Evidence For Density-Dependent Effects On Body Composition Of Grizzly Bears (*Ursus Arctos*) In The Greater Yellowstone Ecosystem



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Understanding the processes that drive population dynamics is <u>critically important</u>…

… *yet* measuring the **performance-density relationship** in long-lived mammalian species demands **long-term data**

⇩

In **carrying capacity**-regulated species this relationship is inferred and **rarely assessed**

⇩

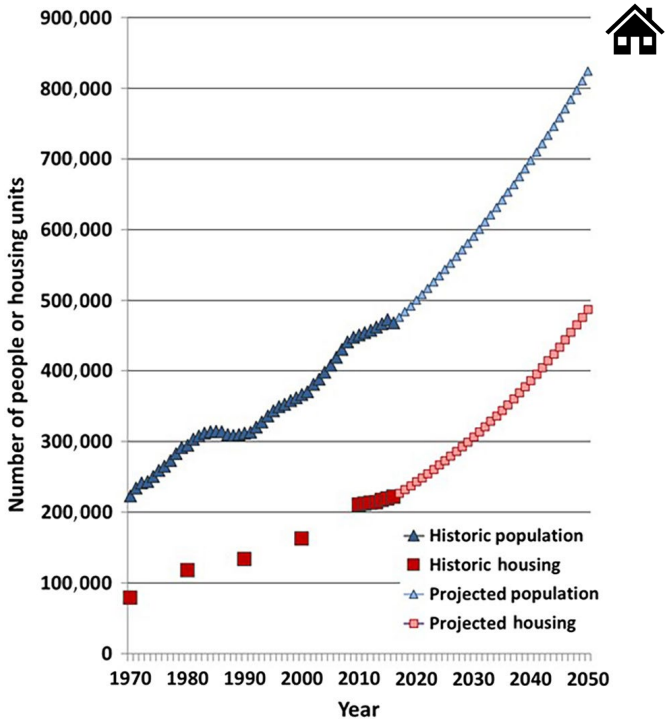
Only possible in a **few animal populations** globally



