Section 5: Path analysis and handling real data

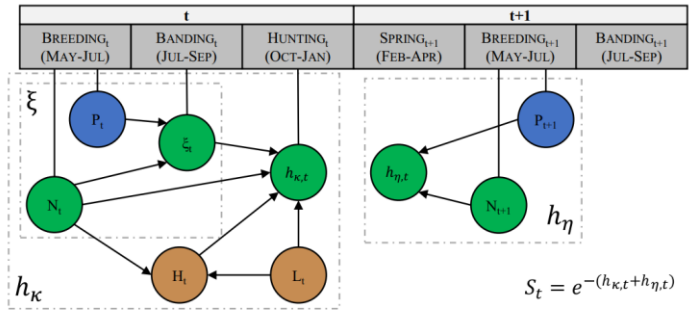


FIGURE 2 Directed acyclic graph demonstrating the hypothesized relationships among mallard breeding pair abundance (N), the number of ponds (P), harvest limits (L), the abundance of duck hunters (H), fecundity (ξ), harvest mortality hazard rate (h_κ), natural mortality hazard rate (h_η) and survival (S) for mallards marked and released in the Prairie Pothole Region of the United States and Canada, 1974–2016. Arrows represent covariate effects, grey dashed lines enclose separate generalized linear models and vertical solid lines denote the time period or interval when parameters were estimated, where survival (S) and natural mortality in year t are estimated from banding in year t to banding in year $t+1$. We estimated age-specific band recovery probabilities (f) as a function of age-specific harvest probability (κ), reporting rate (r) and crippling rate (c), $f = \kappa(1-c)r$. We note that we hypothesized the same relationships among demographic components for both juvenile and adult females.

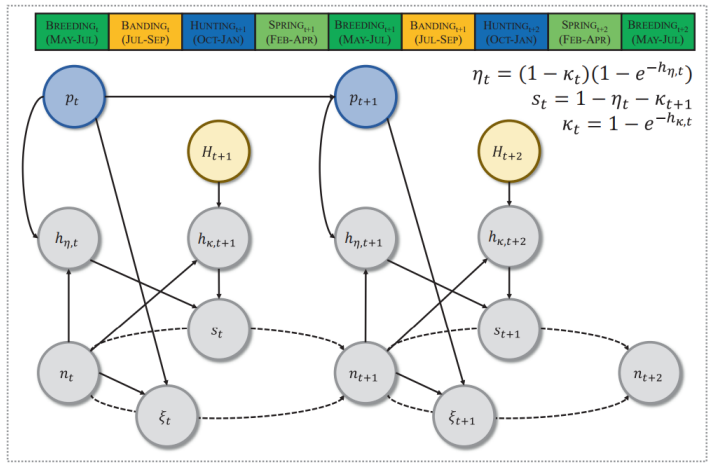
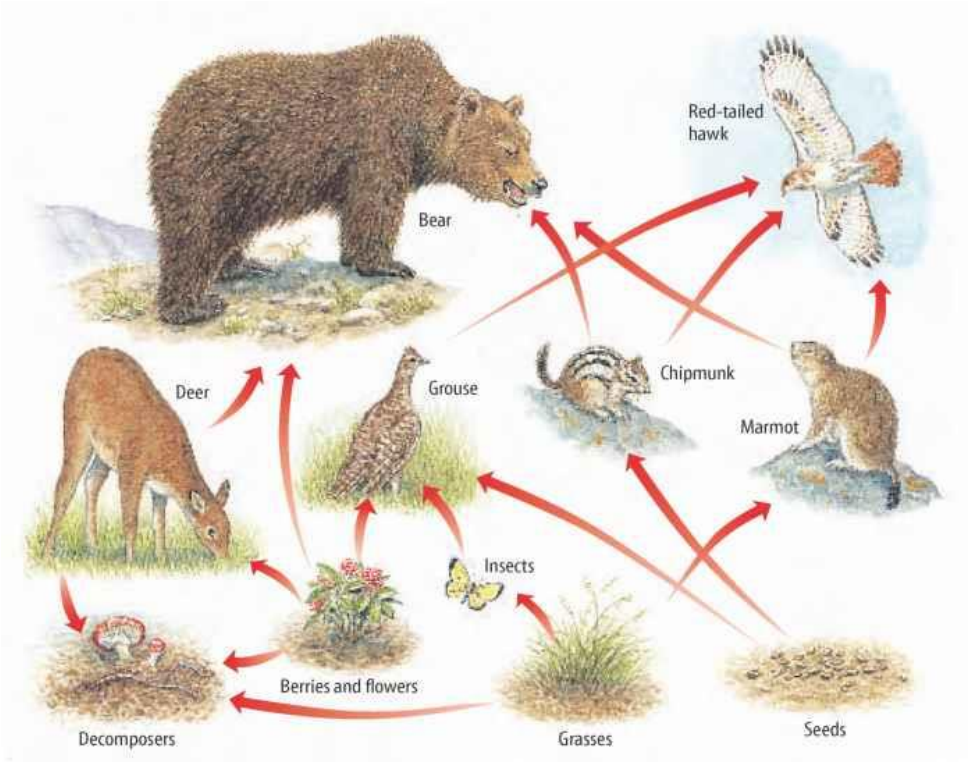
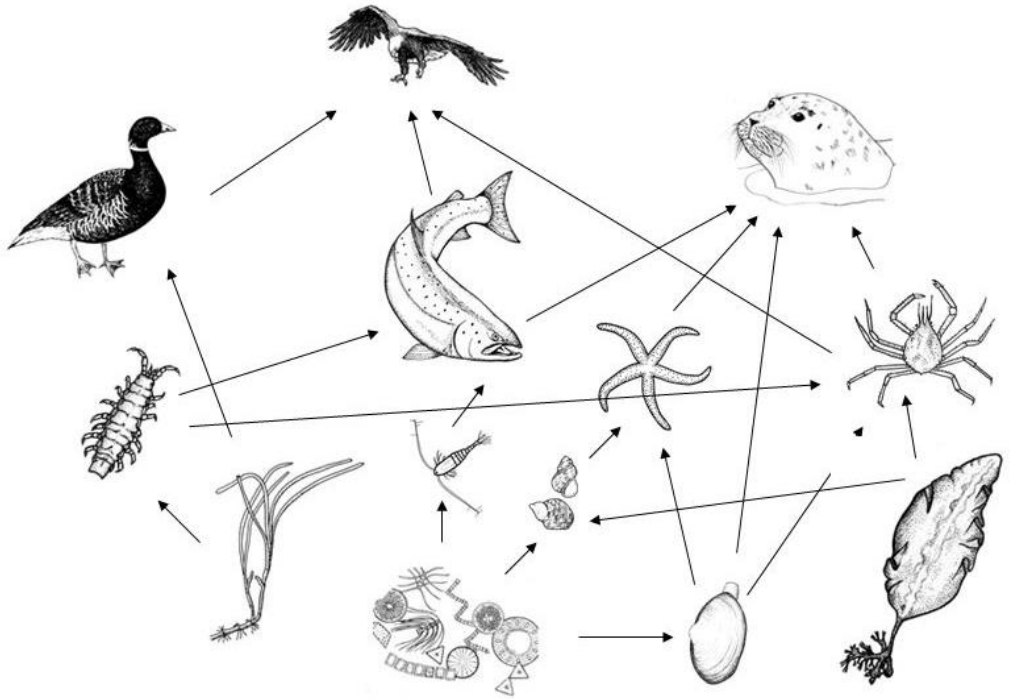


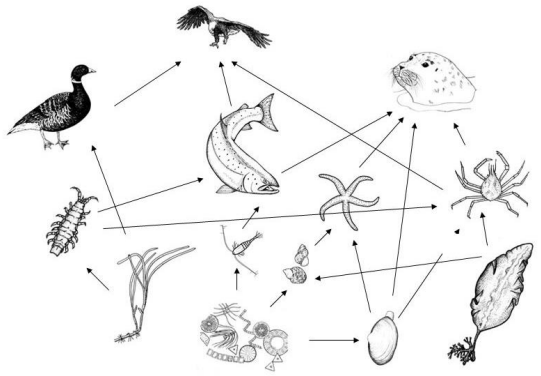
FIGURE 2 A directed acyclic graph demonstrating the relationships among abundance (**n**), ponds (**p**; blue), fecundity (**ξ**), hunting mortality hazard rate ($\mathbf{h_\kappa}$), natural mortality hazard rate ($\mathbf{h_\eta}$), survival (**s**) and the number of duck hunters (**H**; brown) for blue-winged teal breeding in the North American Prairie Pothole Region across the annual cycle (1973–3016). Solid arrows represent estimated directional relationships, and dashed arrows represent processes leading to changes in population abundance.

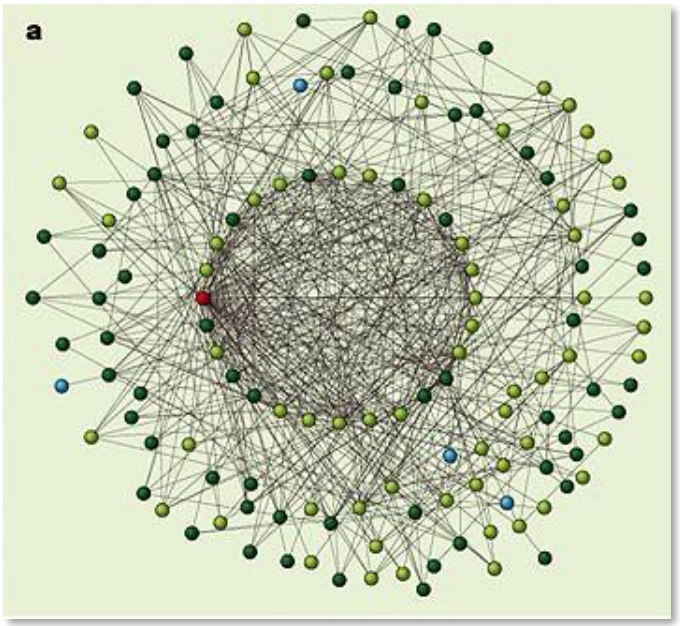
Ecological systems are fascinating





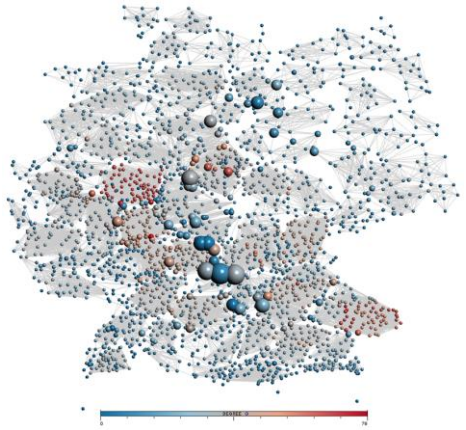
Ecological reality is a bit more complex





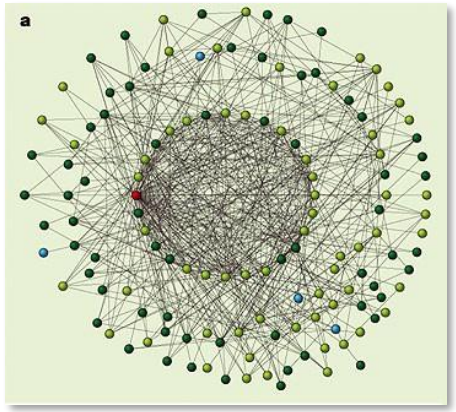
Montoya et al. **(2006)** *Nature*

Ecological systems are unbelievably complex!



