Eqn. 1 Data generating process for snails

$$y_{ij} = \beta_0 = \beta_1 x_{ij} + \gamma w_i + \epsilon_{ij} \tag{1}$$

Eqn. 2 Naive model

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + \epsilon_{ij} \tag{2}$$

Eqn. 3 Random effects/mixed model

$$\begin{aligned} y_{ij} &= \beta_0 + \beta_1 x_{ij} + \delta_i + \epsilon_{ij} \\ \delta_i &\sim \mathcal{N}\left(0, \sigma^2_{site}\right) \\ \epsilon_{ij} &\sim \mathcal{N}\left(0, \sigma^2\right) \end{aligned} \tag{3}$$

Eqn. 4 Model separating plot and site error

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + \epsilon_{ij} + \ u_i \tag{4}$$

Eqn. 5 Fixed Effects Transformation

$$\begin{aligned} y_{ij} - \overline{y_i} &= \beta_1 \left(x_{ij} - \overline{x_i}\right) + \left(\epsilon_{ij} - \overline{\epsilon_i}\right) + \left(u_i - \overline{u_i}\right) \\ &= \beta_1 \left(x_{ij} - \overline{x_i}\right) + \left(\epsilon_{ij} - \overline{\epsilon_i}\right) \end{aligned} \tag{5}$$

Eqn. 6 Fixed Effects Dummy and Means Models

$$\begin{aligned} y_{ij} &= \beta_1 x_{1ij} + \sum \lambda_i x_{2i} + \epsilon_{ij} \\ &= \beta_1 x_{1ij} \ + \lambda_i + \epsilon_{ij} \end{aligned} \tag{6}$$

Eqn. 7 Group Mean Covariate Model/Mundlak Device

$$\begin{aligned} y_{ij} &= \beta_0 + \beta_1 x_{ij} + \beta_2 \overline{x_i} + \delta_i + \epsilon_{ij} \\ \delta_i &\sim \mathcal{N}\left(0, \sigma^2_{site}\right) \\ \epsilon_{ij} &\sim \mathcal{N}\left(0, \sigma^2\right) \end{aligned} \tag{7}$$

Eqn. 8 Group Mean Centered Model

$$y_{ij} = \beta_0 + \beta_1 \left(x_{ij} - \overline{x_i}\right) + \beta_2 \overline{x_i} + \delta_i + \epsilon_{ij} \tag{8}$$

Eqn. 9 First Differences Model

$$\begin{aligned} y_{ij} - \ y_{i(j-1)} &= \beta_1 x_{1ij} - \beta_1 x_{1i(j-1)} + \lambda_i j - \lambda_i (j-1) + \epsilon_{ij} - \epsilon_{i(j-1)} \\ \Delta y_{ij} &= \beta_1 \Delta x_{1ij} + \lambda_i + \Delta \epsilon_{ij} \end{aligned} \tag{9}$$

Box 2, Eqn. 1

$$y_{ijk} = \ \beta_1 x_{1ijk} \ + \lambda_k + \ \eta_{ij} \ + \epsilon_{ijk}$$

Box 2, Eqn. 2

$$y_{ijk} = \beta_0 + \beta_1 x_{ijk} + \beta_2 \overline{x_k} + \beta_3 \overline{x_{ij}} + \delta_k + \delta_{ij} + \epsilon_{ijk}$$