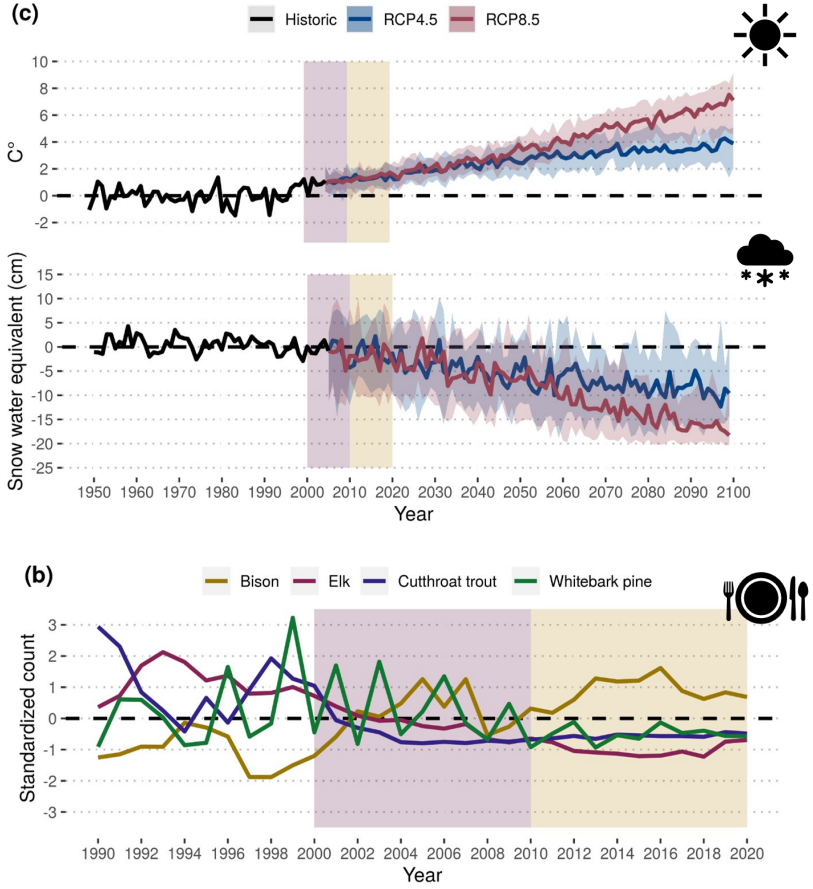
DALL·E, generated via ChatGPT 2024

A changing Greater Yellowstone Ecosystem

Hansen & Phillips, 2018

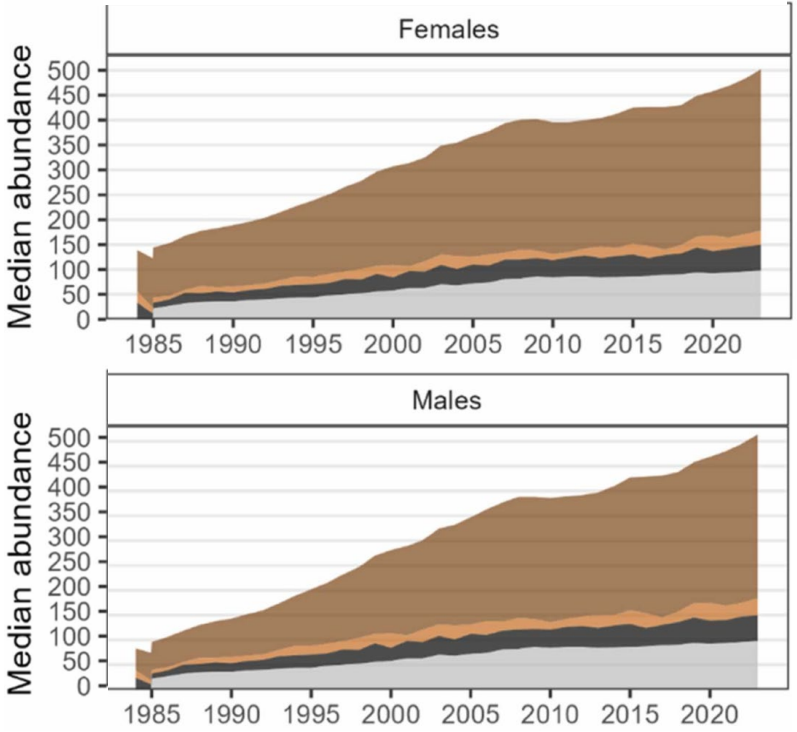


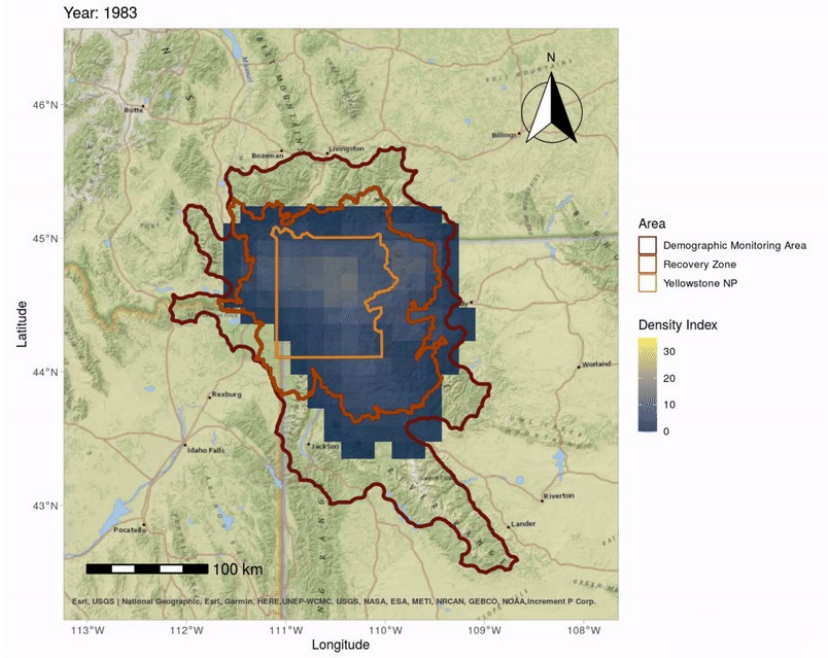
Corradini et al, 2023



A growing and expanding grizzly bear population

Gould et al, 2024





Corradini et al, 2023

Research questions

Ecological principle		Hypothesis	Prediction
Population regulatory mechanisms in long-lived mammals are mediated by individual performance [a, b]	H1	Individual grizzly bear lean body mass declines as population density increases	(i) Lean body mass of bears is negatively correlated with grizzly bear population density



Research captures

- From 1978 to 2020 (>**40 years**)
- Fitted with VHF/GPS collars
- Age, body composition (lean *vs.* fat)
- **418 individual bears (146 ♀, 272 ♂)**

Population-level information

- Sex-specific growth pattern (*Lean body mass*)
- Population density index (Bjornlie et al., 2014)



Modelling approach

GAMM *(H_I & H_{II})*

Lean mass ~ Age + Density + Life stage + *Zones*

$$Y_{\text{Lean Mass}} \sim \beta_0 + \beta_1 \log(\text{Age}) + \beta_2\, \text{Density} + \beta_3\, \text{Zones} + \beta_4\, \text{Life Stage} + \beta_5\, (\text{Density} \times \text{Zones}) + \beta_6\, (\text{Density} \times \text{Life Stage}) + \zeta_{\text{Year}} + \varepsilon$$

GLMM *(H_{III})*

Fat % ~ Julian + Density + Life stage + *Decade*

$$Y_{\text{Body Fat}} \sim \beta_0 + \beta_1\, \text{Julian} + \beta_2\, \text{Capture Decade} + \beta_3\, \text{Density} + \beta_4\, \text{Life Stage} + \beta_5\, (\text{Julian} \times \text{Capture Decade}) + \beta_6\, (\text{Density} \times \text{Life Stage}) + \zeta_{\text{Year}} + \varepsilon$$



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S5. Lean body mass of mature grizzly bears throughout the active season

