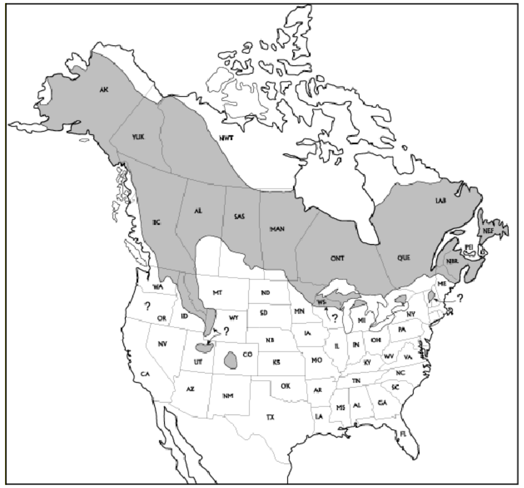
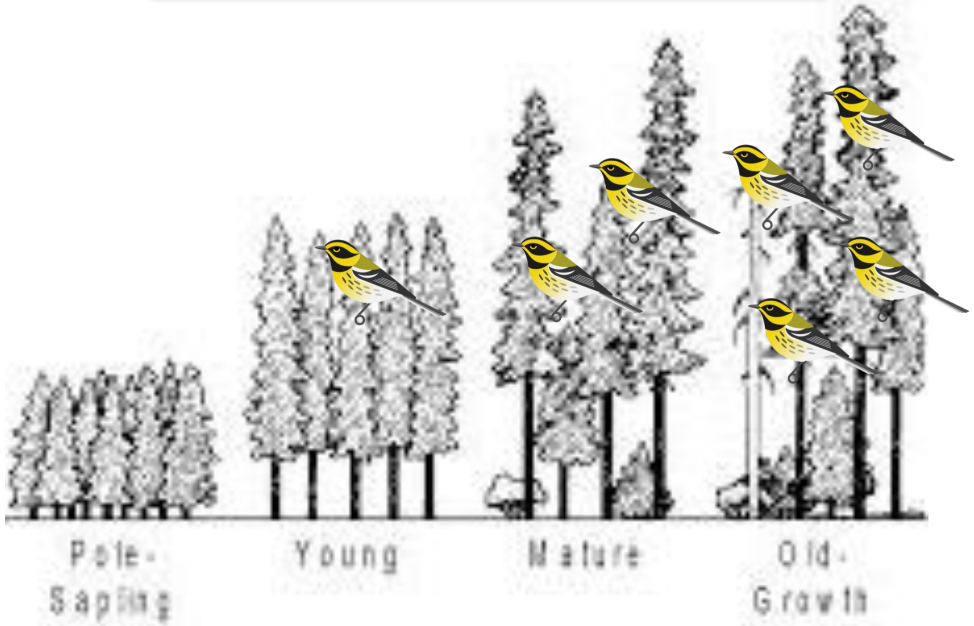
Using SEMs to model occupancy and species interactions