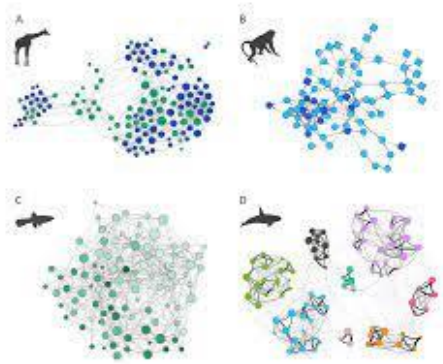
Climate network

Abiotic systems



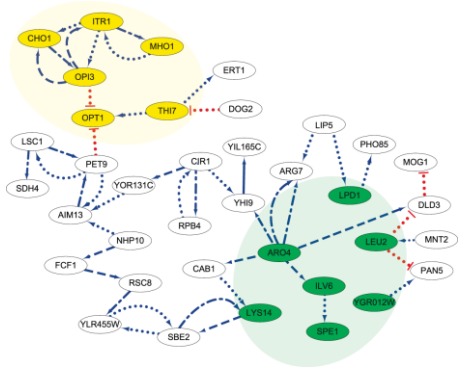
Food Network

Within communities



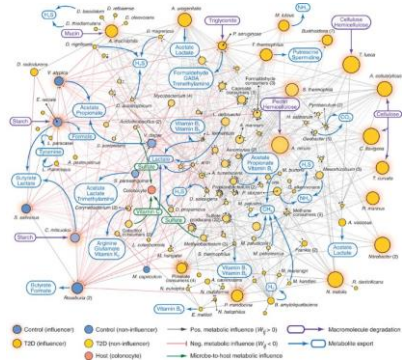
Social Network

Within populations



Gene Network

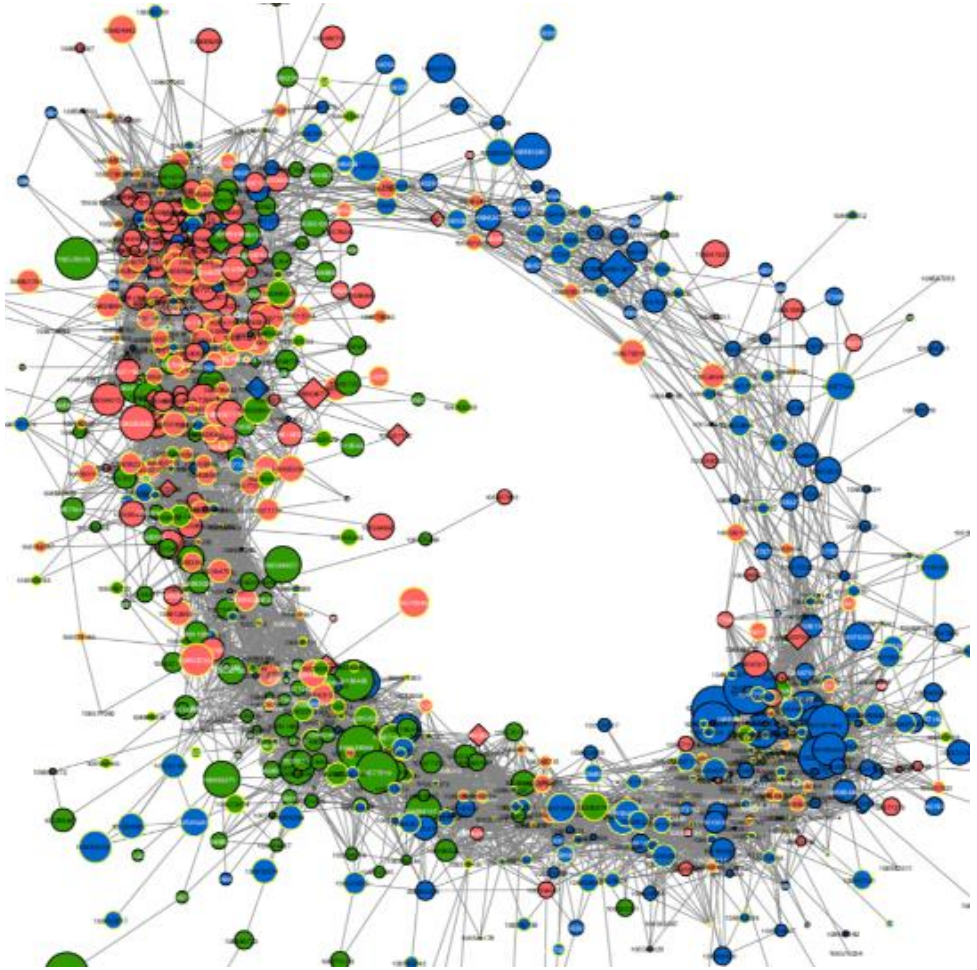
Within individuals



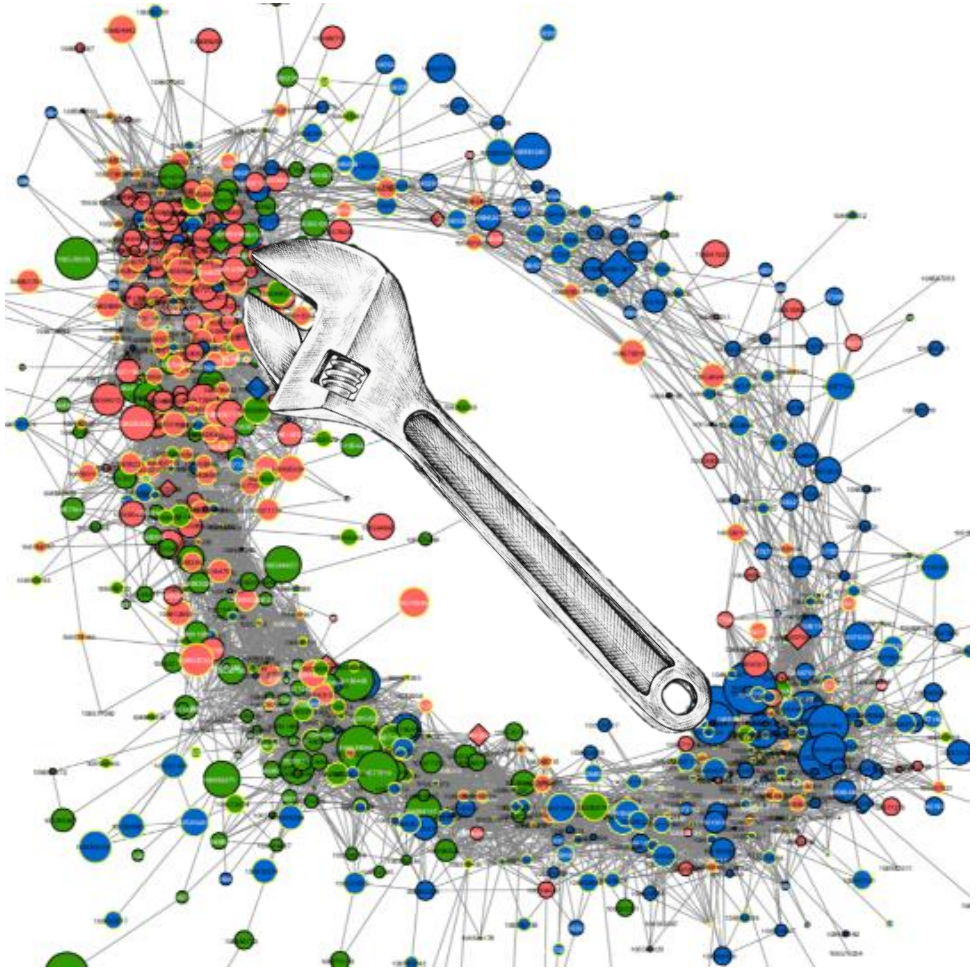
Microbial Network

Within individuals

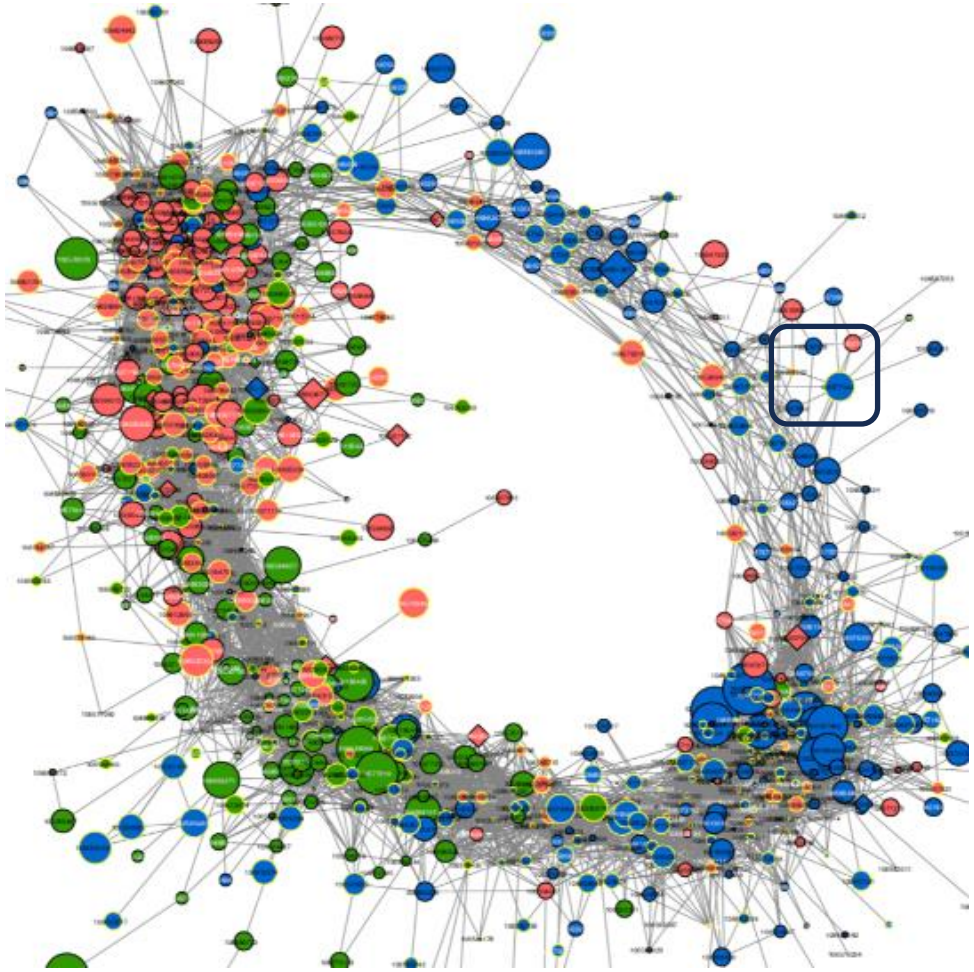
Ecological systems are fascinating and beautiful!



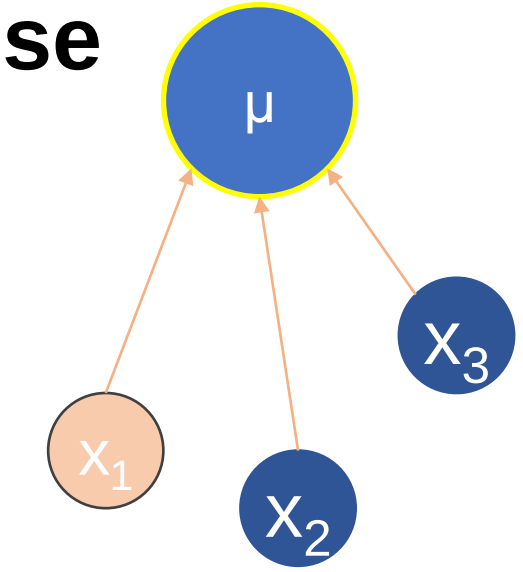
There’s a disconnect…



GLMs dominate ecological analyses



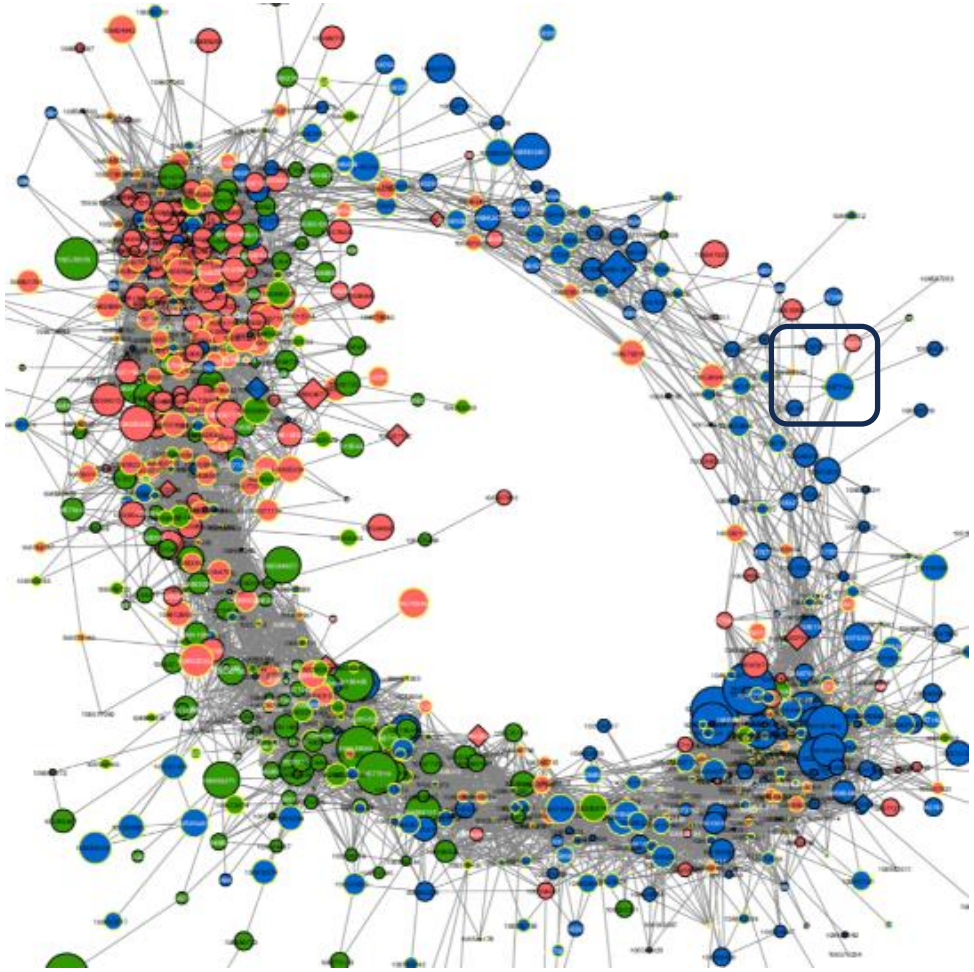
Response



Covariates

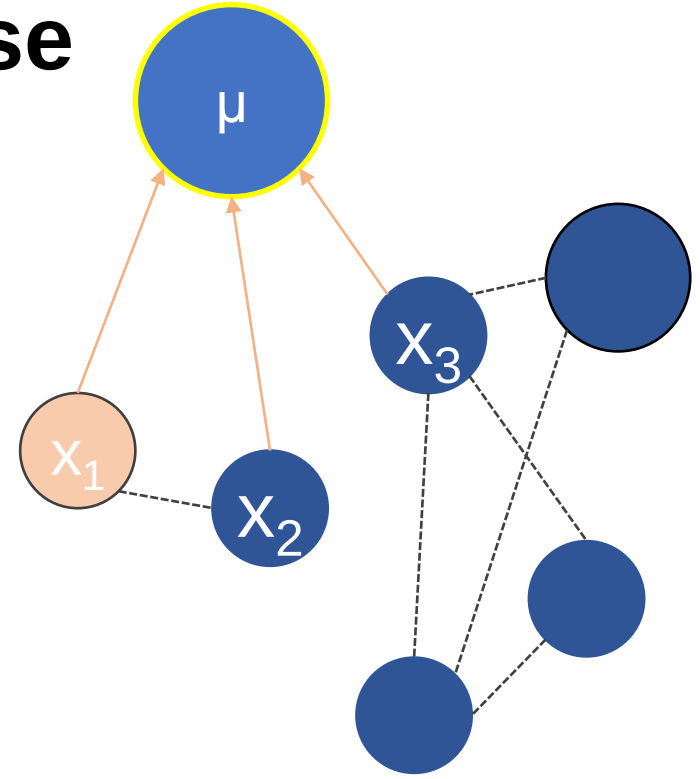
```
glm(y ~ x1 + x2 + x3)
```

Covariates are often collinear, or correlated



Response

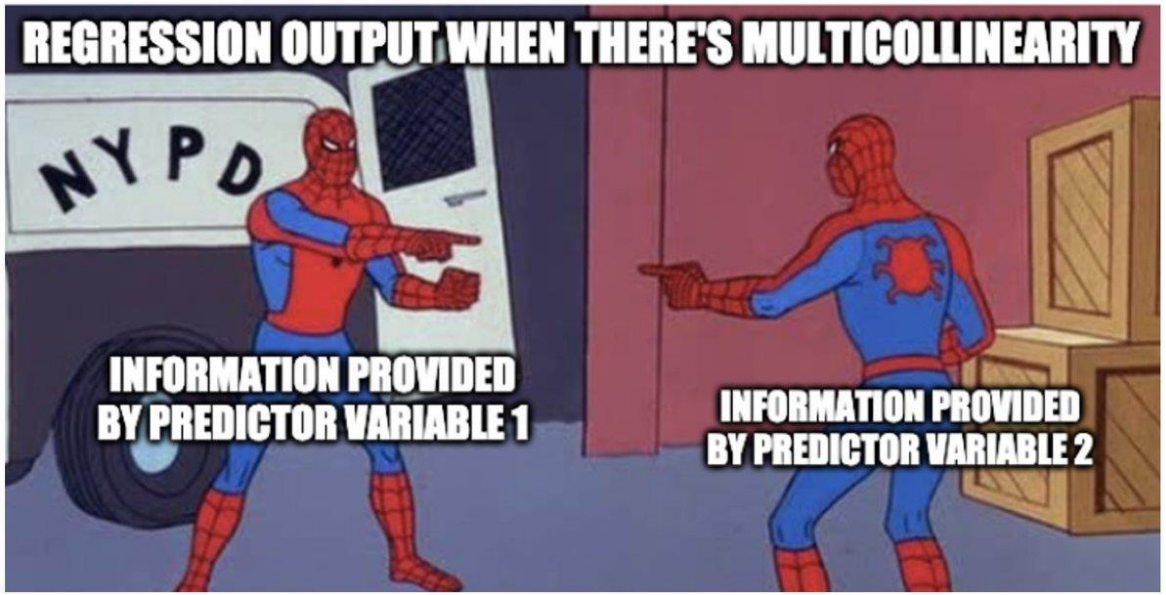
Covariates

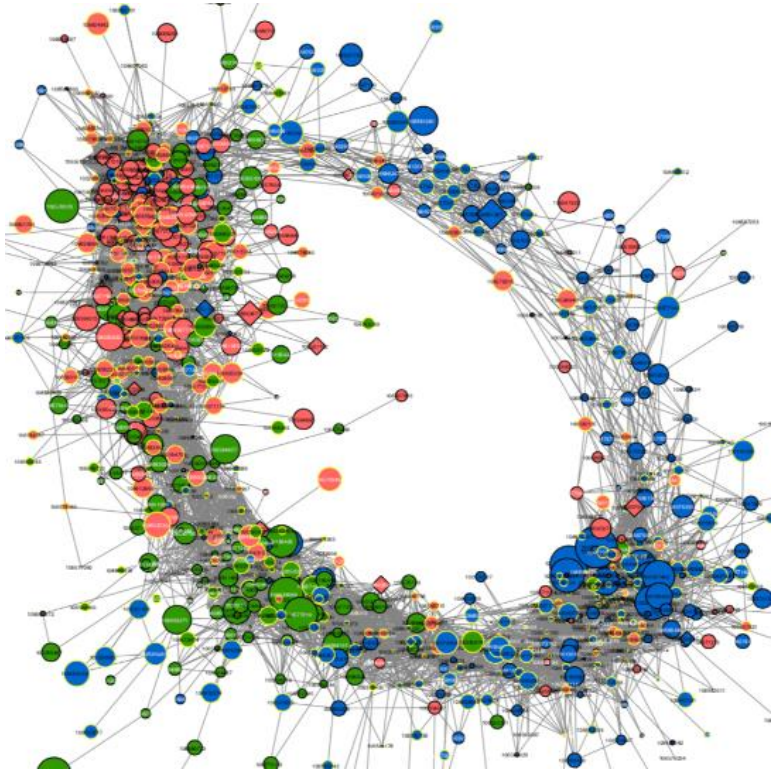


How many of you have had to…

exclude multicollinear (r > 0.7 [r > 0.5?]) covariates?