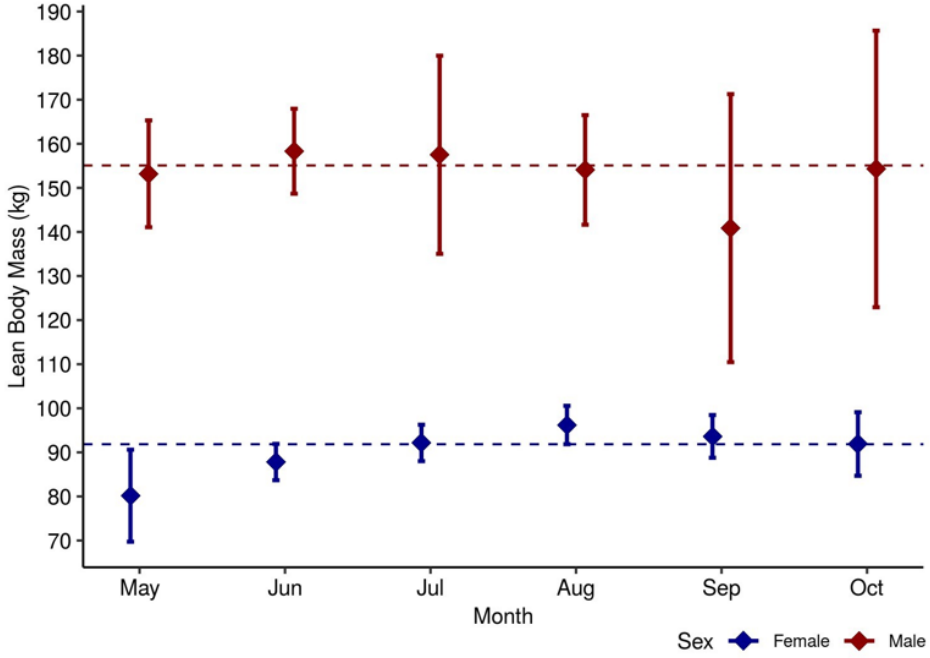

Figure S5 – Mean lean body mass (kg) and 95% confidence intervals of grizzly bears in the Greater Yellowstone Ecosystem that have reached 95% of their maximum body mass (female: ≥7 years old, male: ≥14 years old, see Figure 3), from May through October, 2000–2020. The dashed lines (blue for females, red for male) represent the overall means.

Corradini et al, 2023

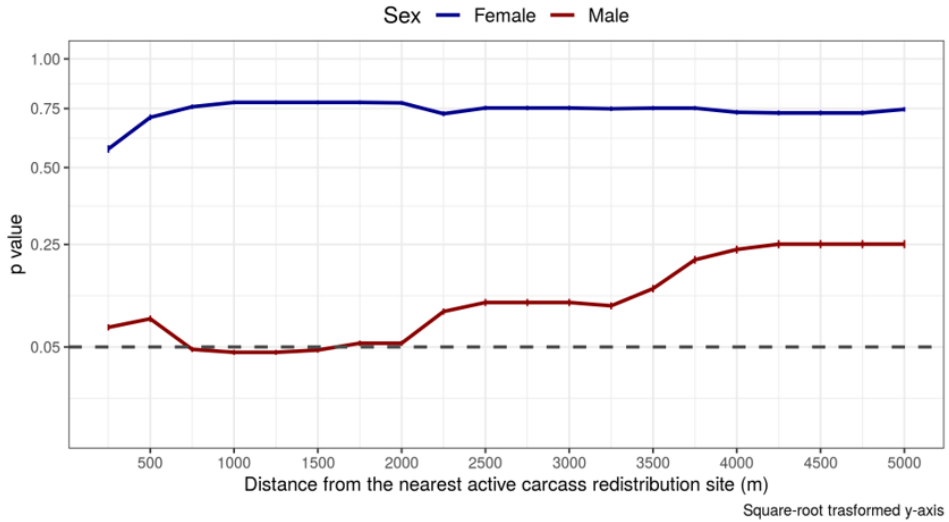

Figure S2 - Statistical threshold for relationship between lean body mass (kg) of grizzly bears and capture proximity to carcass redistribution sites (m) in Yellowstone and Grand Teton National Parks, 2000–2020. For each nearest distance to an active carcass redistribution site, the *t*-test *p*-values (mean with 95% confidence interval) for the difference in lean body mass between grizzly bears captured within and outside that distance are reported. To better visualize the departure from the 0.05 cutoff (dashed line), the y-axis was square-root transformed.