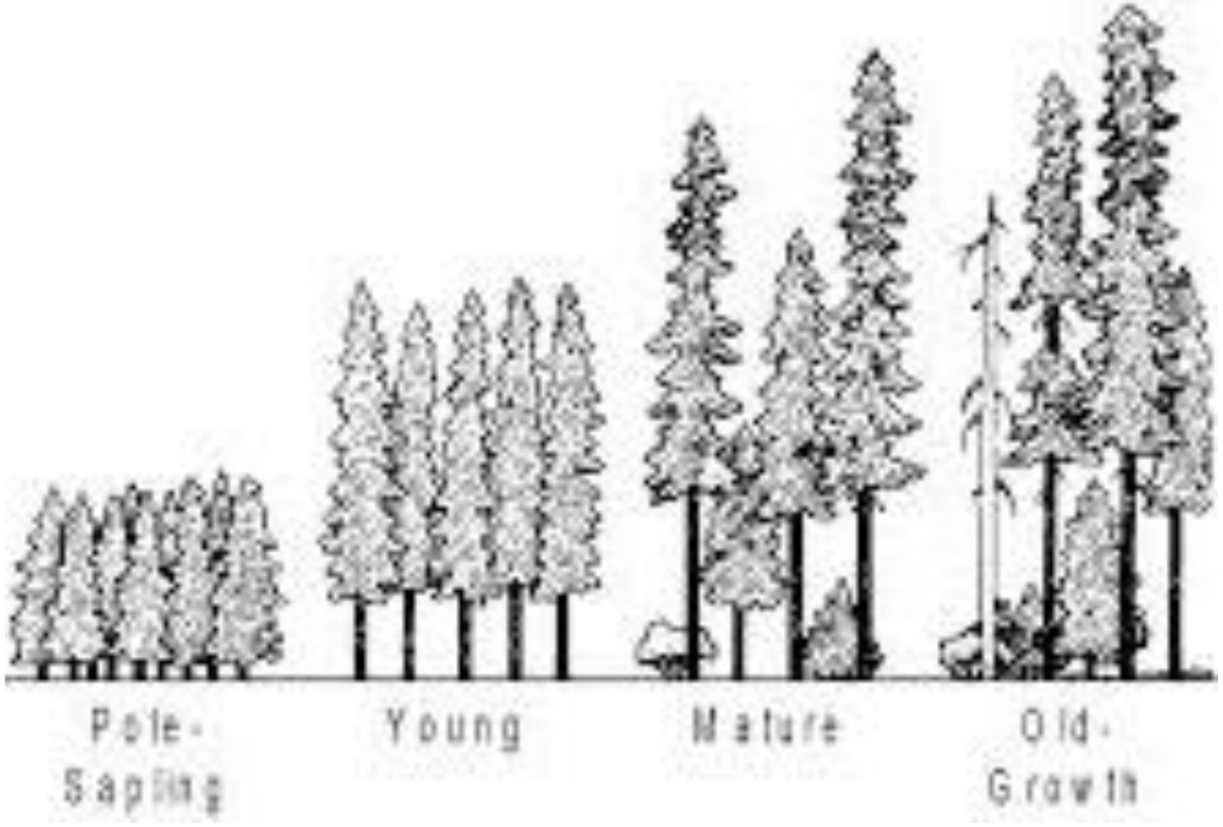


Two exercises today…

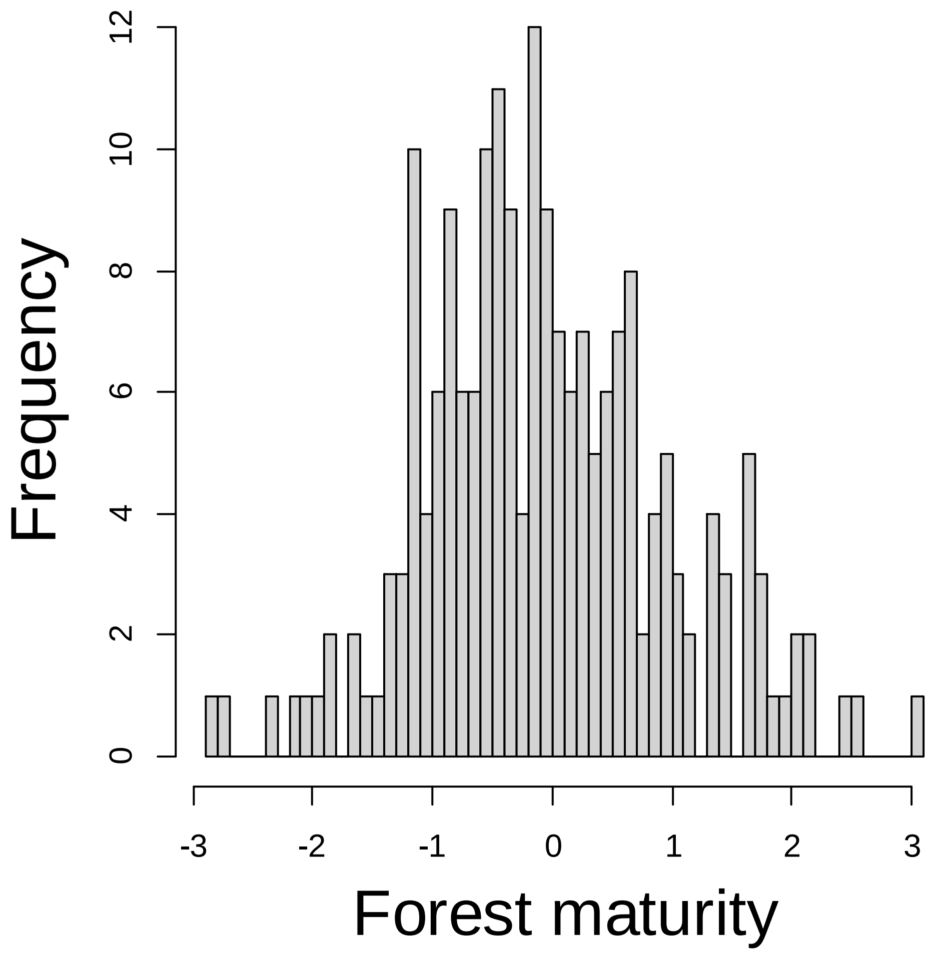
1. Townsend's warbler occupancy

2. Felid occupancy and competition

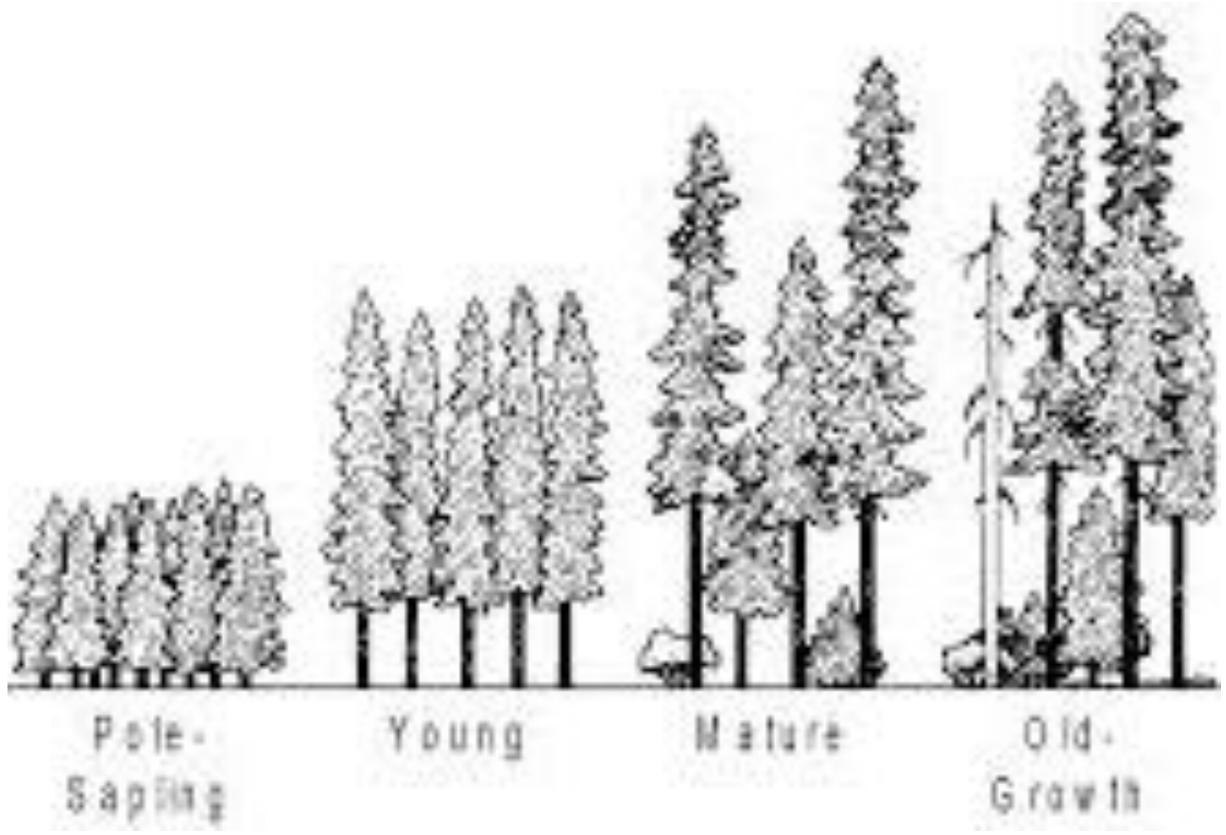
Townsend’s warbler example



Step 1: simulate variation in forest maturity



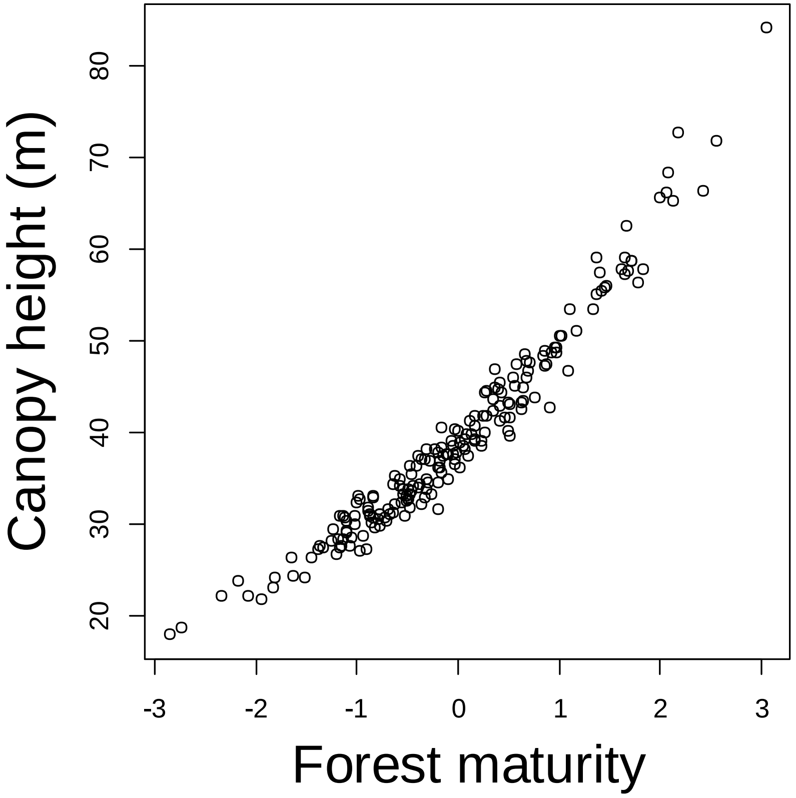
$$\boldsymbol{m} \sim \text{normal}(0, 1)$$

