha_2)) \\
& \times \text{normal}(\alpha_1 | \mu_1, \sigma_1)\text{normal}(\alpha_2 | \mu_2, \sigma_2) \\
& \times \text{normal}(\mu_1 | 0, 1000)\text{half-normal}(\sigma_1 | 0, 1) \\
& \times \text{normal}(\mu_2 | 0, 1000)\text{half-normal}(\sigma_2 | 0, 1).
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
[\theta_1, \theta_2 | \boldsymbol{y_1}, \boldsymbol{y_2}] \propto\ & \text{binomial}(y_1 | n_1, \text{logit}^{-1}(\alpha_1)) \\
& \times \text{binomial}(y_2 | y_1, \text{logit}^{-1}(\alpha_2)) \\
& \times \text{normal}(\alpha_1 | \mu_1, \sigma_1)\text{normal}(\alpha_2 | \mu_2, \sigma_2) \\
& \times \text{normal}(\mu_1 | 0, 1000)\text{half-normal}(\sigma_1 | 0, 1) \\
& \times \text{normal}(\mu_2 | 0, 1000)\text{half-normal}(\sigma_2 | 0, 1).
\end{aligned} \tag{4}
$$

Exponential decay



(a) Directed acyclic graphs for the hierarchical models for seed bag rates. Solid arrows depict the relationships among random variables, and dashed arrows depict the deterministic relationships.