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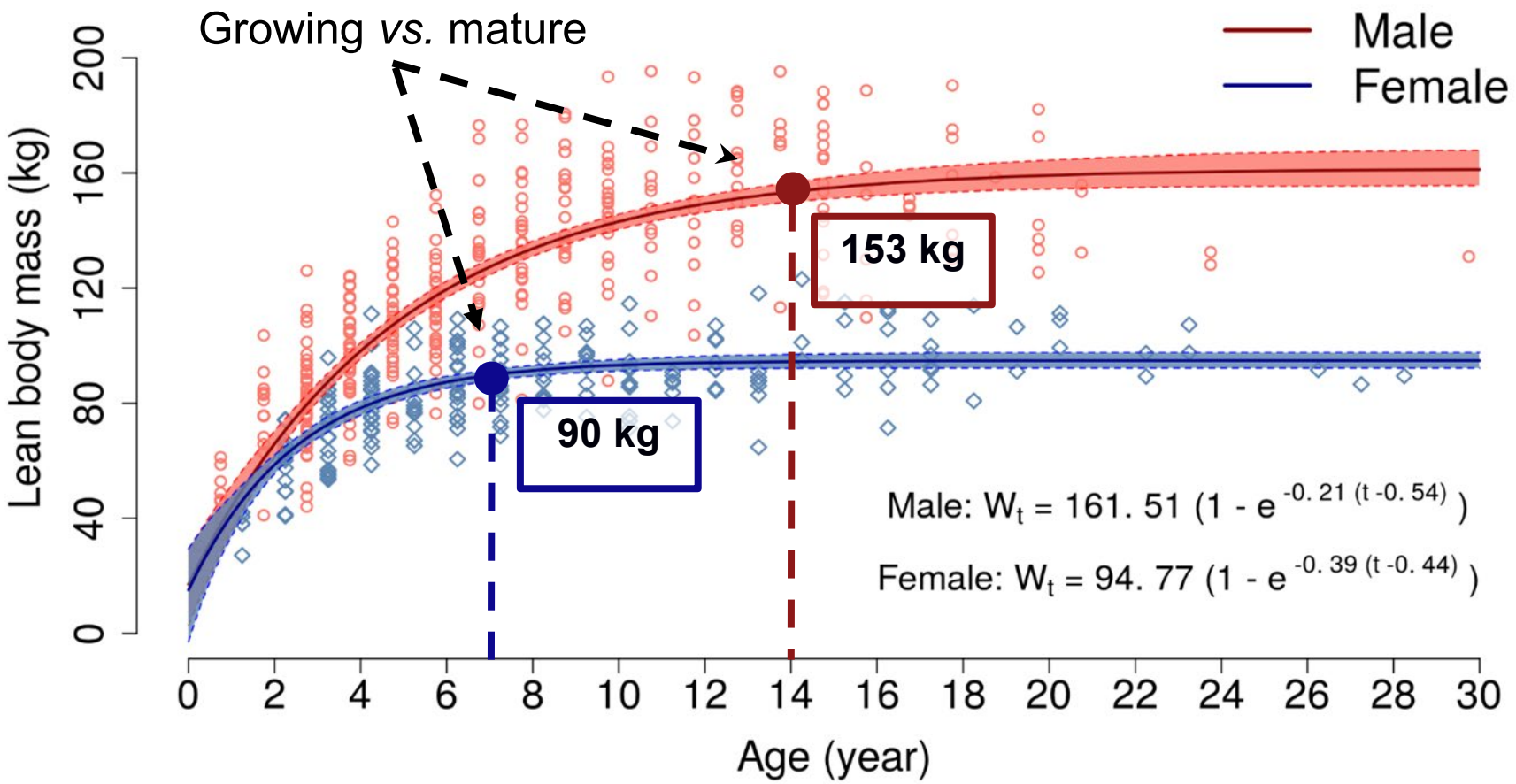