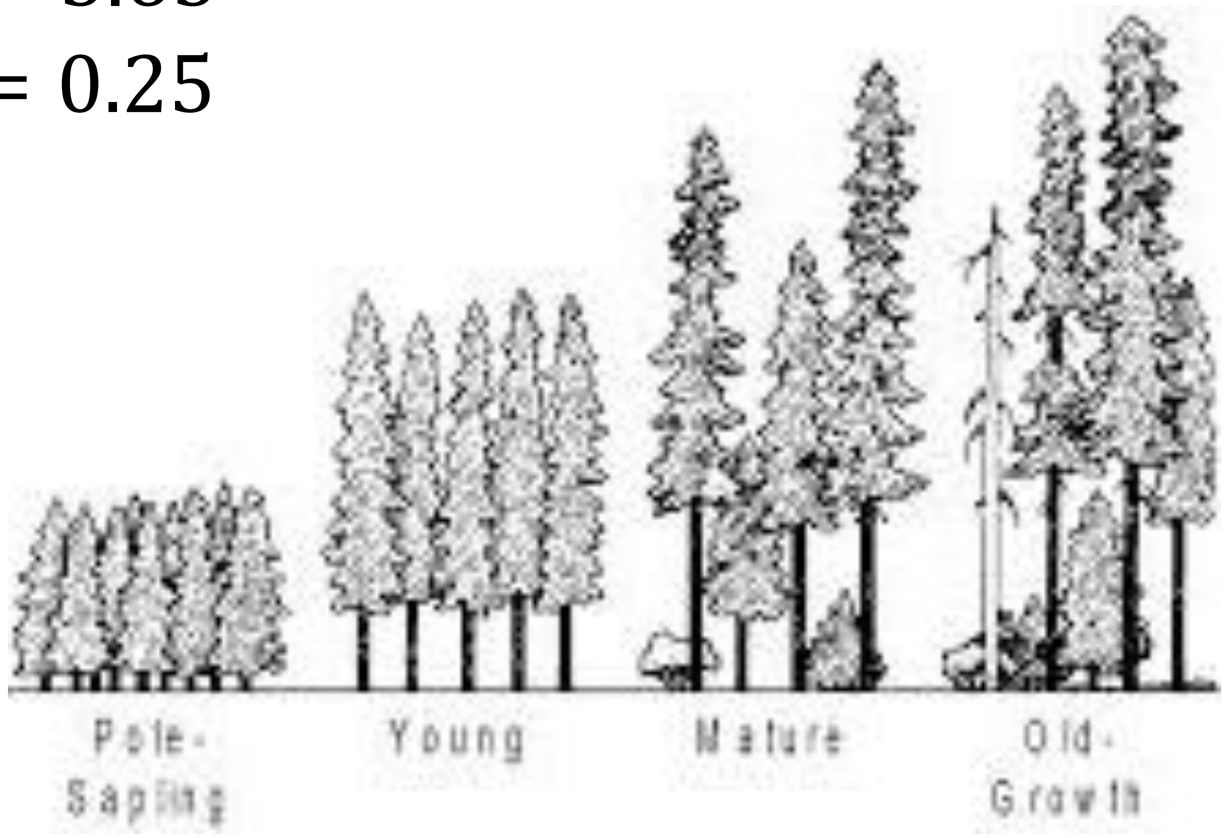


Step 2: simulate variation in canopy height (c)

$$\boldsymbol{c} \sim \text{lognormal}(\alpha_1 + \beta_1 \boldsymbol{m}, \sigma_c = 0.05)$$

