Model for Estimating Abundance of Parturient Females: Take 2

$$
\begin{aligned}
y_{it} &\sim \begin{cases} 0 & , z_{it} = 0 \\ \text{Bern}(p) & , z_{it} = 1 \end{cases} \\
z_{it} &\sim \begin{cases} 0 & , r_{it} = 0 \\ \text{Bern}(\phi_{it}) & , r_{it} = 1 \end{cases} \\
r_{it} &\sim \text{Bern}(\psi_{it})
\end{aligned}
$$

$$
\begin{aligned}
p &\sim \text{Beta}(\alpha_p, \beta_p) \\
\text{logit}(\phi_{it}) &= \mathbf{x}_{it}^T \boldsymbol{\beta} \\
\text{logit}(\psi_{it}) &= \mathbf{w}_{it}^T \boldsymbol{\alpha} \\
\boldsymbol{\beta} &\sim \text{N}(\boldsymbol{\mu}_\beta, \Sigma_\beta) \\
\boldsymbol{\alpha} &\sim \text{N}(\boldsymbol{\mu}_\alpha, \Sigma_\alpha)
\end{aligned}
$$

Notation:
parturient: a female is parturient in a given year if she gave birth that year

parturient females in year t are individuals $i = 1, \ldots, n_t, \ldots, N_t, \ldots, M_t$
n_t is the number of observed parturient females in year t
N_t is the total abundance of parturient females in year t
M_t is the augmented data for year t
t is years

y_{it} indicates if individual i was sighted with a pup in year t
z_{it} indicates if individual i **survived and had a pup** in year t
r_{it} indicates if individual i was recruited into the reproducing population in year t
p is probability of detecting an individual with her pup
ϕ_{it} is the probability of individual i surviving from year $t-1$ to year t and having a pup in year t
ψ_{it} is the probability that individual i was recruited into the reproducing population in year t

Derived quantity:

$N_t = \sum_{i=1}^{M} z_{it}$ is the abundance of parturient females in year t

Thoughts
What are the covariates you want to include? If we only look at age and el nino then these only differ by year, not individual, and we can make p, ψ, and ϕ only differ across years.

Do we need to augment the data at all? I think I'm getting my models confused. If we are summing z_i's I don't think we actually have to augment it at all. Right?