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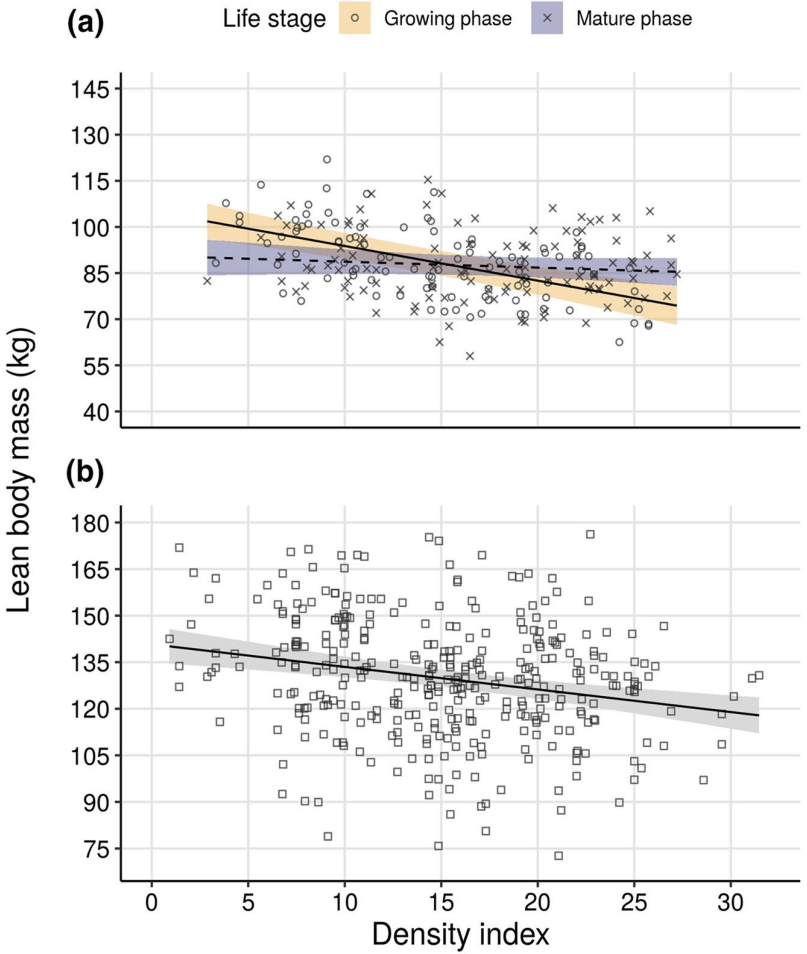
Hypotheses 1 & 2

- **Density <u>best predictor</u>** (♀ & ♂)
- **Growing** bears affected by density (♀)
- **YNP** bears not affected by density (♂)



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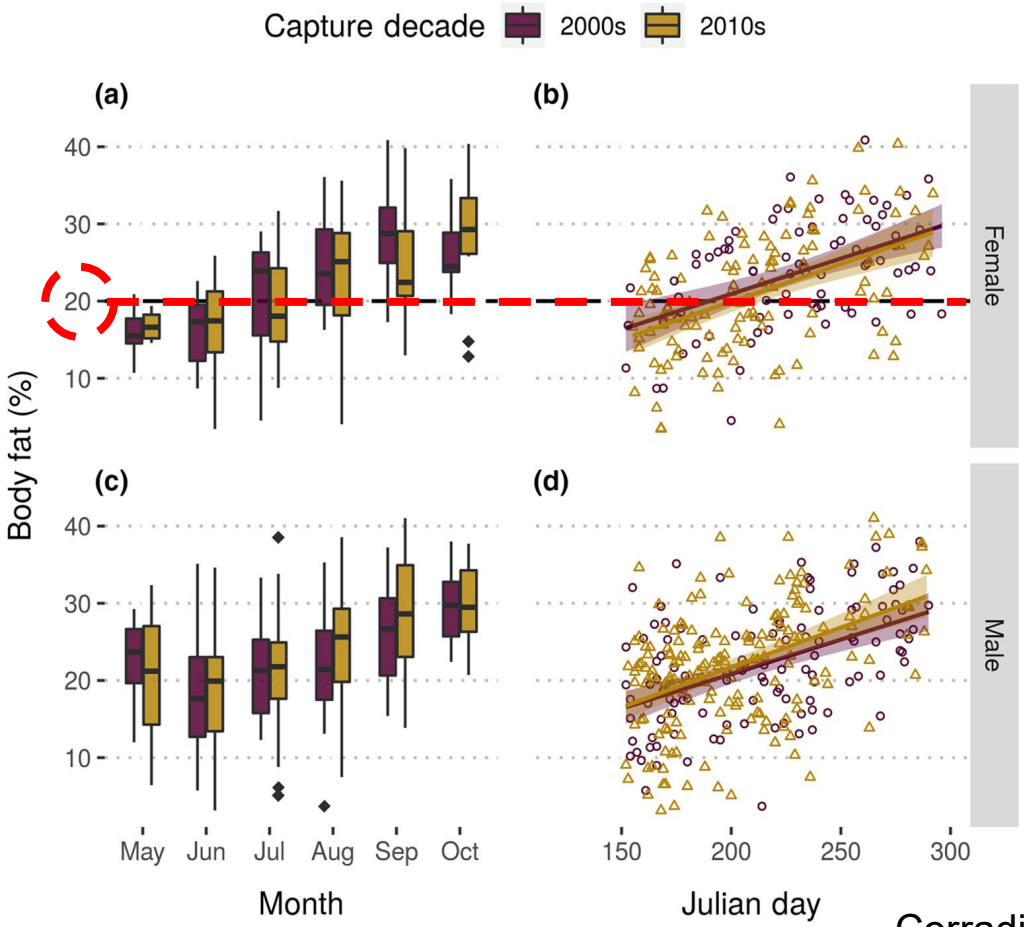
Hypotesis 3