We do this for good reasons

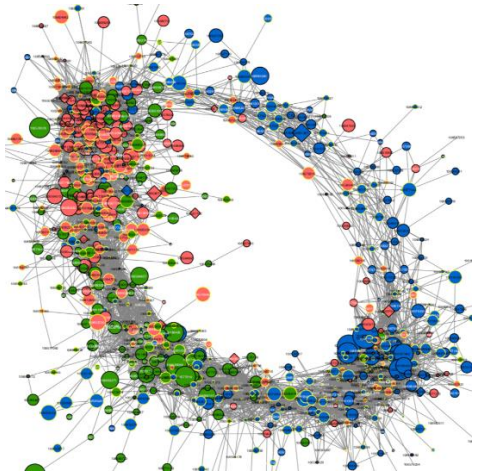




Graham **(2003)** *Ecology*; Cade **(2015)** *Ecology*

We often do this in weird ways

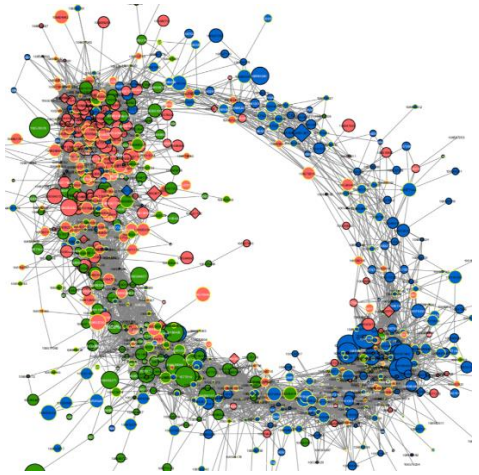
- test which fit ‘best’ | model selection
- haphazardly? (autocratically)
- |r| > 0.7 is a problem, |r| = 0.694 is fine...



Why were they collinear?

Why were they collinear?

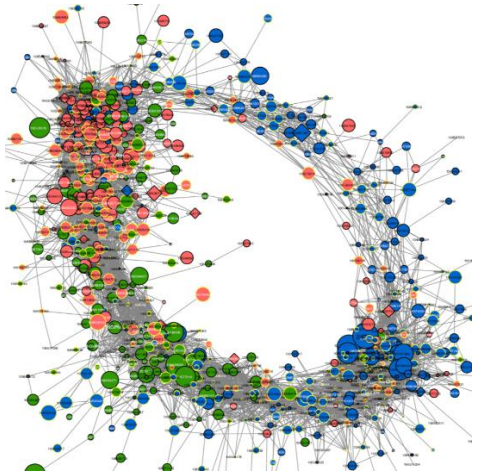
- ~~‘random’?~~



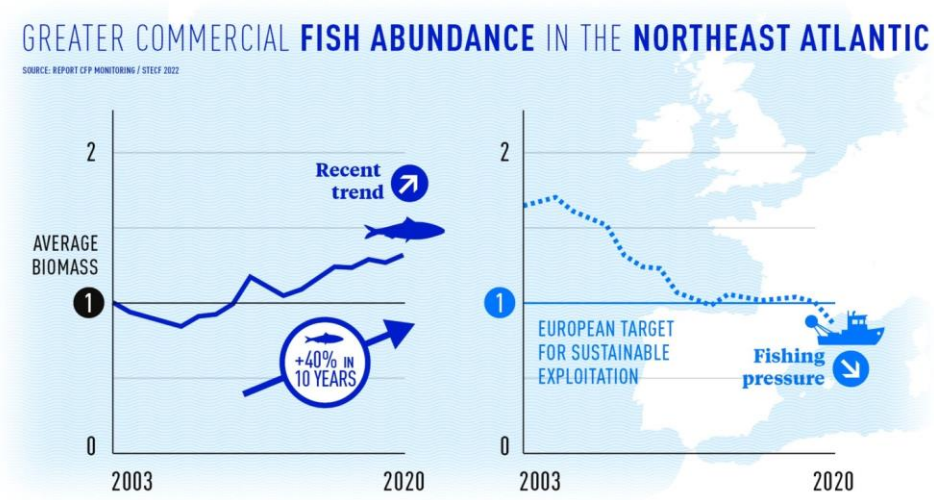
Why were they collinear?

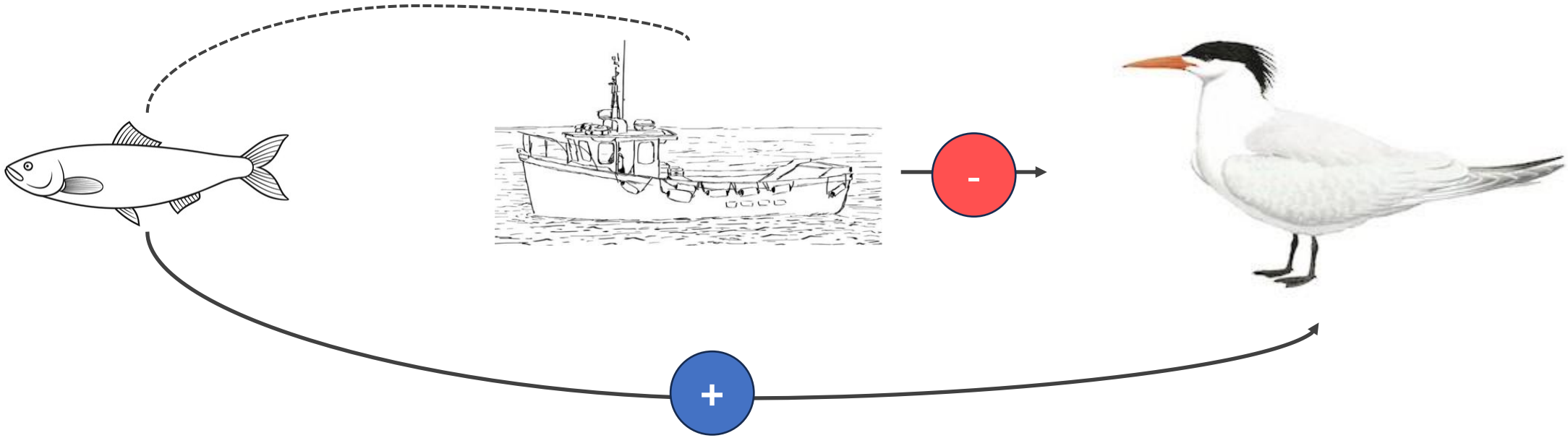
- ~~‘random’?~~

1) One affects the other directly or indirectly



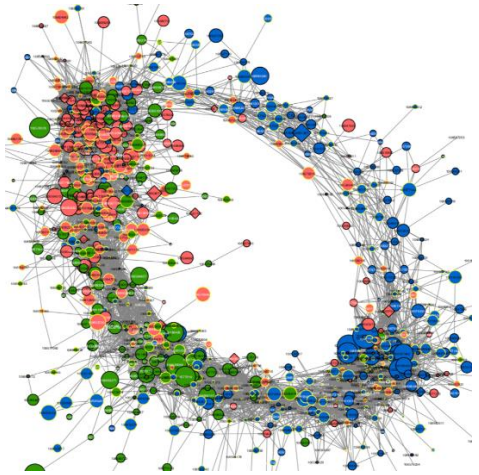
e.g. problem





Fish and fishing are collinear because fishing affects fish

Why were they collinear?



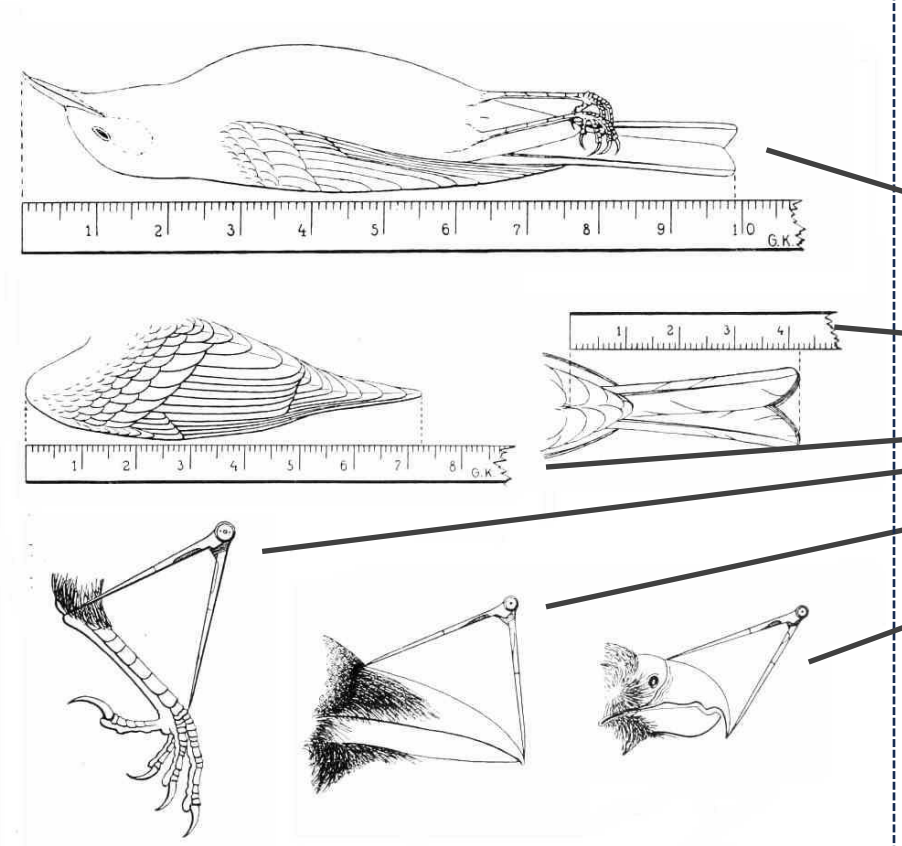
- ~~‘random’?~~

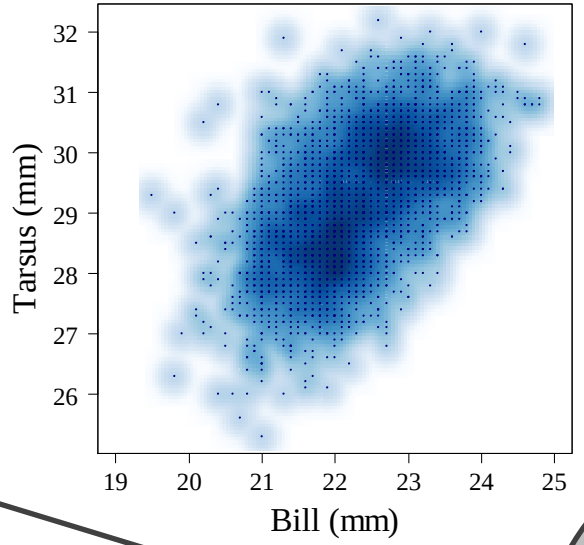
1) One affects the other directly or indirectly

2) They’re a result of an underlying latent process
   - i.e., we’re measuring the same thing

e.g. problem

Morphometric measurements



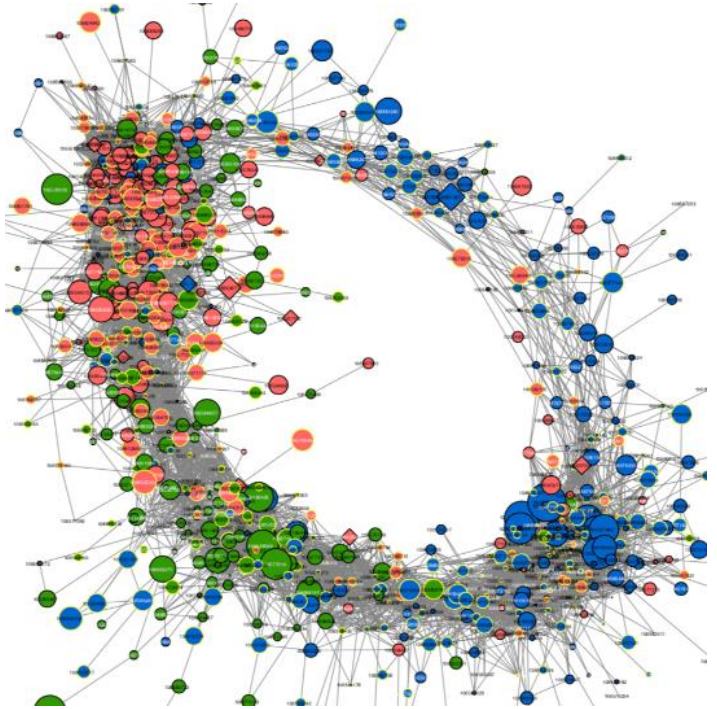


θ

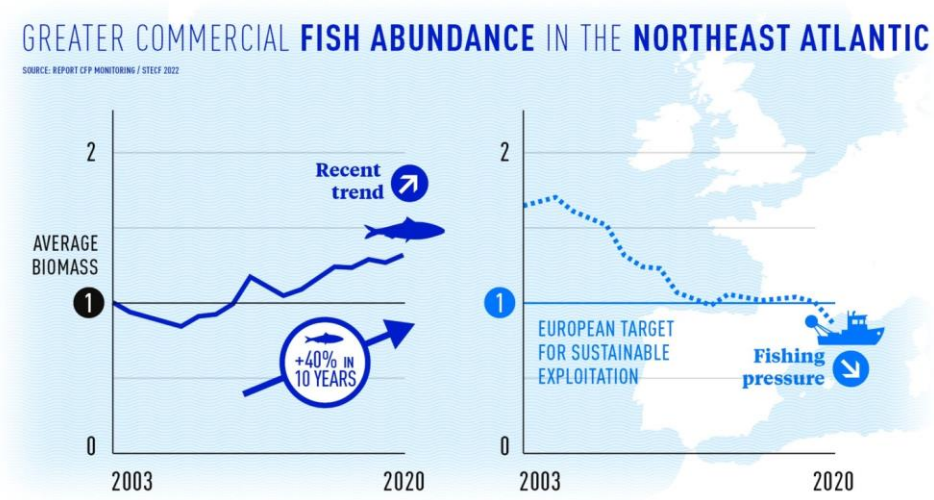
These are all measurement of different aspects of ‘size’

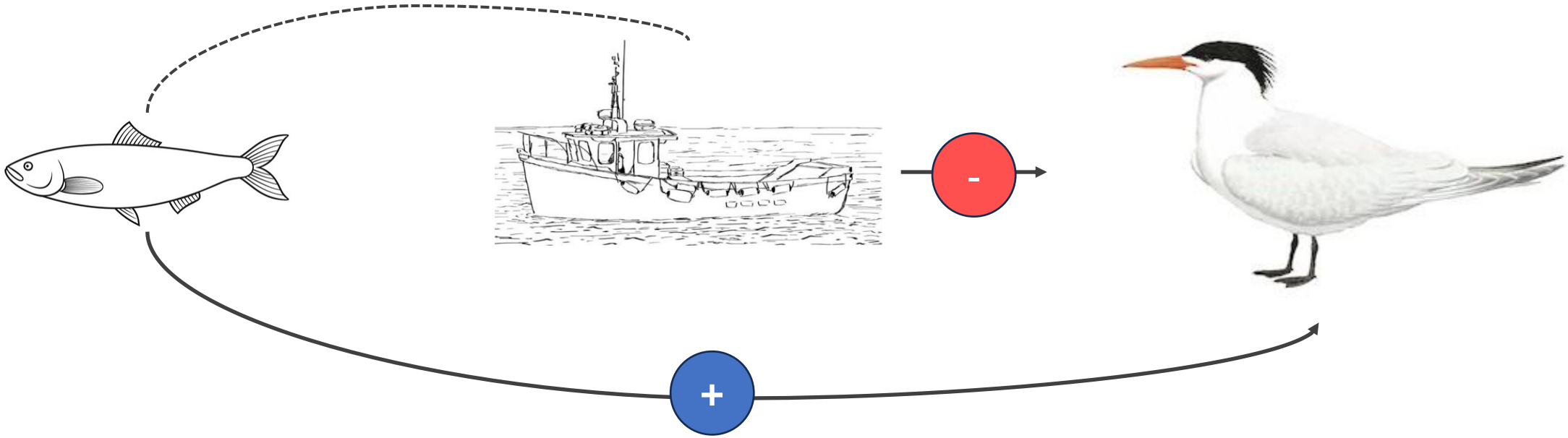
Instead of fighting or fearing multicollinearity…

We should expect it, appreciate it, and seek to understand and use it.



