Population Ecology III: A Brief Tour of Future Highlights

EFB 390: Wildlife Ecology and Management

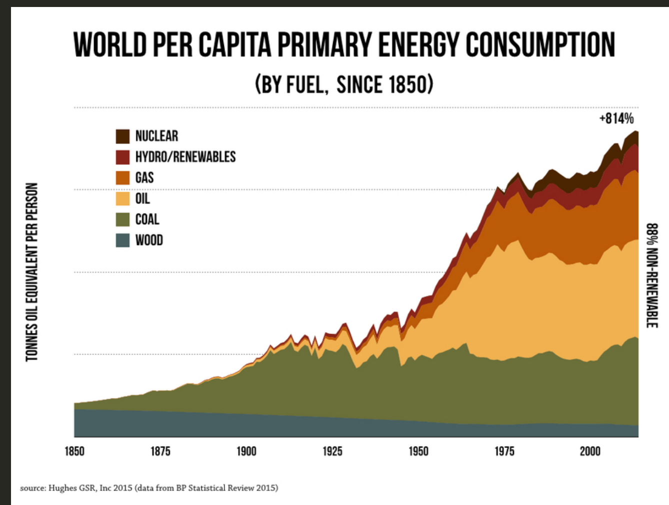
Dr. Elie Gurarie

October 18, 2022

Terrific seminar!

Limits to growth

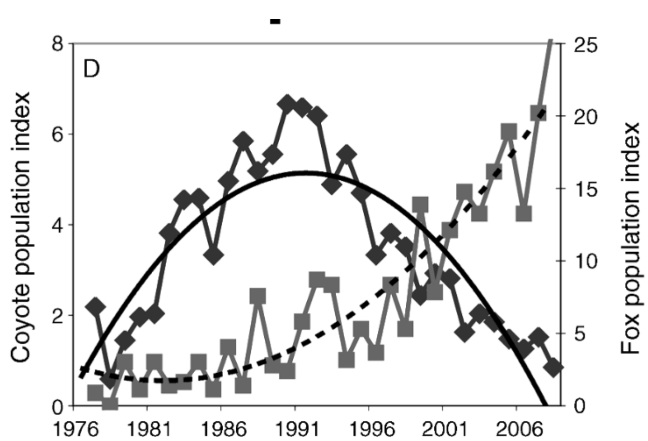
- space
- resources
- food
- *habitat*



Important additional factor: **Species Interactions**

Competitive Exclusion Principle

Two species **occupying the same niche** can coexist

In *theory* Fox (*Vulpes vulpes*) and Coyote (*Canis latrans*) can't co-exist across southern Minnesota prairie / farmland

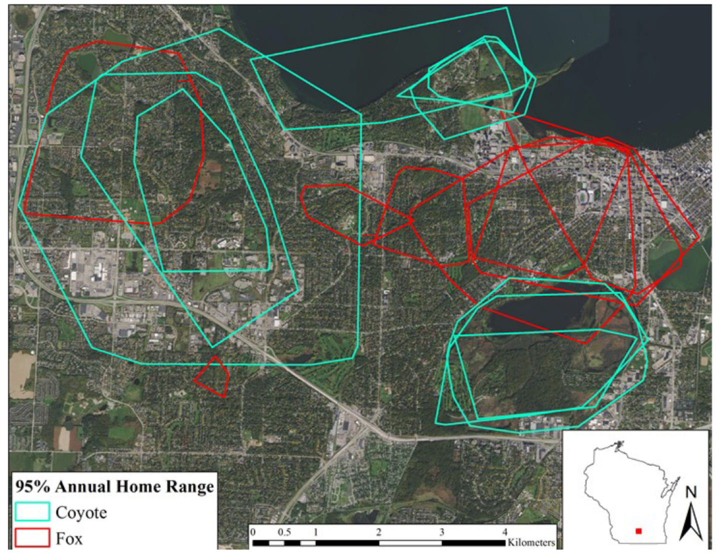
Levi and Wilmers (2021) *Ecology* 93(4)

Except they often do! (via niche partitioning)

RESEARCH ARTICLE

Coexistence of coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) in an urban landscape

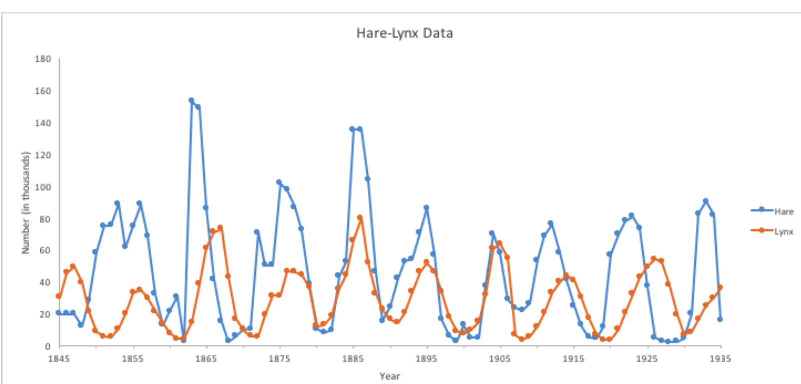
Marcus A. Mueller*, David Drake, Maximilian L. Allen



Madison, Wisconsin

Predator-prey dynamics

Based (mainly) on fur sales from the Hudson Bay Company in Canada over 100 years. Roughly a 9 to 11 year, fairly synchronous, cycle.