$$\alpha_1 = 3.65$$
$$\beta_1 = 0.25$$

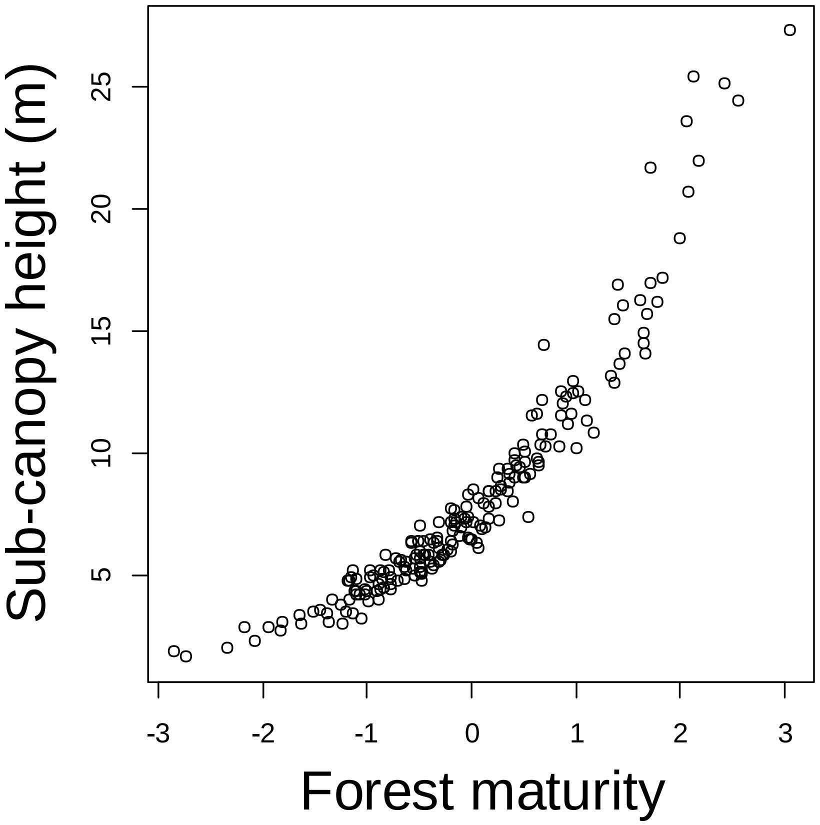


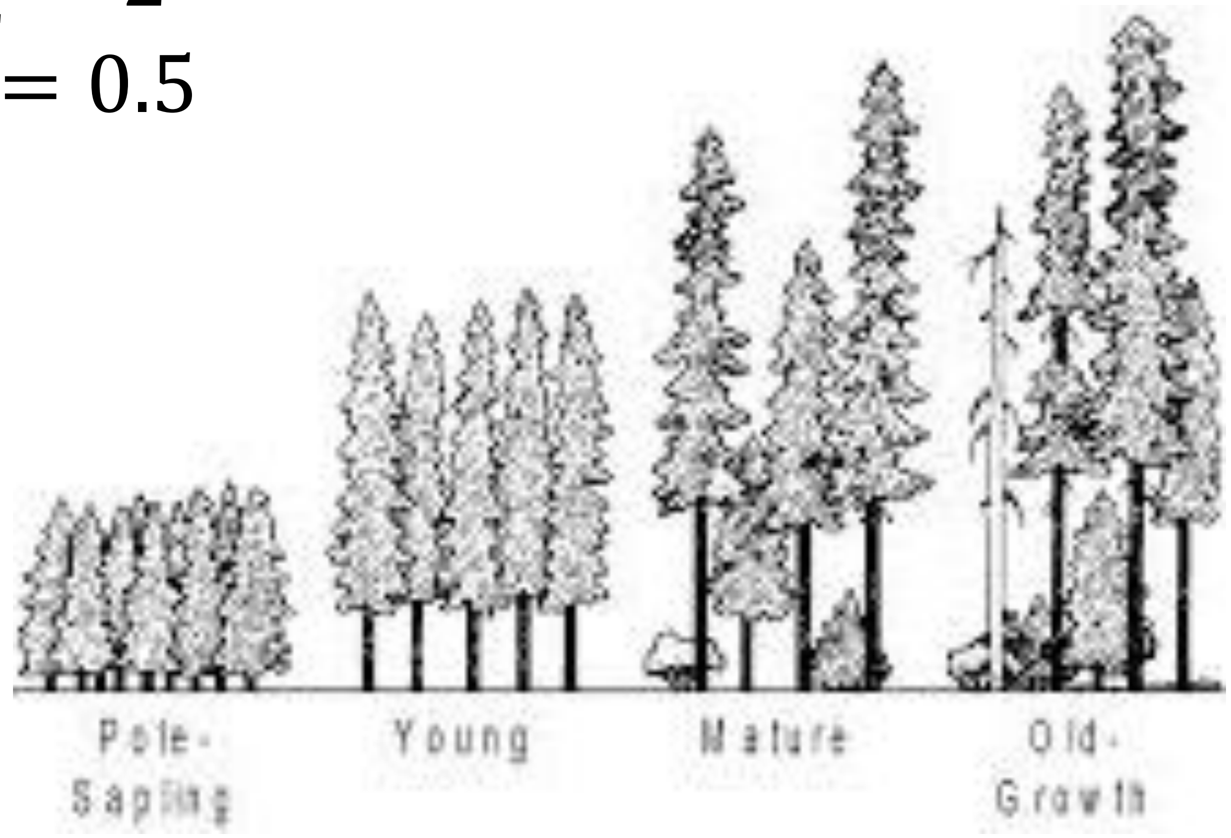


Step 3: simulate variation in sub-canopy height (s)

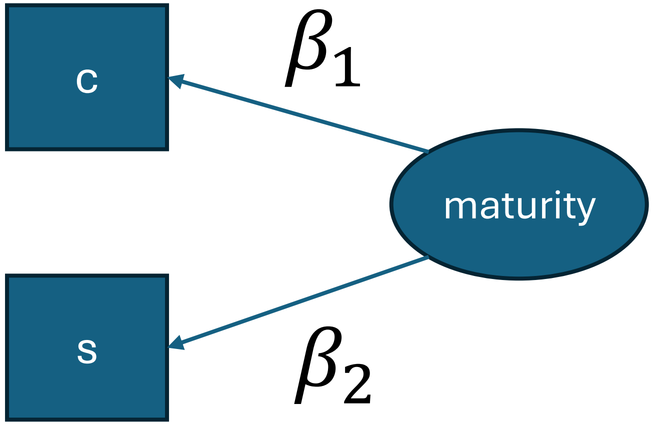
$$\boldsymbol{s} \sim \text{lognormal}(\alpha_2 + \beta_2 \boldsymbol{m}, \sigma_s = 0.05)$$

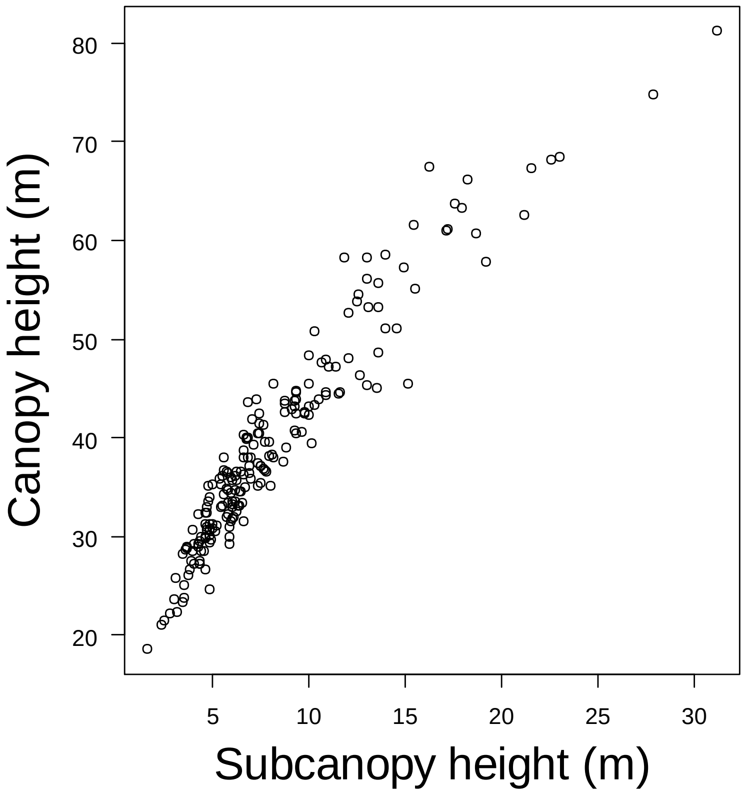
$$\alpha_2 = 2$$
$$\beta_2 = 0.5$$



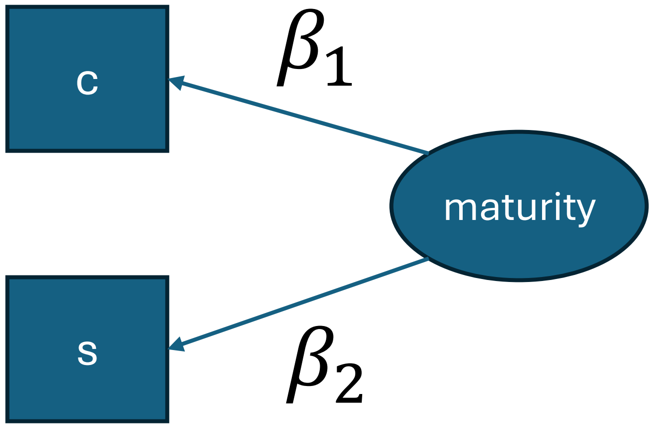


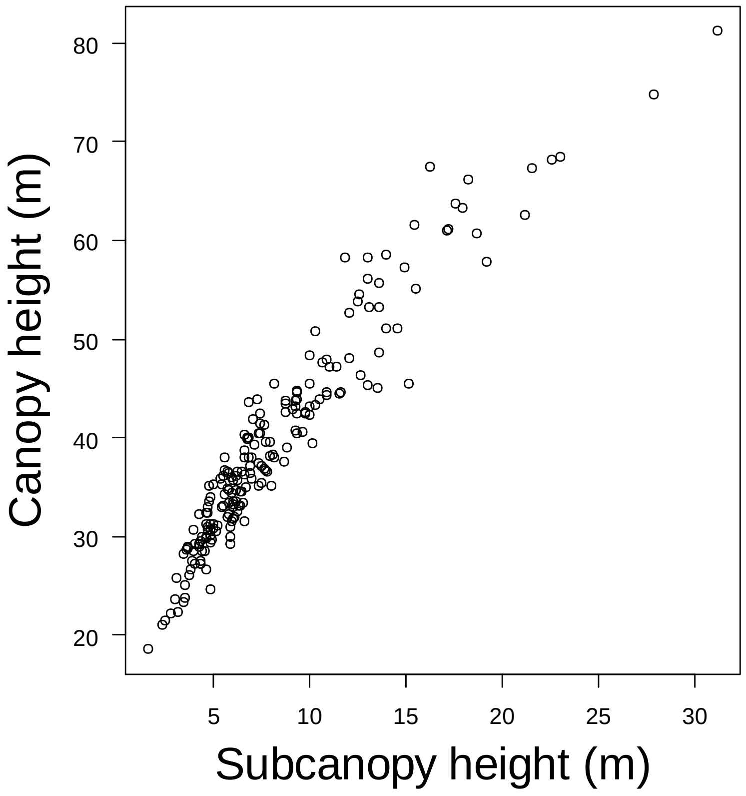
The hypothesis: older forests will have greater canopy heights and greater sub-canopy heights