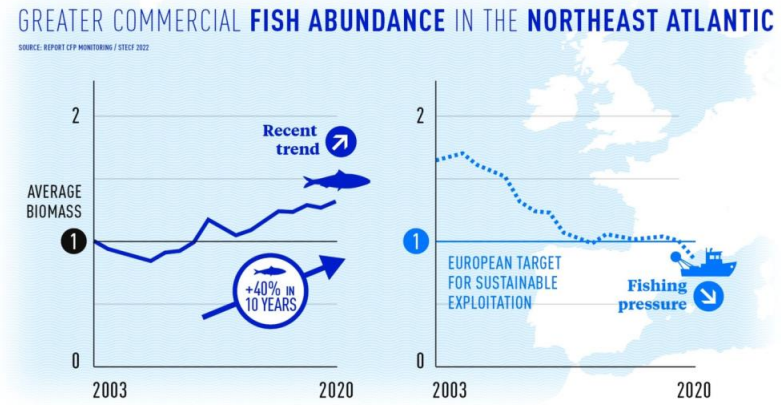
e.g. problem

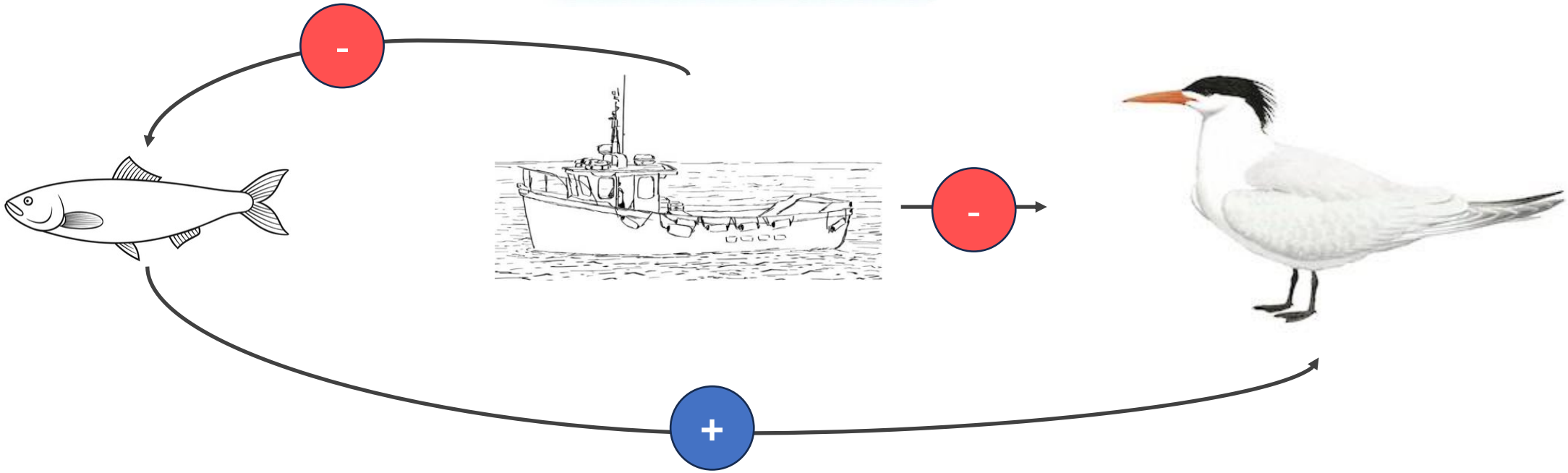




Fish and fishing are collinear because fishing affects fish

e.g. solution via path analysis





Fish and fishing are collinear because fishing affects fish, we can model that

SEMs often feel overwhelming?!

Special Section: Observational Studies

Structural Equation Modeling for Observational Studies

JAMES B. GRACE,[1] *United States Geological Survey National Wetlands Research Center, 700 Cajundome Boulevard, Lafayette, LA 70506, USA*

$$y_1 = \alpha_1 + \gamma_{11}x_1 + \zeta_1 \quad (1)$$

$$y_2 = \alpha_2 + \gamma_{21}x_1 + \gamma_{22}x_2 + \beta_{21}y_1 + \zeta_2 \quad (2)$$

$$y_3 = \alpha_3 + \gamma_{31}x_1 + \gamma_{32}x_2 + \beta_{31}y_1 + \beta_{32}y_2 + \zeta_3 \quad (3)$$

Simplifying the LISREL system for the case where there are no latent variables and ignoring the intercept terms, a generalized representation of a system of such equations is

$$Y = BY + \Gamma X + \zeta \quad (4)$$

Grace et al. **(2008)** *Journal of Wildlife Management*

Everything is overwhelming if we don’t know the language

1) Put the **Taulov** on the **Golv**

2) Arrange four **Stefans** on the **Taulov**

3) Put the **Krokig** between the **Stefans**

4) Put the **Nattjasmin** over the **Stefans** and **Krokig**

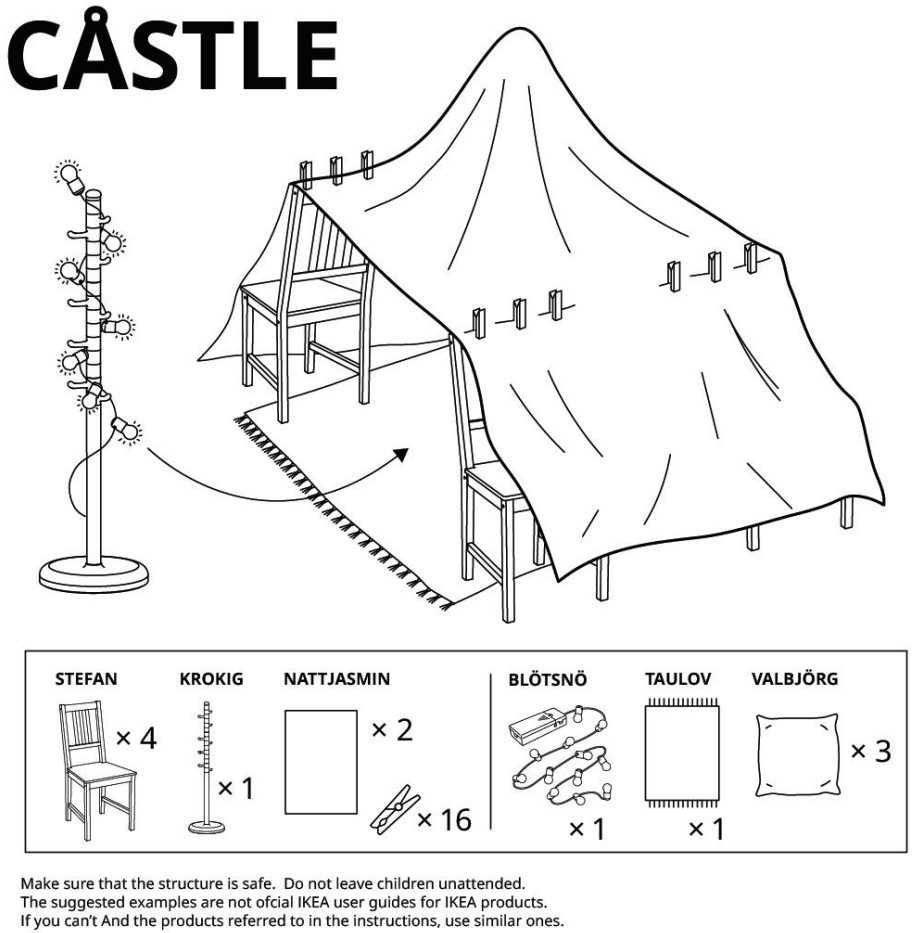
Everything is overwhelming if we don’t know the language

1) Put the **rug** on the **floor**

2) Arrange four **chairs** on the **rug**

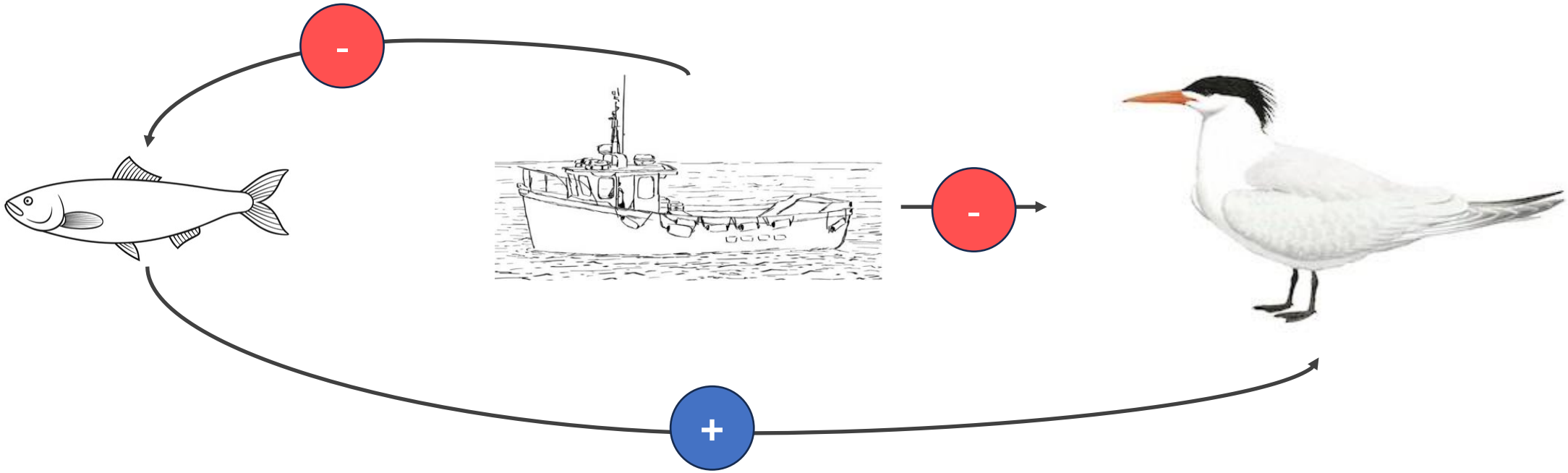
3) Put the **lamp** between the **chairs**

4) Put the **blanket** over the **chairs** and **lamp**



SEMs are intuitive

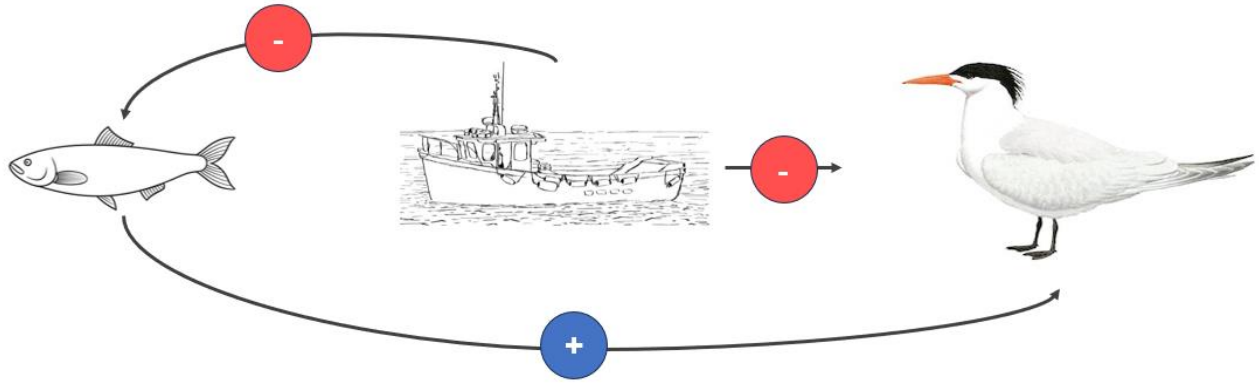
1) Draw a diagram of how you think your system works



SEMs are intuitive

1) Draw a diagram of how you think your system works

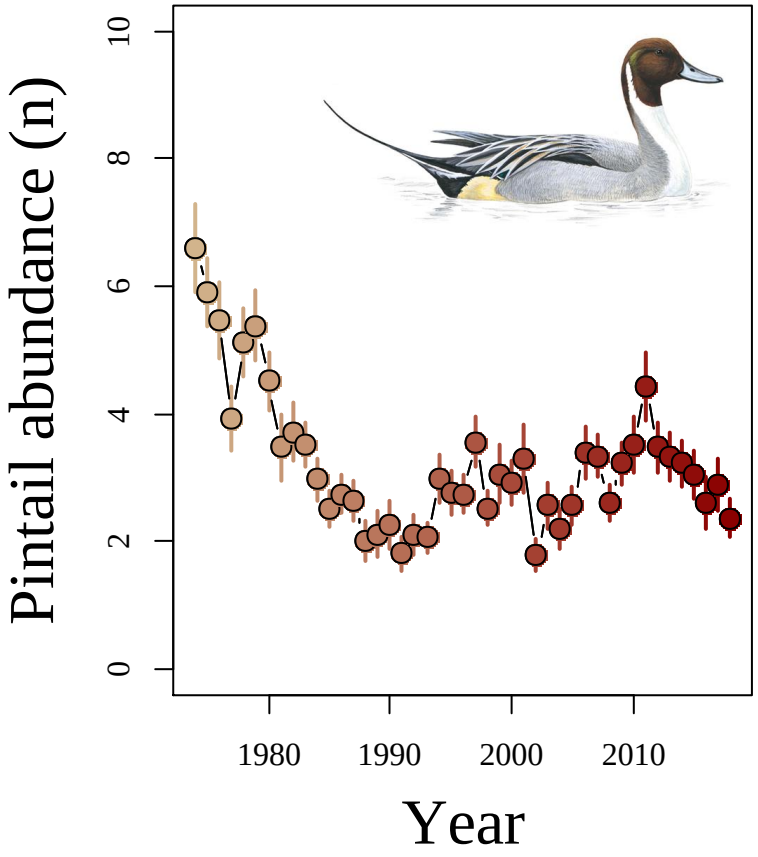
2) Write more than one linear model that represents your diagram

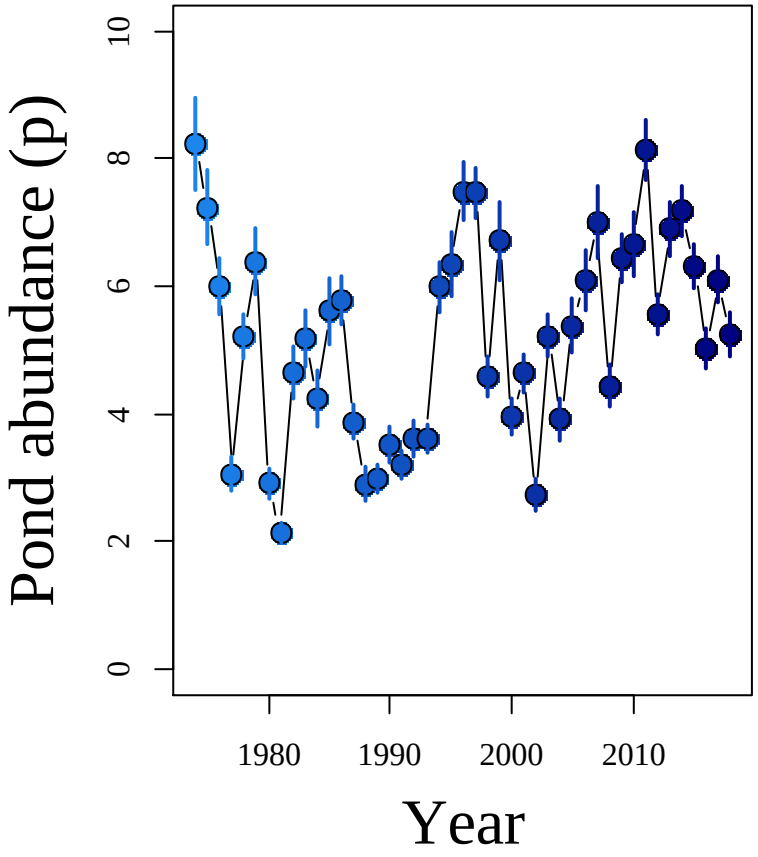



```
sem('fish ~ fishing
     terns ~ fish + fishing')
```

How many ducks will we shoot if *X*?