- **Julian <u>best predictor</u>** (♀ & ♂)
- **Density <u>not significant</u>** (♀ & ♂)
- **Capital breeding** strategy was maintained



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Discussion

- **Longitudinal data** to investigate complex responses that emerge over time (40 yrs)
- **Density-dependence** emerges at the **individual** level by decreasing performance (lean body mass) → lower reproductive performance (♀) at the **population** level
- **Intraspecific competition** - In an opportunistic large omnivore more important than ecosystem perturbations and interspecific competition → Shift in feeding tactics



Acknowledgement



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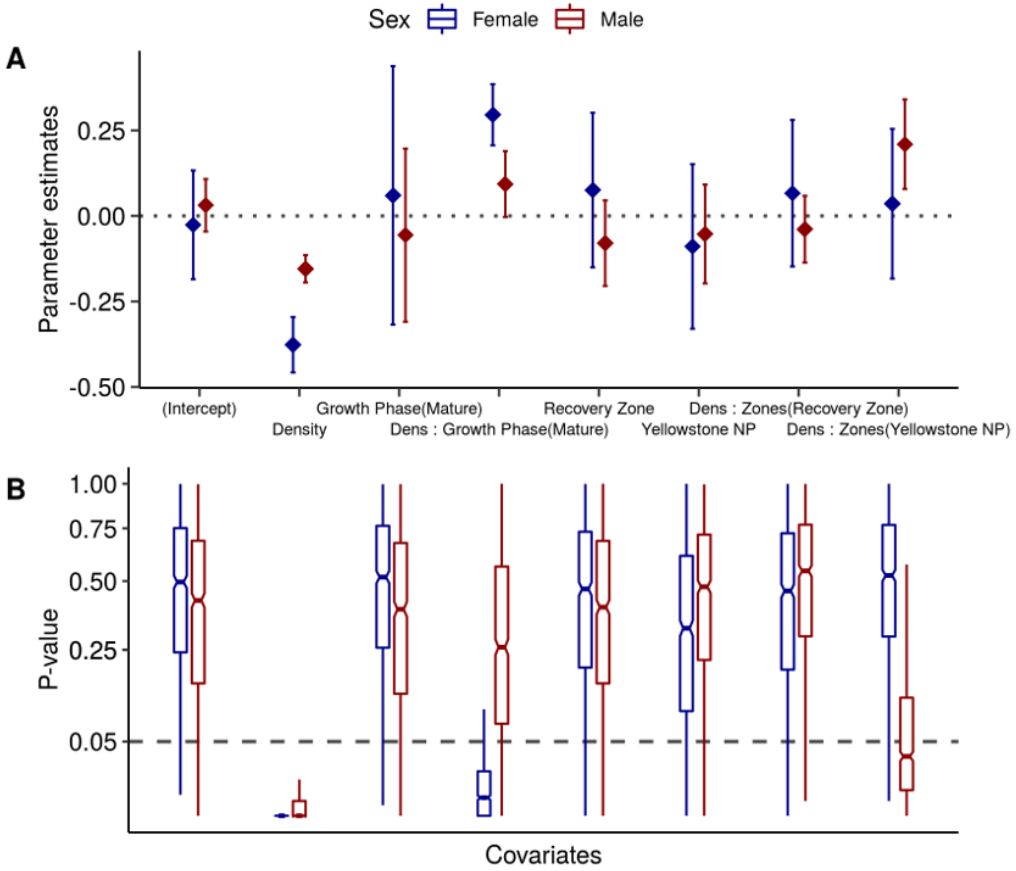
All the member agencies of the Interagency Grizzly Bear Study Team for contributing data