<u>The most important caveat</u>: if things aren't collinear, then you can't assign them to a latent variable

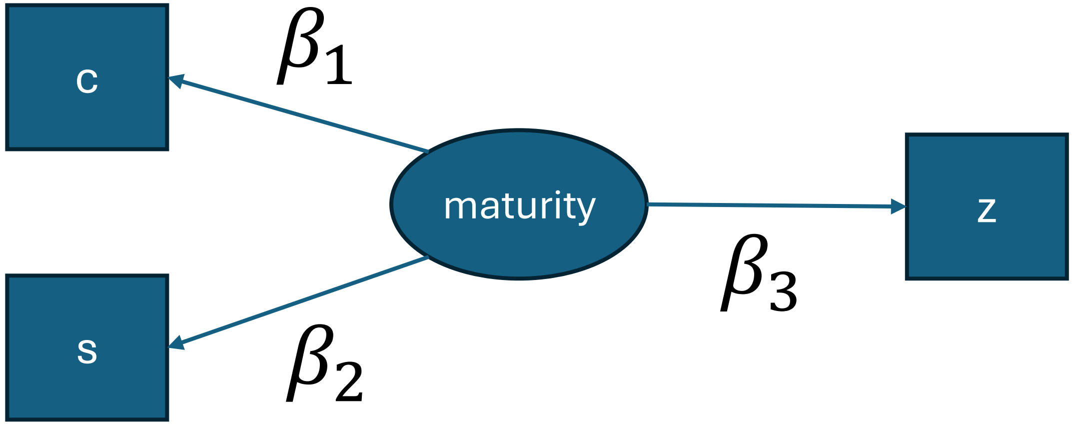


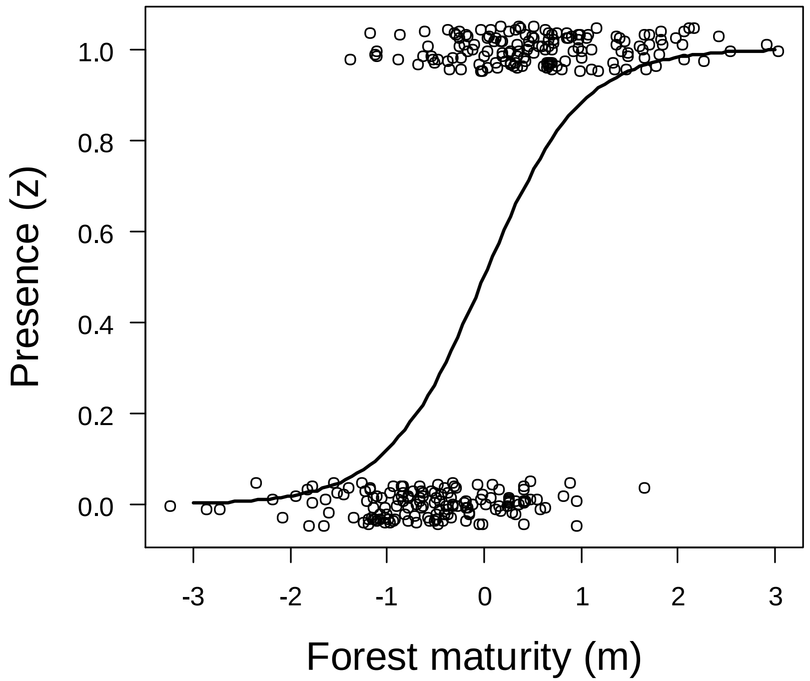


Step 4: simulate variation in warbler occupancy (z)

$$\boldsymbol{z} \sim \text{Bernoulli}(\text{logit}^{-1}(\alpha_3 + \beta_3 \boldsymbol{m}))$$

$$\alpha_3 = 0$$
$$\beta_3 = 2$$





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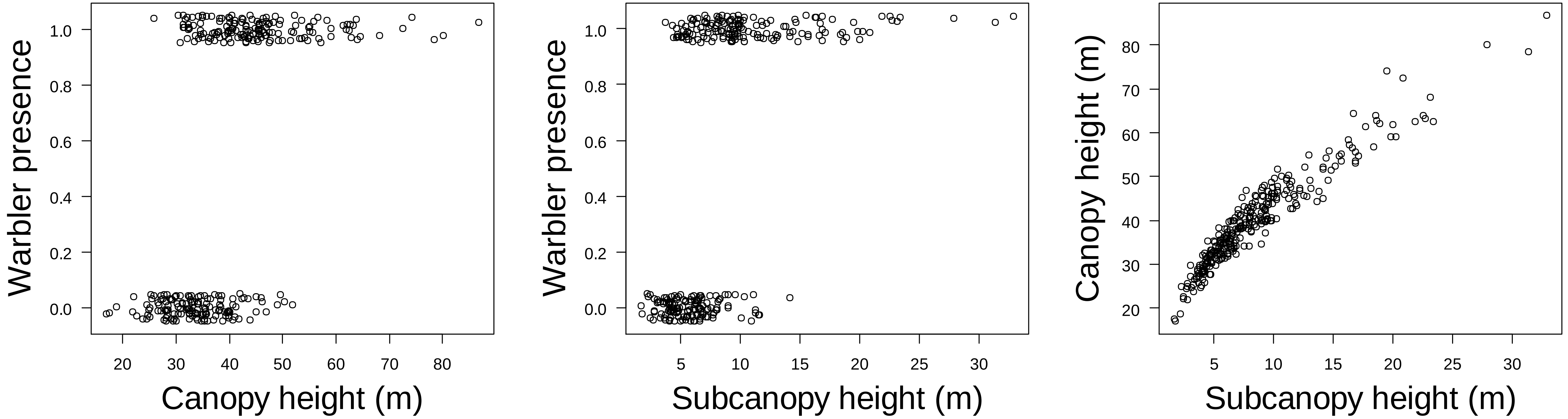

Step 5: simulate detection* data (y)

$$\boldsymbol{y} \sim \text{binomial}(\boldsymbol{z} \times v, p)$$

$$p = 0.35$$

$$v = 5$$

So… if warblers aren't there (z = 0), we won't see them

$$\boldsymbol{y} \sim \text{binomial}(\boldsymbol{0} \times v, p)$$

$$v = 5$$

$$p = 0.35$$

$$\boldsymbol{y} \sim \text{binomial}(\boldsymbol{z} \times v, p)$$

If they are there (z = 1), we'll see them 0 to 5 times

$$\boldsymbol{y} \sim \text{binomial}(\mathbf{1} \times v, p)$$

$$v = 5$$

$$p = 0.35$$

$$\boldsymbol{y} \sim \text{binomial}(\boldsymbol{z} \times v, p)$$

A quick primer on occupancy models

$$y_1 = [1, 0, 0, 0, 0, 0, 0, 1, 0, 0] \qquad z_1 = 1$$

$$y_2 = [0] \qquad z_2 = ?$$

Survey data for the same species at two sites, is it present at site 2?

A quick primer on occupancy models

$$y_1 = [1, 1, 1, 1, 1, 1, 1, 1, 1, 1] \qquad z_1 = 1$$

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A quick primer on occupancy models

$$y_1 = [1, 0, 0, 0, 0, 0, 0, 1, 0, 0]$$
$$y_2 = [0]$$

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Survey data for the same species at two sites, is it present at site 2?