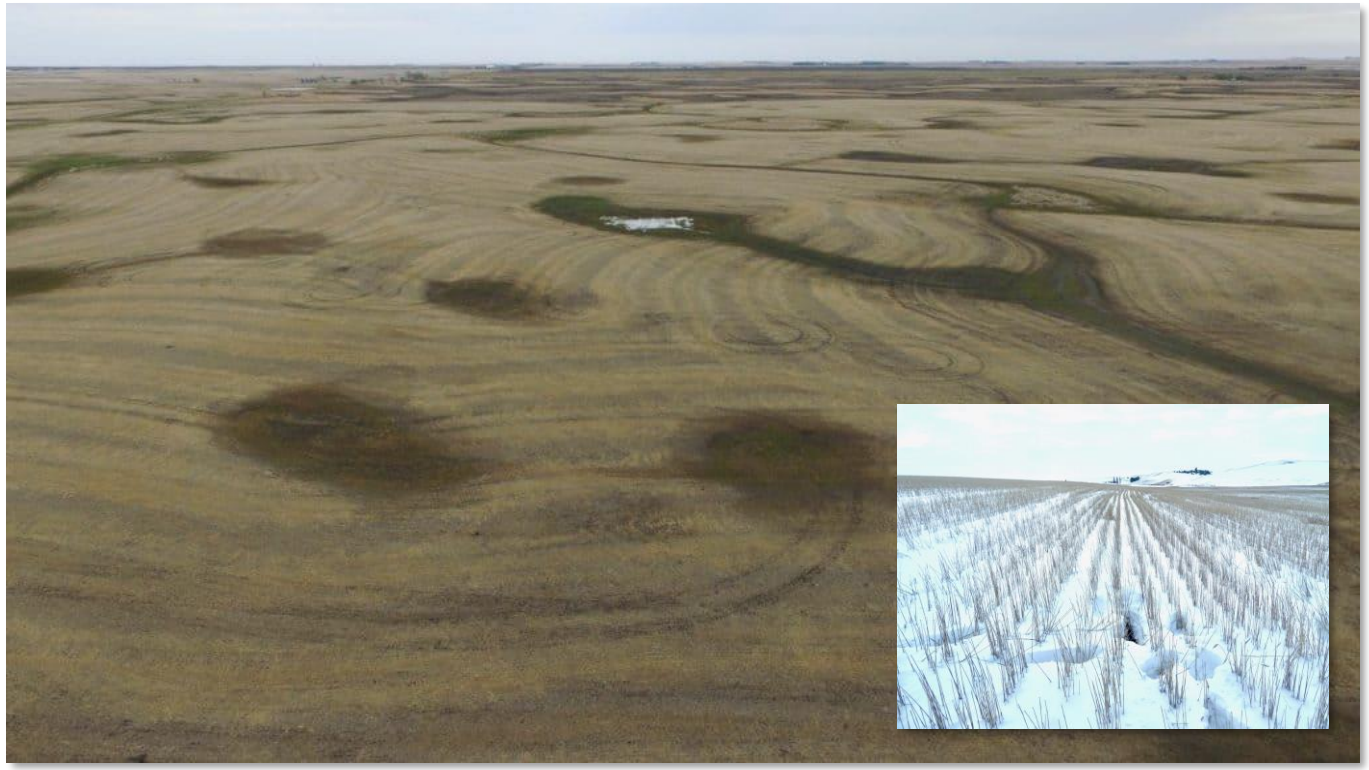
Northern pintails are relatively unique among dabbling ducks



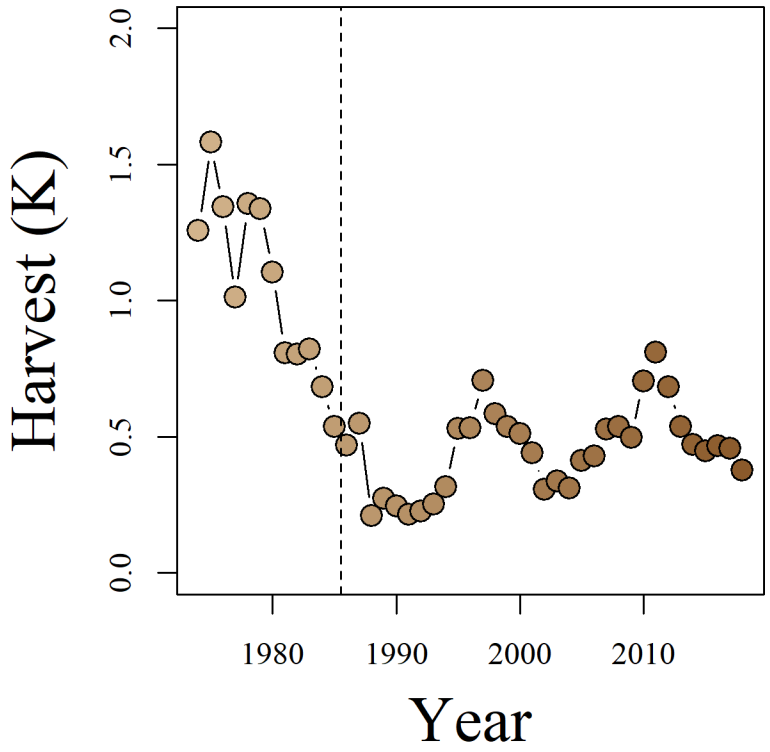


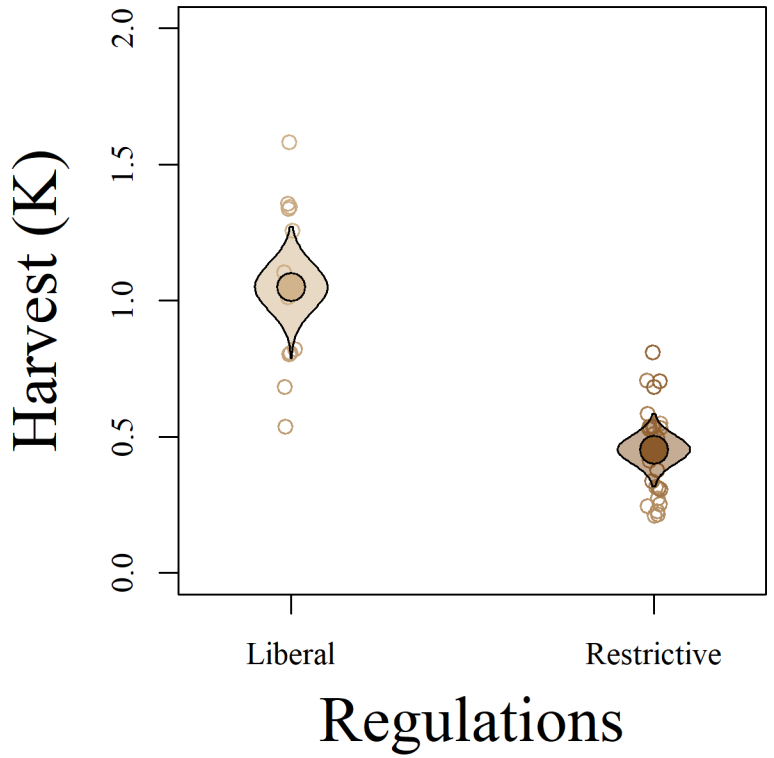
Like other ducks, they like ponds, but haven’t done as well…

A textbook example of an ‘ecological trap’

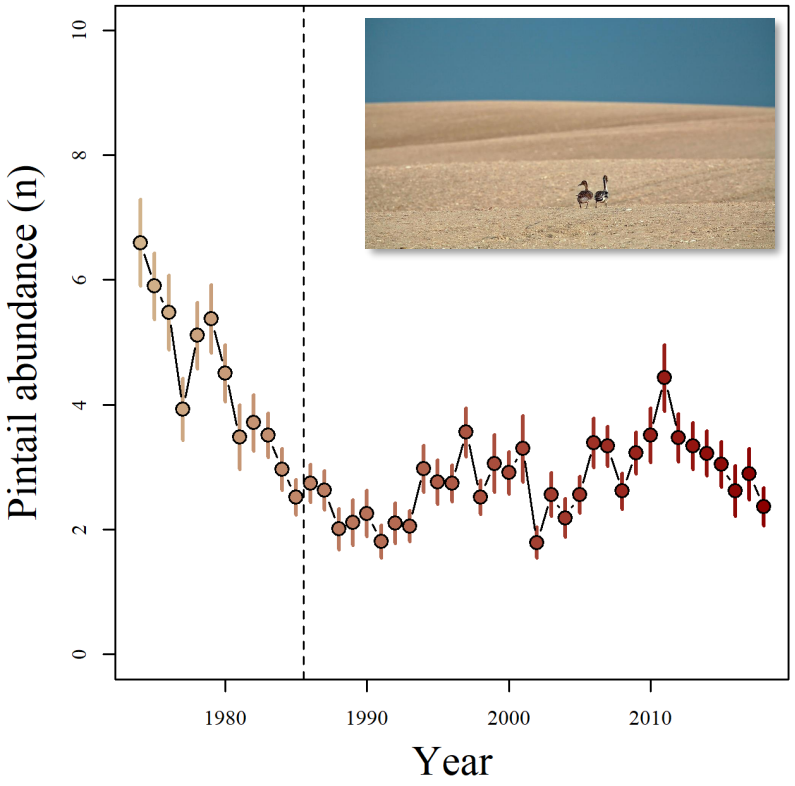


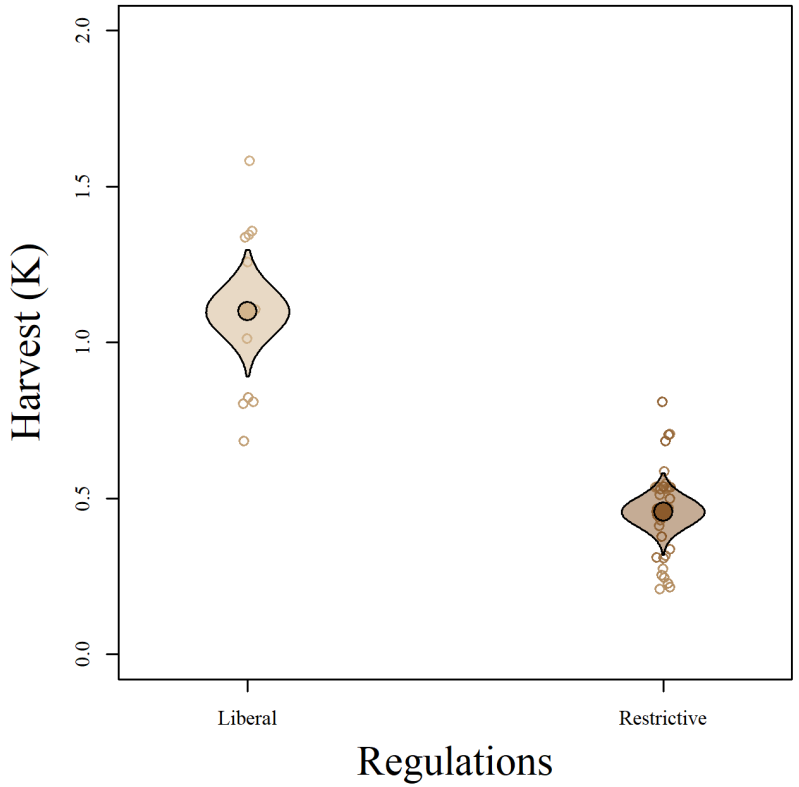
Harvest management has been our main response…