Lean body mass



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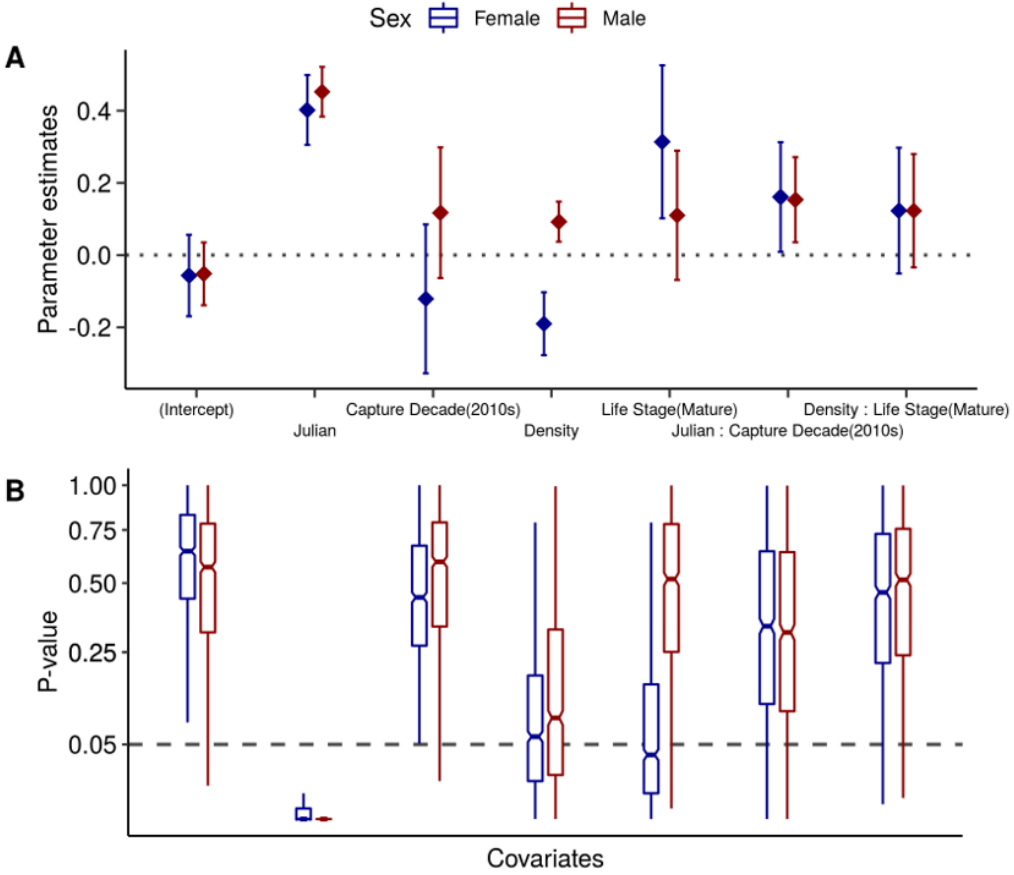
Percent body fat



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