A quick primer on occupancy models

$$y_1 = [1, 1, 1, 1, 1, 1, 1, 1, 1, 1]$$
$$y_2 = [0]$$

$$z_1 = 1$$
$$z_2 = ?$$

Survey data for the same species at two sites, is it present at site 2?

A quick primer on occupancy models

Ecological process

$$\boxed{\boldsymbol{z} \sim \mathrm{Bernoulli}(\mathrm{logit}^{-1}(\alpha_3 + \beta_3 \boldsymbol{m}))}$$

Is this species even present?

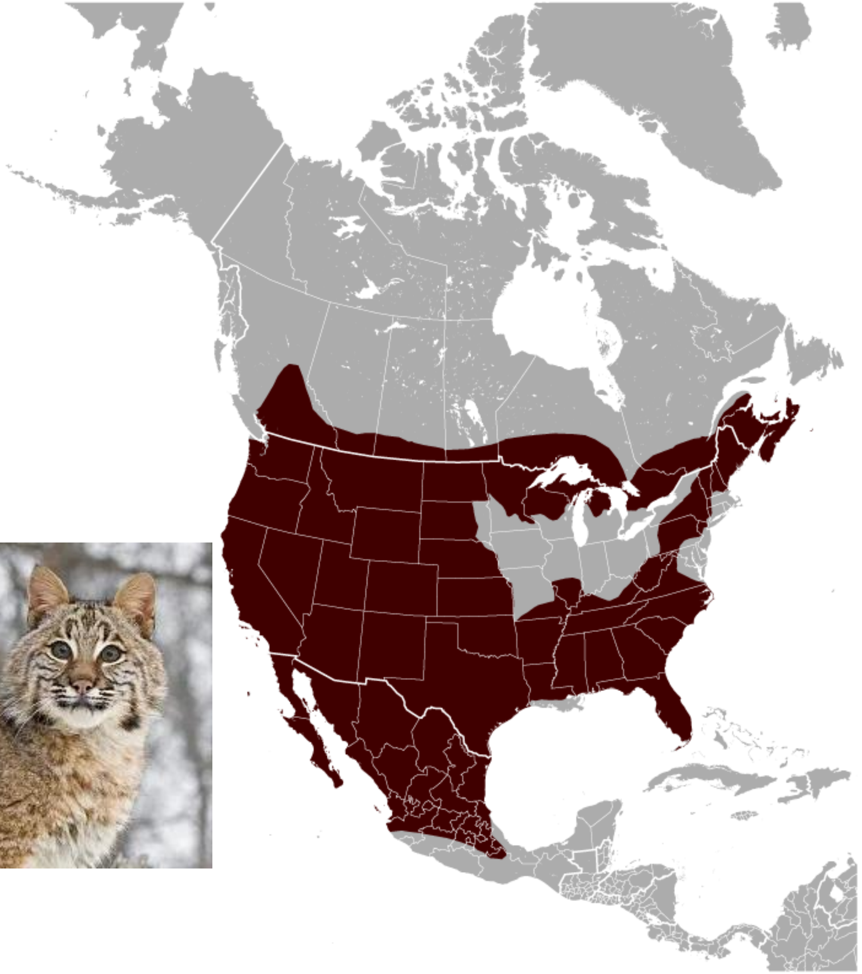
Observation process

$$\boxed{\boldsymbol{y} \sim \mathrm{binomial}(\boldsymbol{z} \times v, p)}$$

Did we detect it?

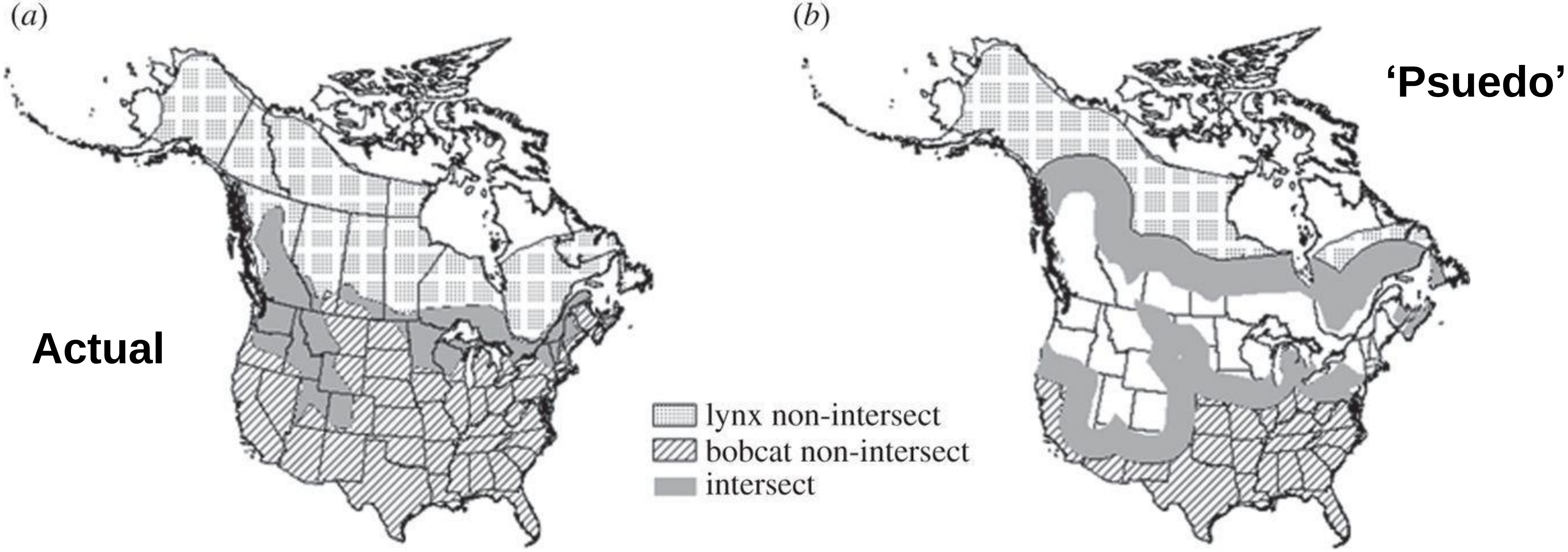
Let’s go to the code, but first cats!

Occupancy of competing felids (bobcat [*Lynx rufus*] **and lynx** [*Lynx lynx*]**)**