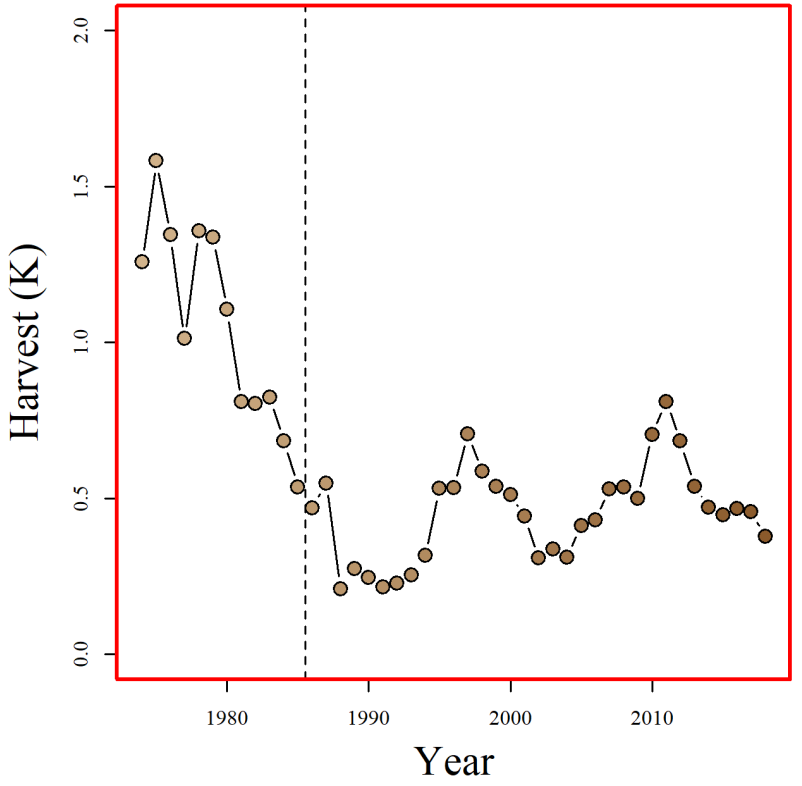




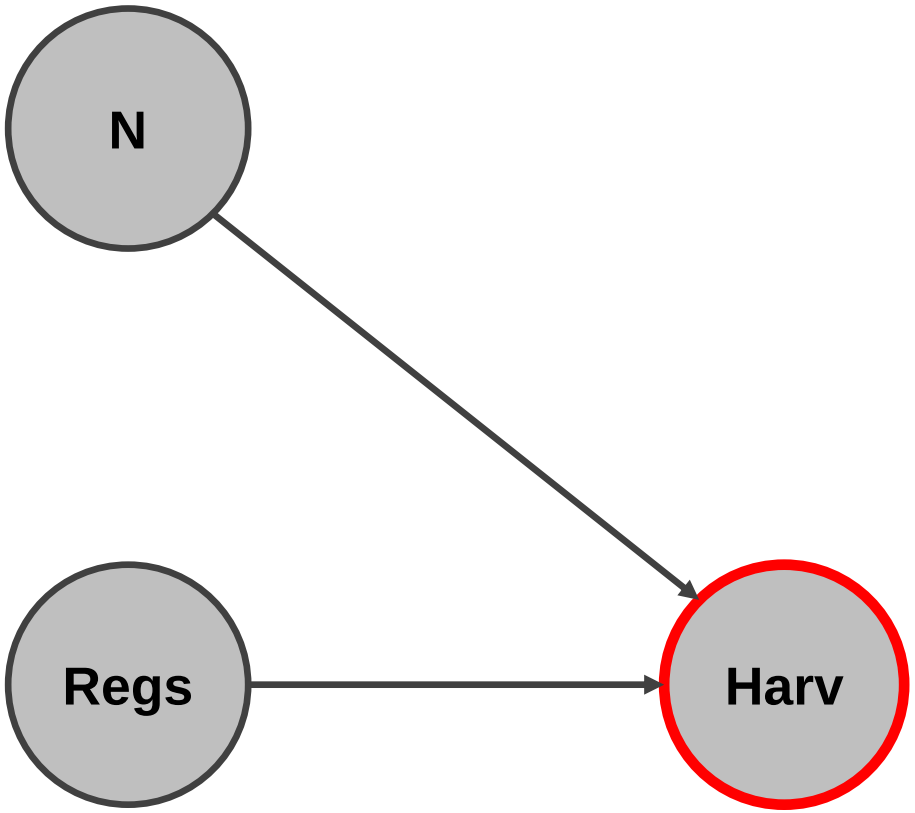
We’ve reached an impasse…



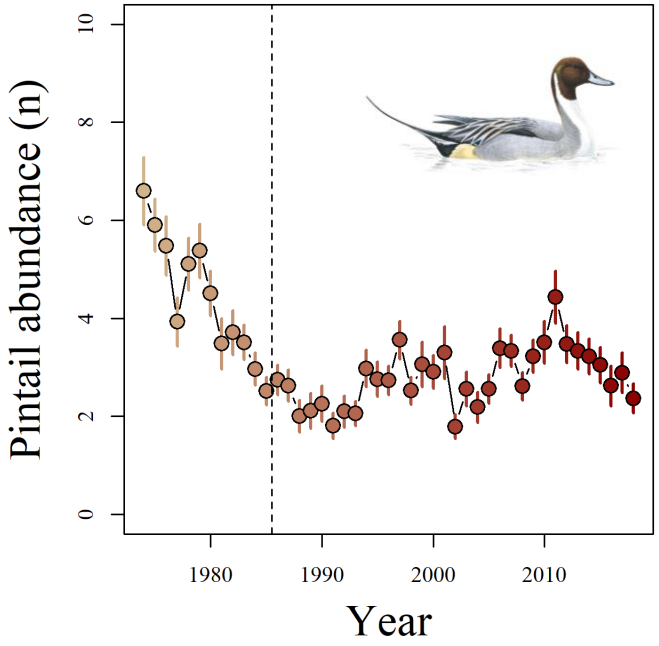


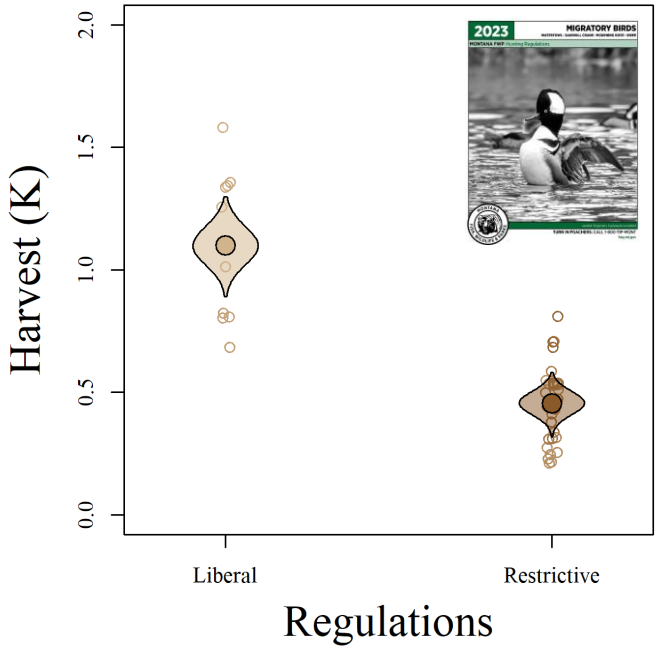


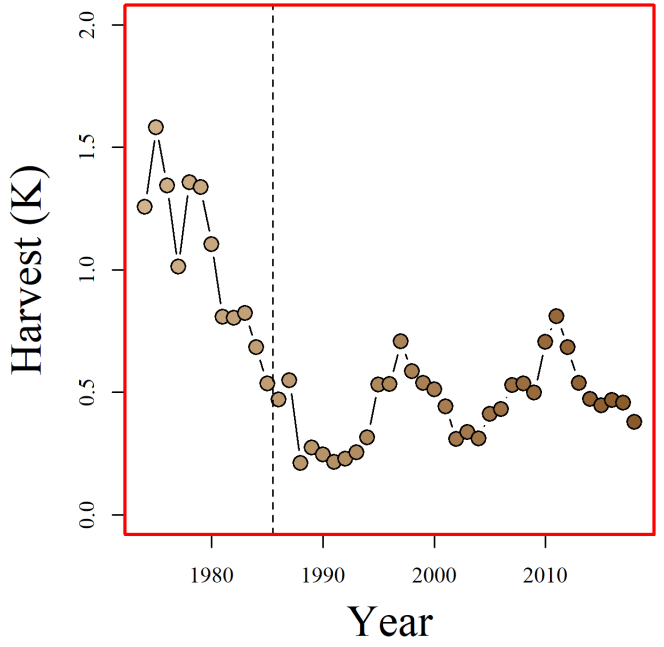
Let's build a better model…



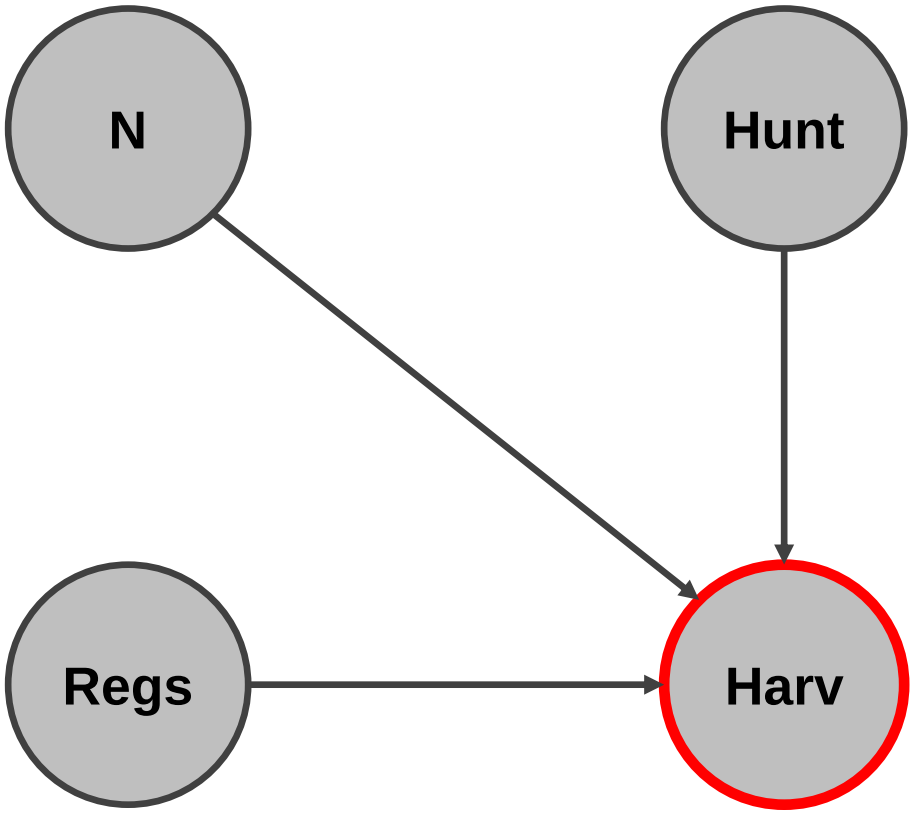

```
glm(K ~ R + N)
```



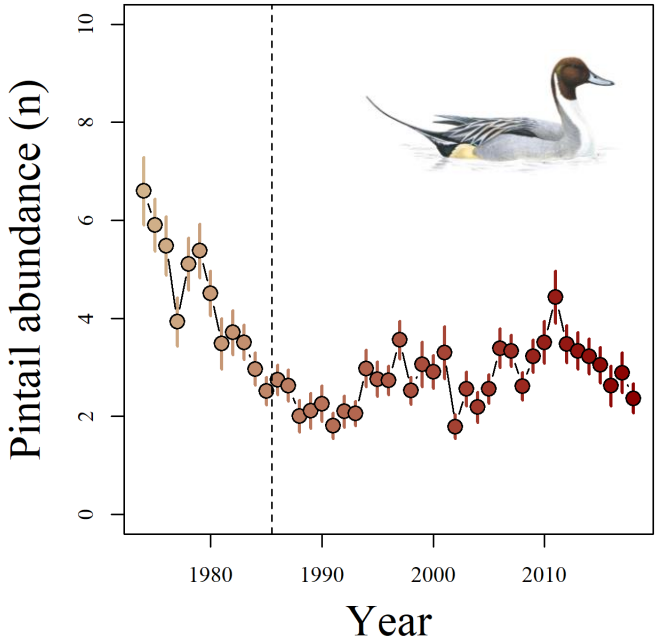


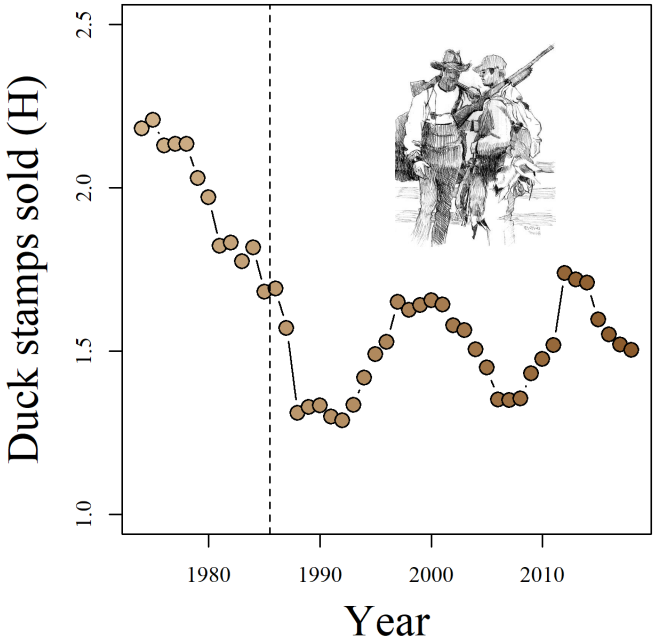


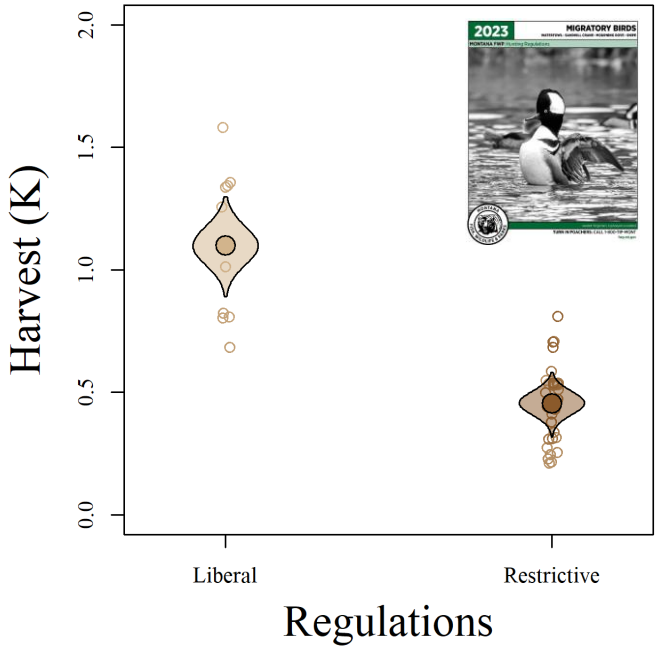
Let's build a better model…

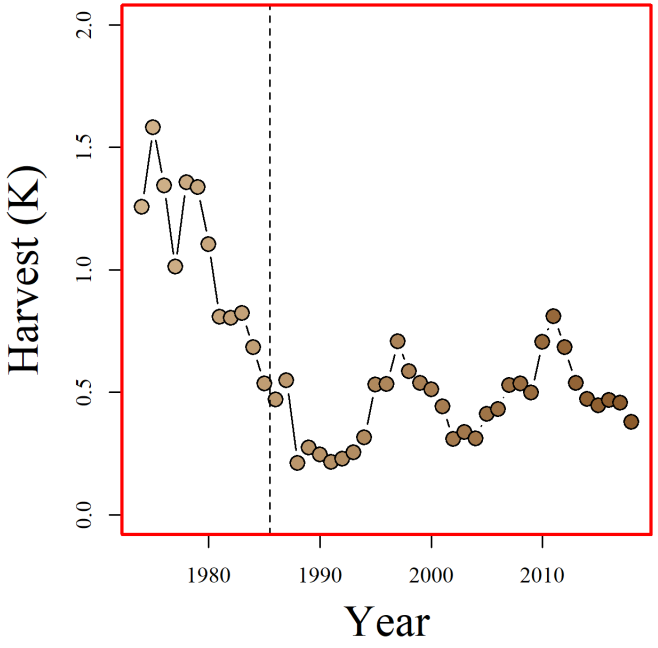



```
glm(K ~ R + N + H)
```

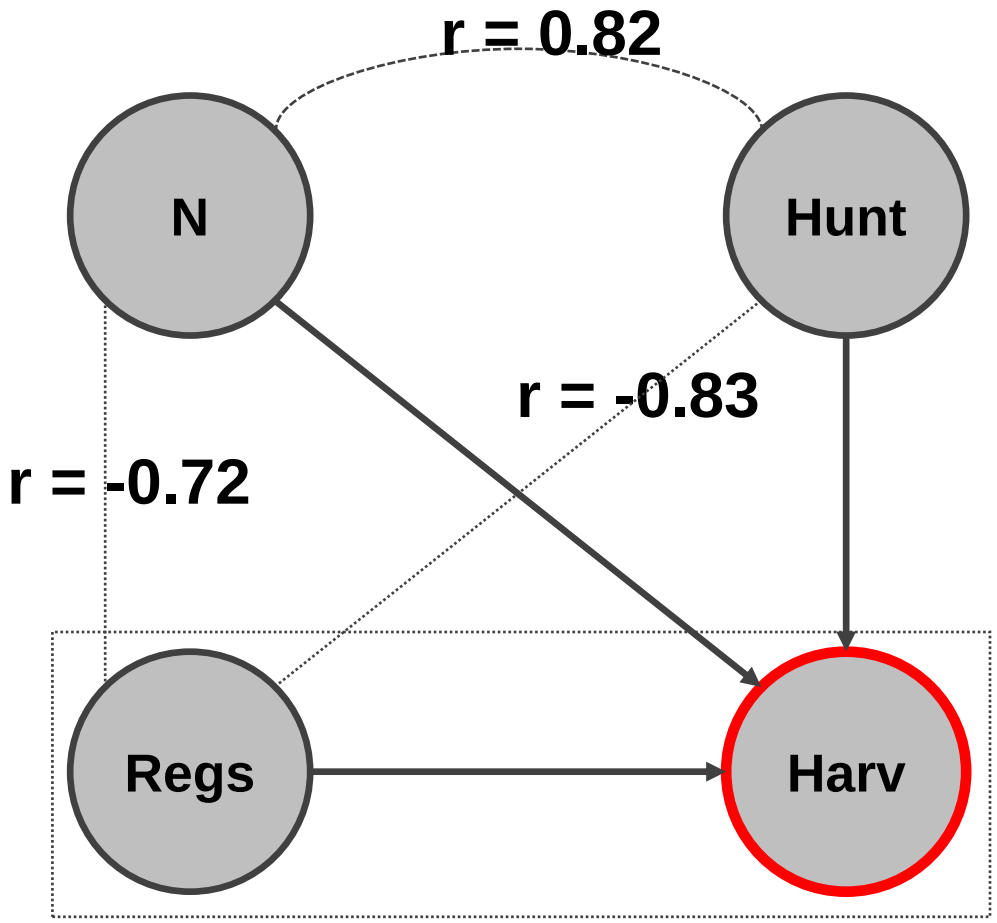




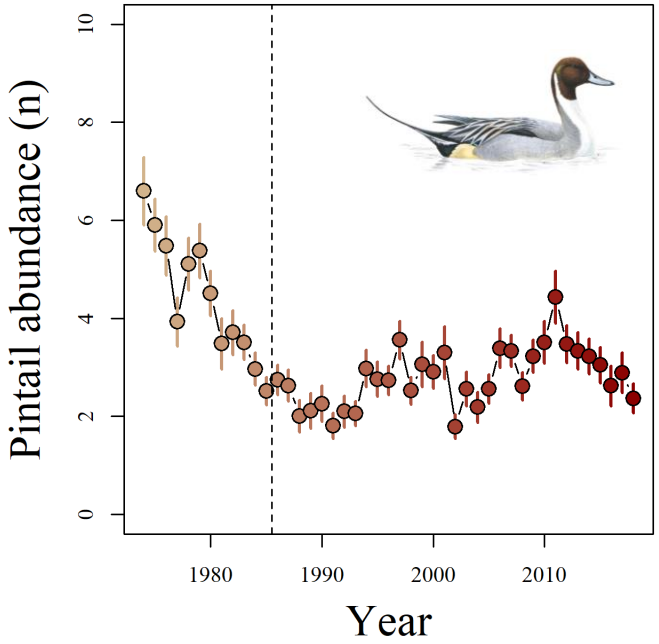


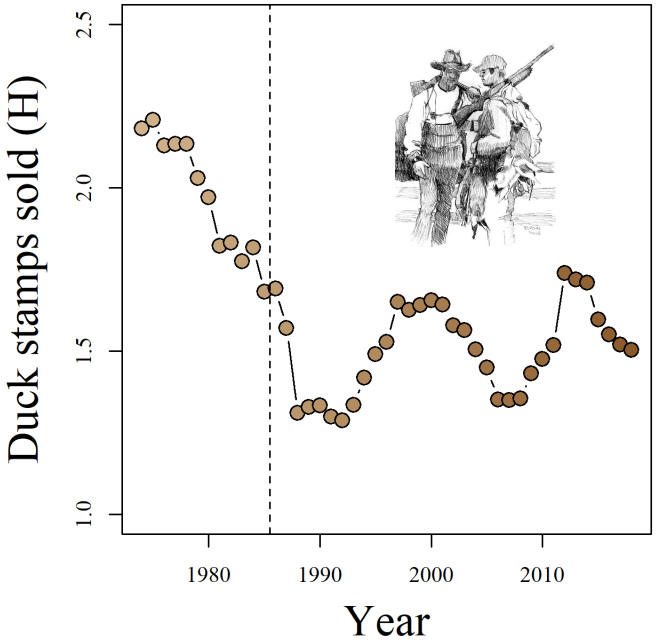


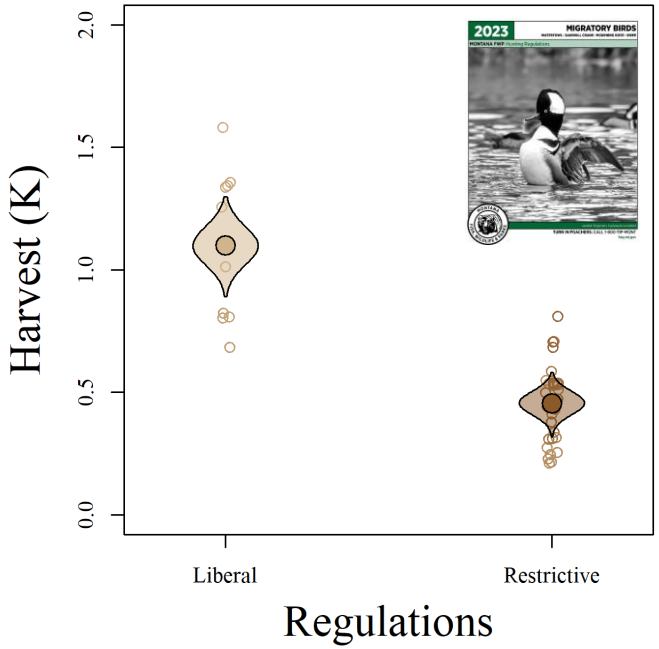
Let's build a better model…

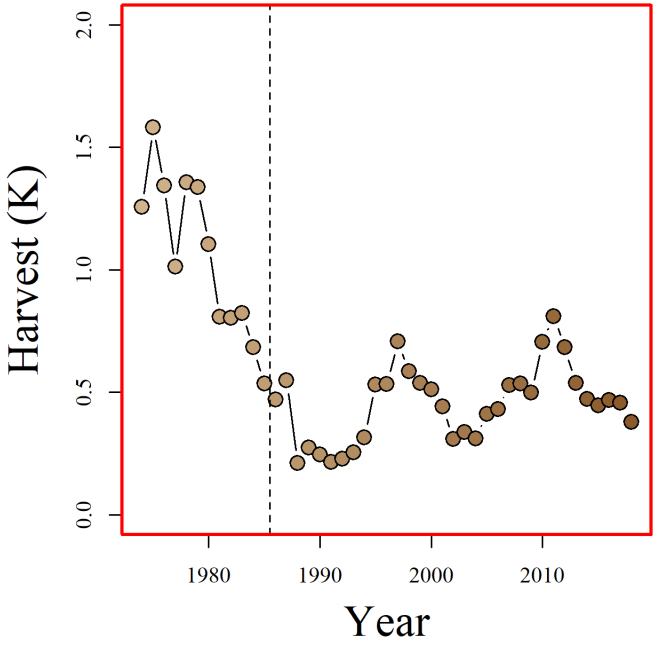



```
glm(K ~ R + N + H)
```







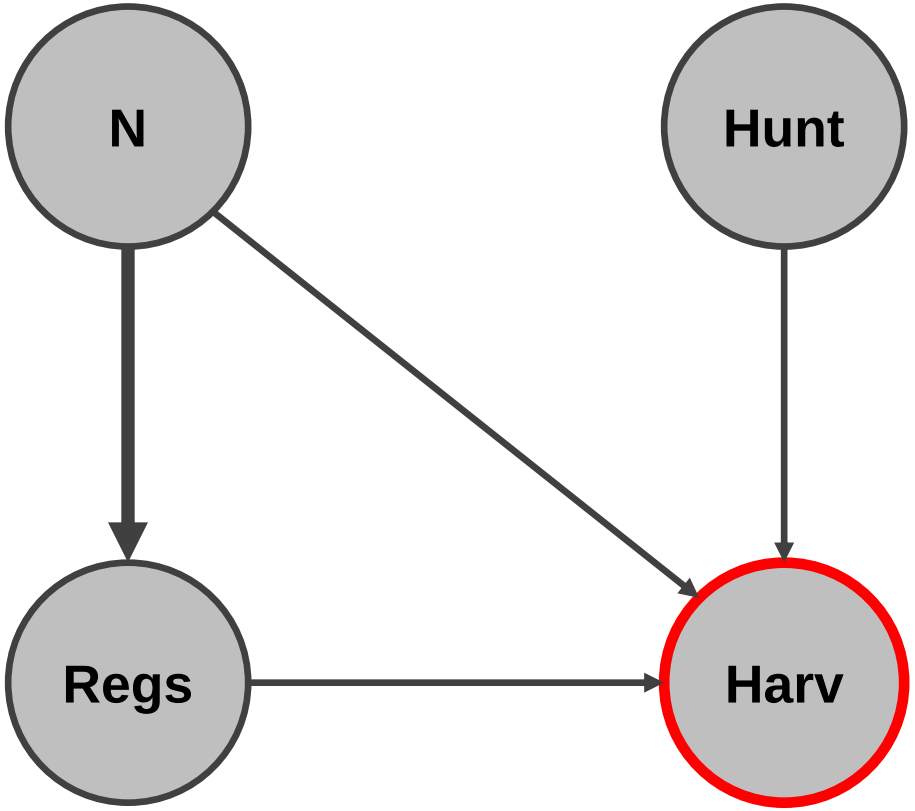


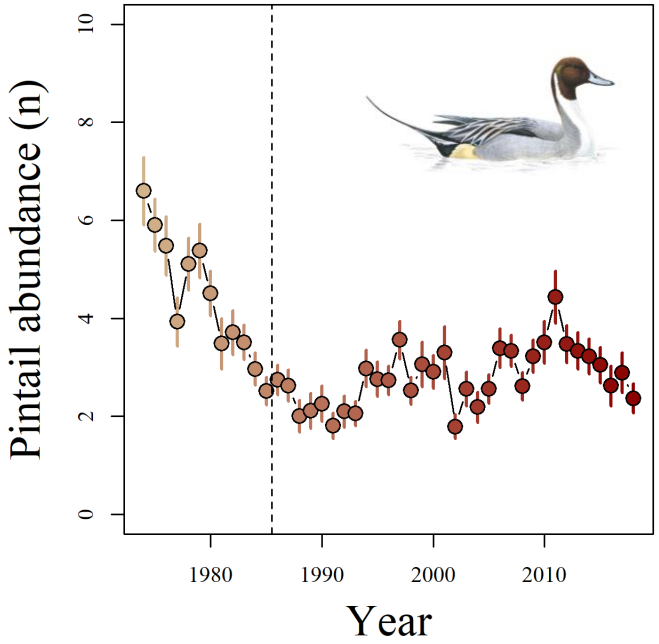
SEMs are intuitive

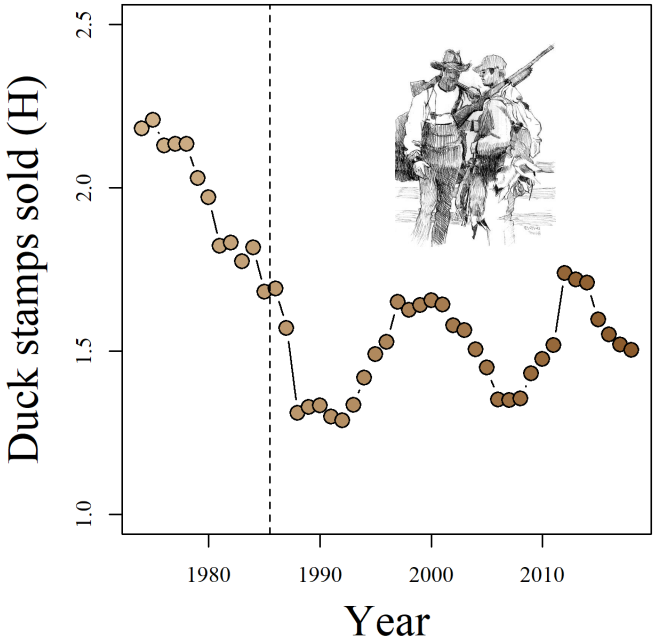
1) Draw a diagram of how you think your system works

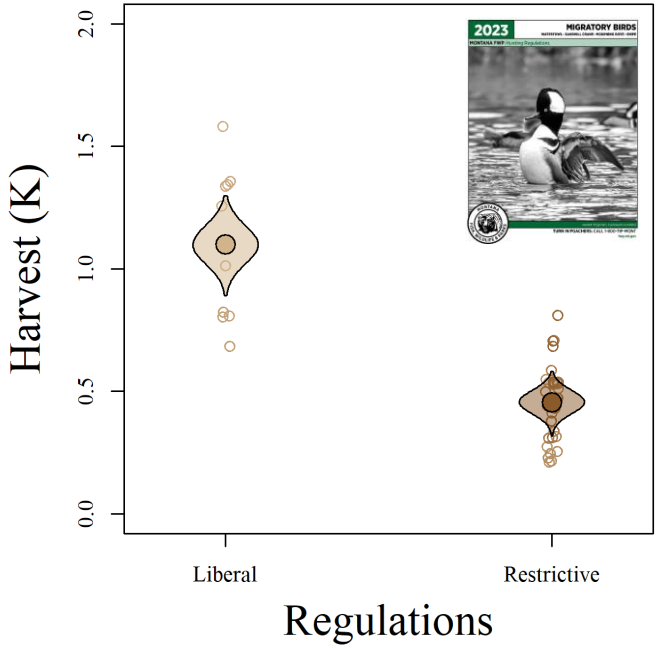
2) Write more than one linear model that represents your diagram