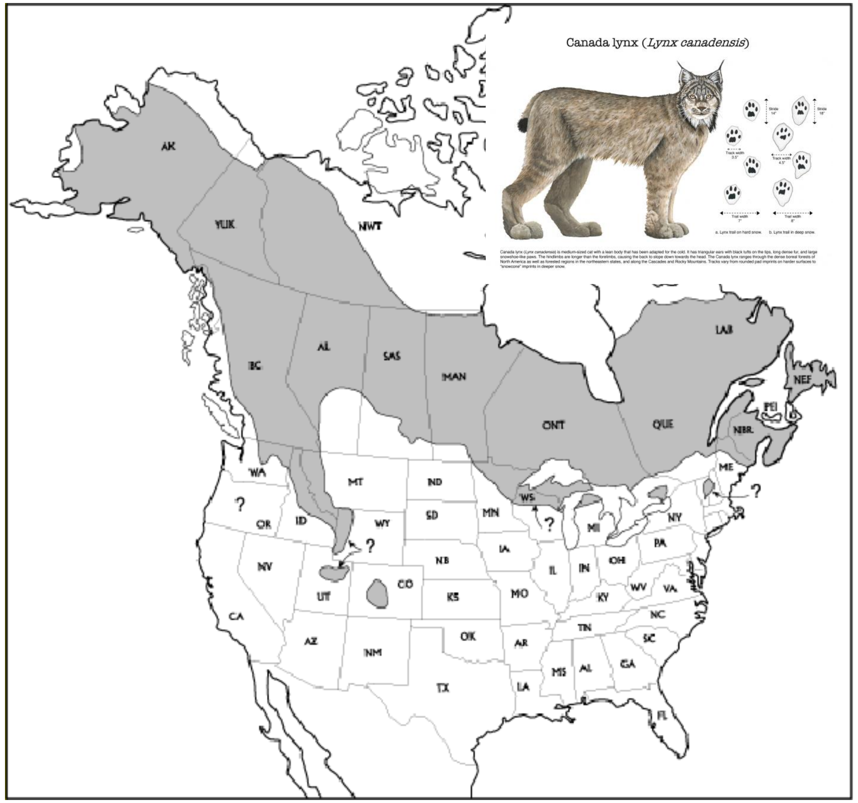
Peers, Thornton, and Murray **(2013)** *Proceedings B*

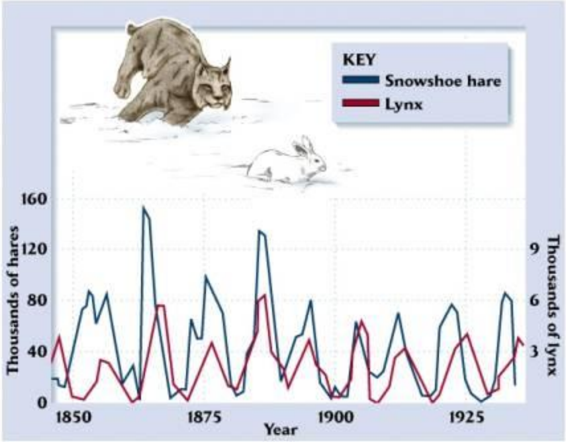
Occupancy of competing felids (bobcat [*Lynx rufus*] **and lynx** [*Lynx lynx*]**)**



Peers, Thornton, and Murray **(2013)** *Proceedings B*

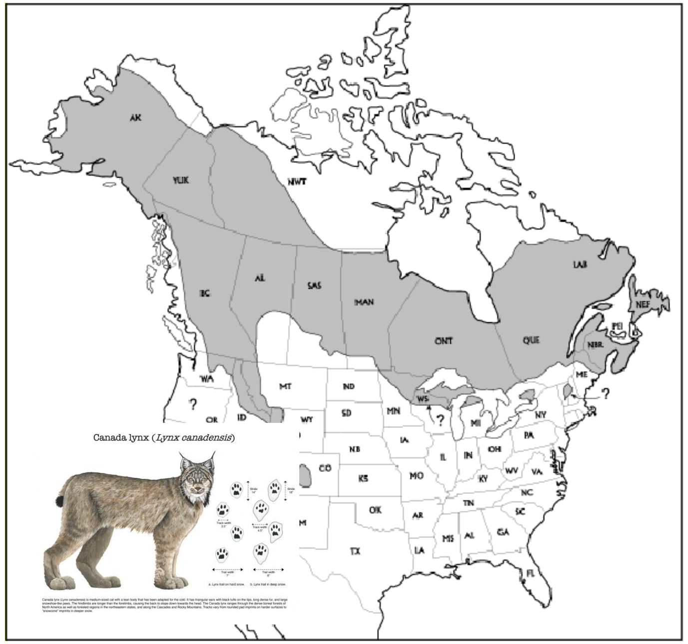
Mechanisms: Prey availability (snowshoe hare; *Lepus americanus*)



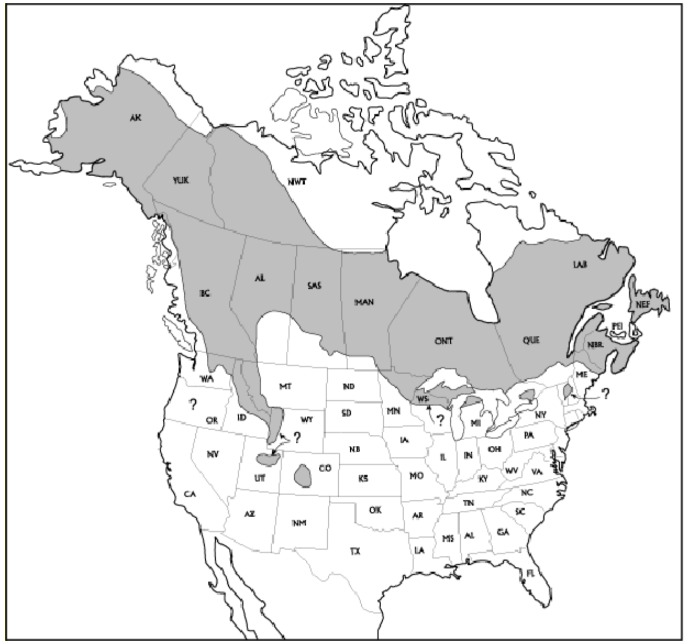


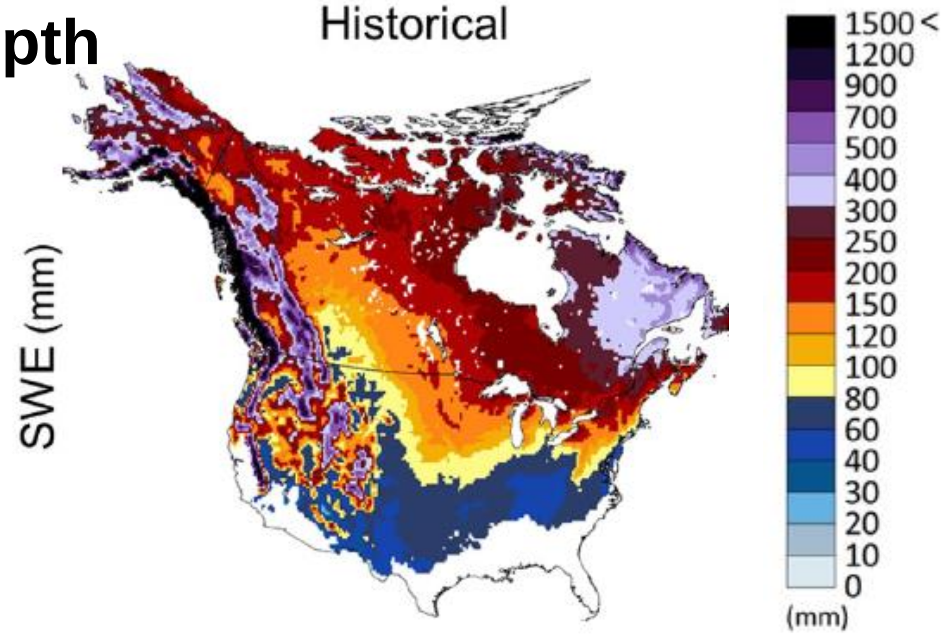
Peers, Thornton, and Murray **(2013)** *Proceedings B*

Mechanisms: Boreal (and montane) forest

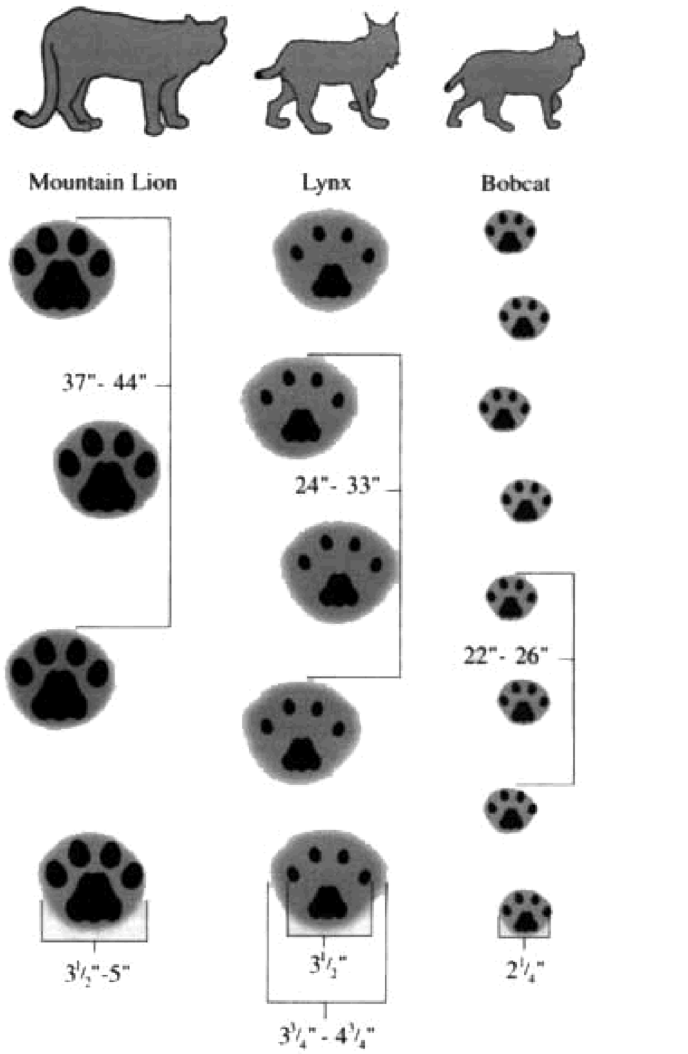


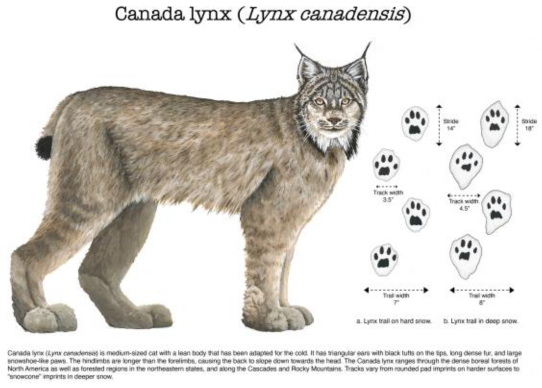
Mechanisms: Snow depth



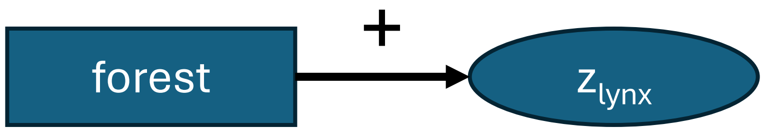


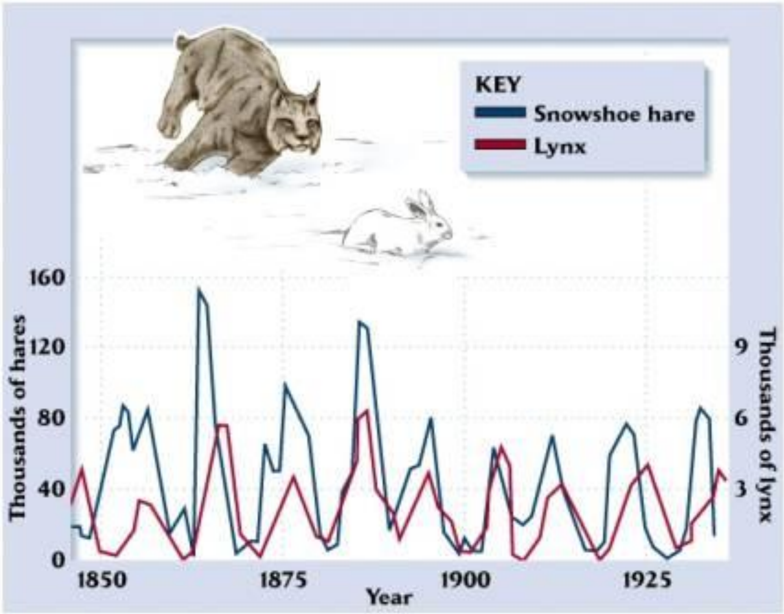
30-100kg **8-14 kg** **6-15 kg**



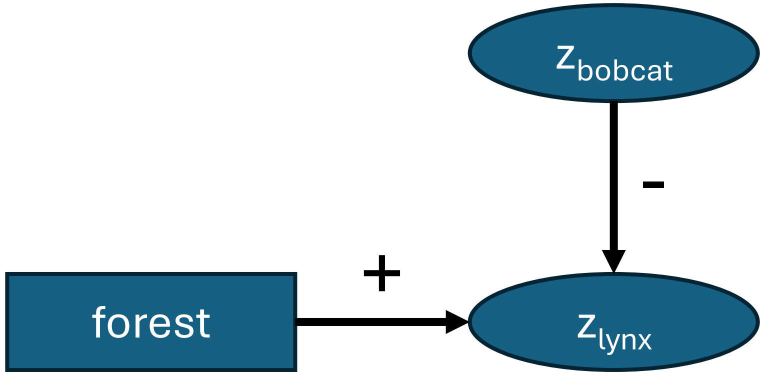


Hypothesis 1: Forests are good for lynx





Hypothesis 2: Bobcats compete with lynx



Evidence for large-scale effects of competition: niche displacement in Canada lynx and bobcat

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[2]School of Environment, Washington State University, Pullman, WA, USA
[3]Panthera, 8 West 40th Street, New York, NY, USA

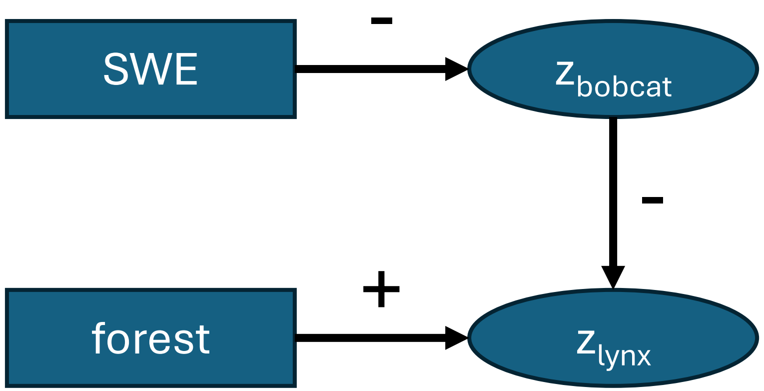
ORIGINAL RESEARCH

Ecology and Evolution WILEY

Fine-scale habitat selection by sympatric Canada lynx and bobcat

Samantha J. Morin[1] | Jeff Bowman[1,2] | Robby R. Marrotte[1] | Marie-Josée Fortin[3]

Hypothesis 3: Deep snow is bad for bobcats, but not for lynx



Criticize this model! (in small groups)