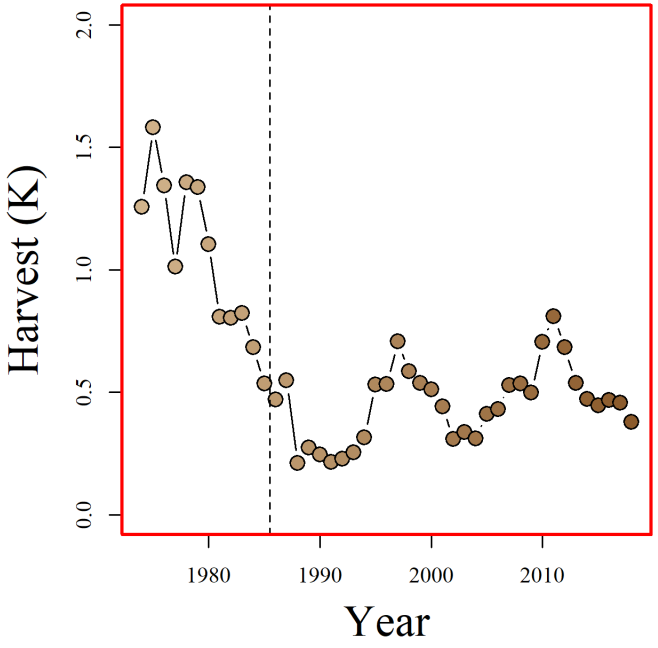
Let's build a better model…



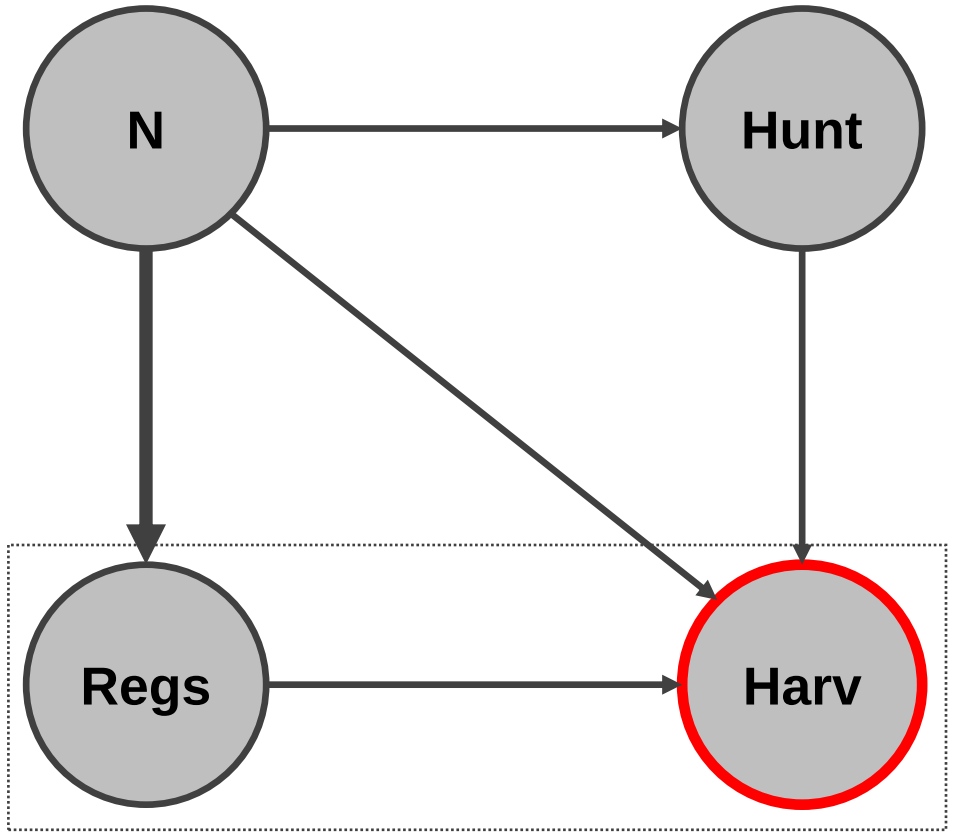


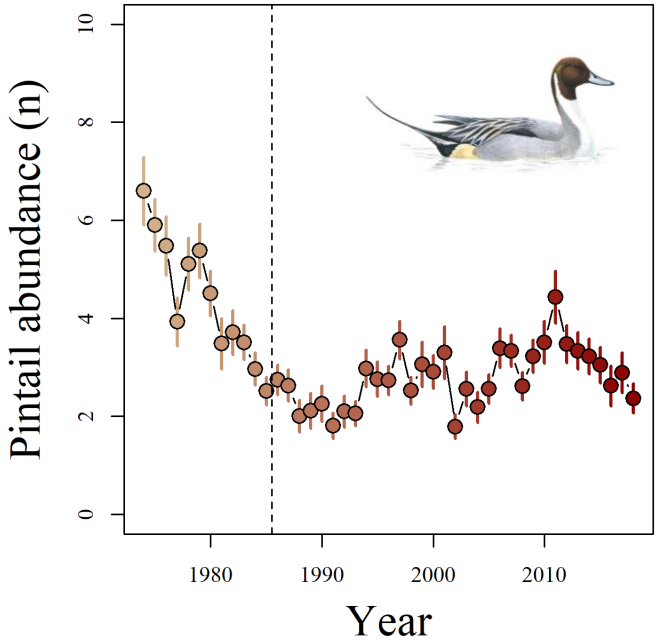


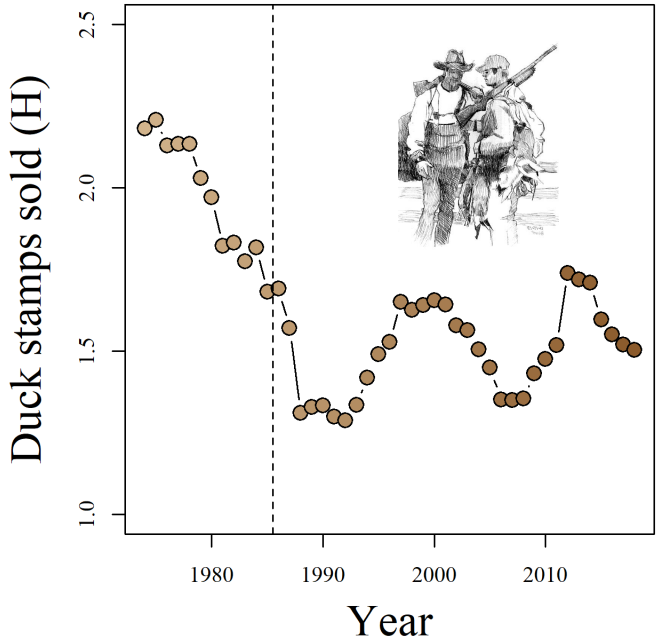


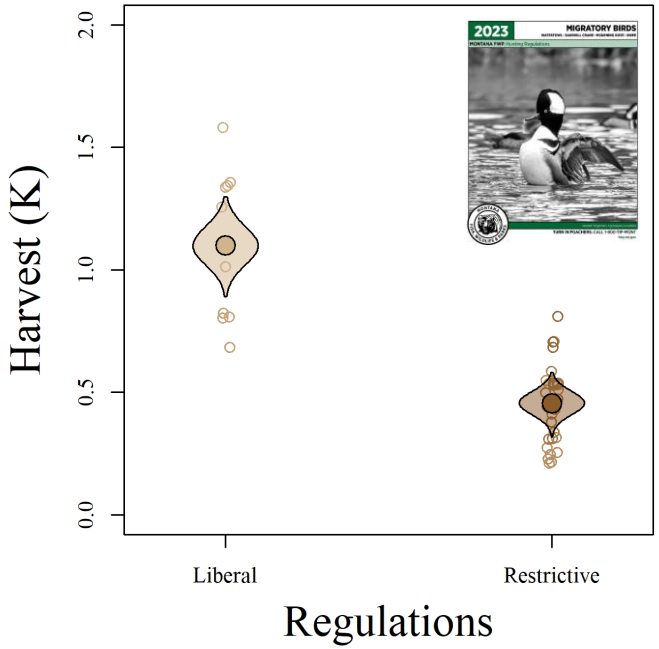


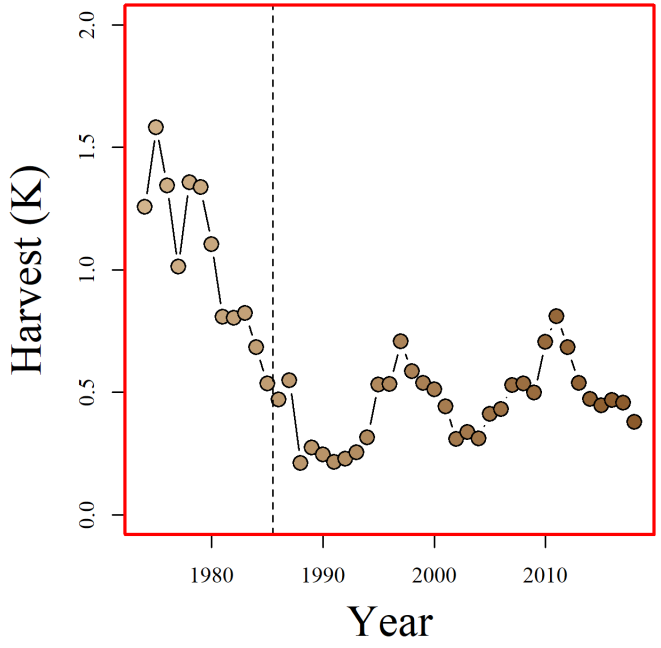
A better model…





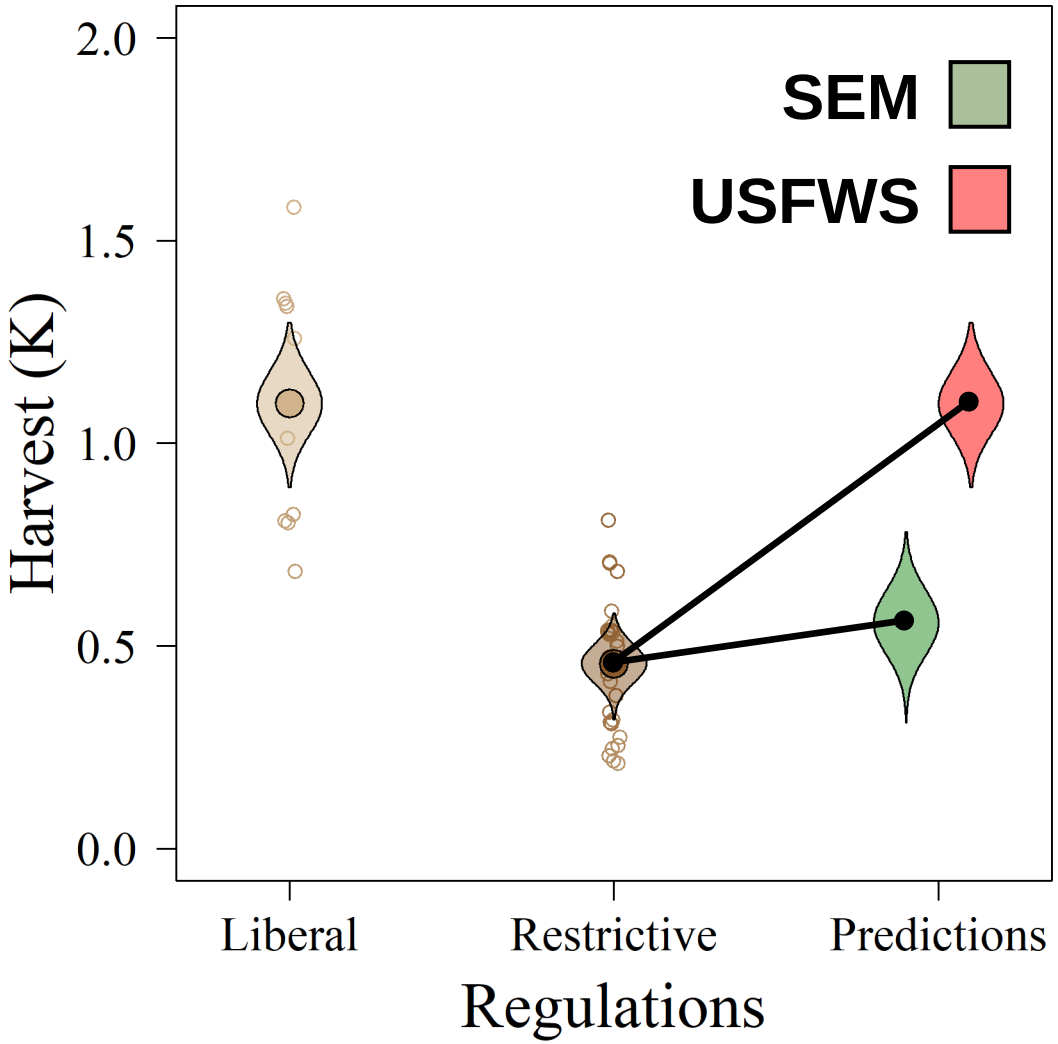


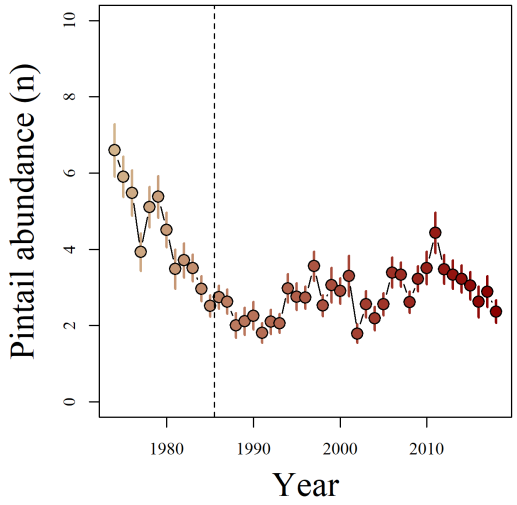


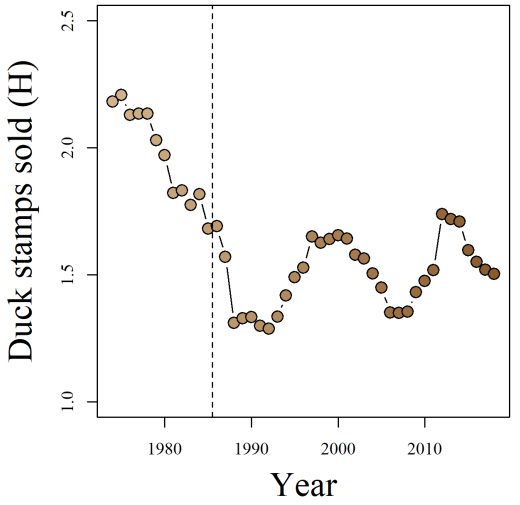


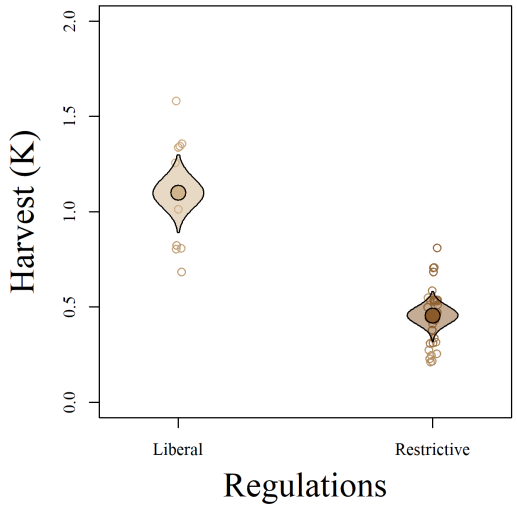
James K. Ringelman
Chair in Waterfowl Conservation

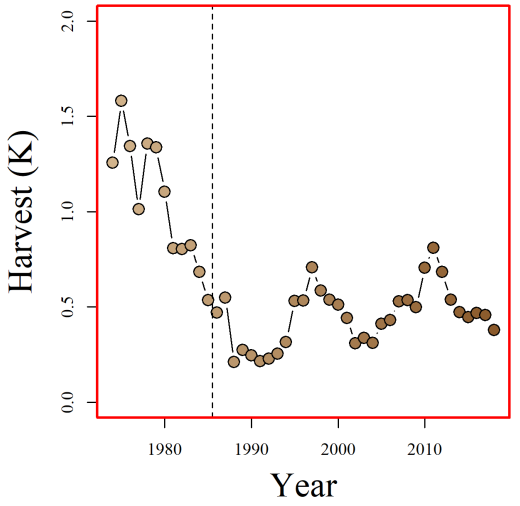
Two models, wildly different conclusions…



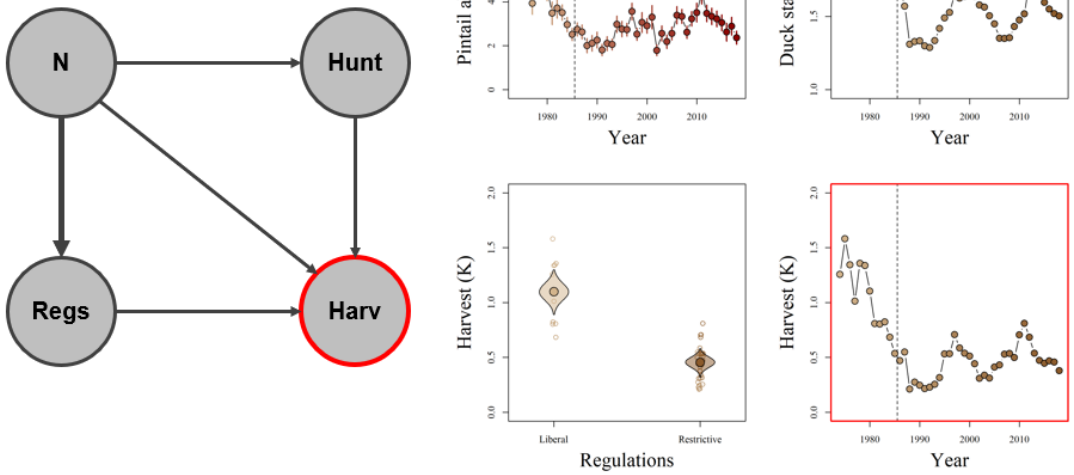


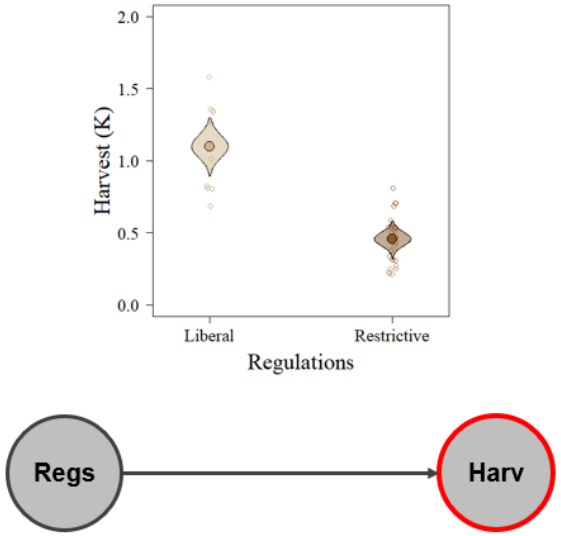






SEMs allow us to model <u>in the same way that we think</u>





<u>This is how we think</u>, and could be how we make decisions

This is currently how we make decisions

Abundance, hunters, and hunting mortality

Script 7

Handling real data (Script 8)