Theory suggests the **predators** and **prey** cycle

… but it turns out that is *probably* not the case.

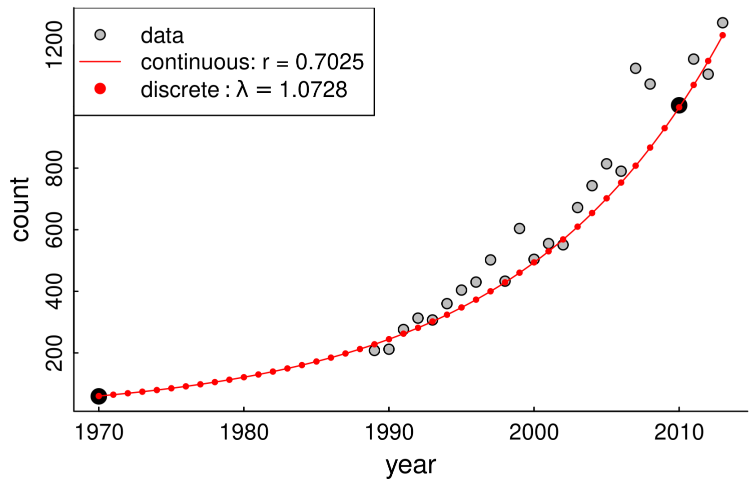
Learn more in **EFB 370: Population Ecology and Management**

Equations and models

Exponential model

$\frac{dN}{dt} = rN$

Basic assumption: Growth rate is proportional to population size



Equations and models

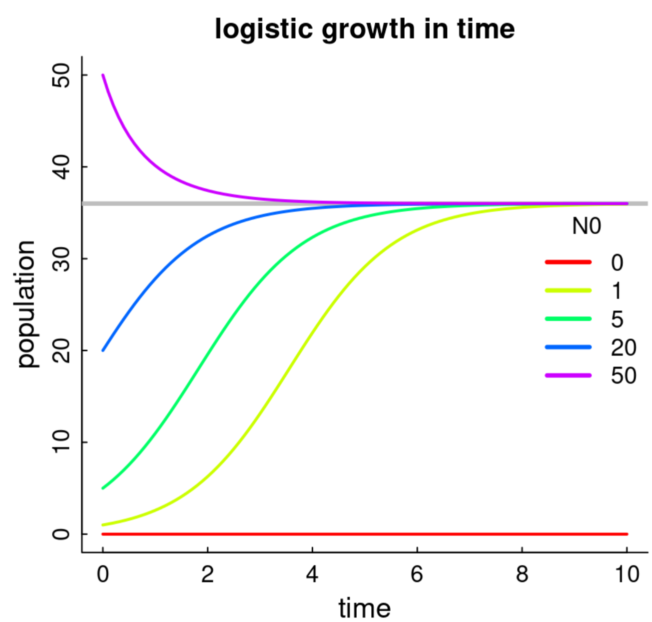
Exponential model

$\frac{dN}{dt} = rN$

Logistic model

$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$

Assumption growth rate goes to 0 at `(N=K)`

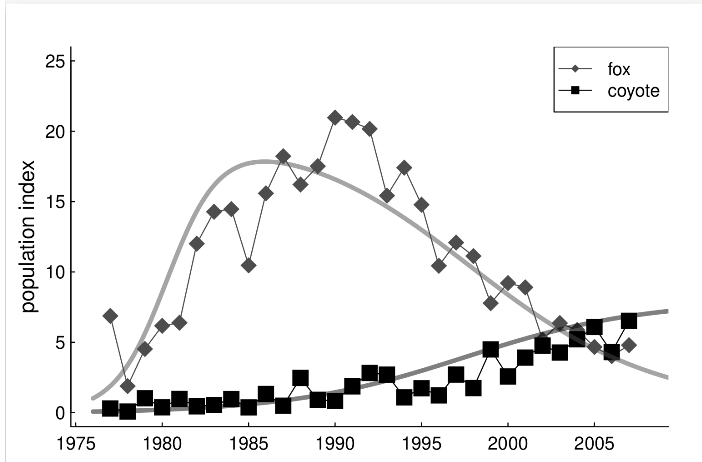


Competition model

$$\frac{dC}{dt} = r_c C \left(1 - \frac{C}{K_c} - \alpha \frac{F}{K_c}\right)$$

$$\frac{dF}{dt} = r_f F \left(1 - \frac{F}{K_f} - \beta \frac{C}{K_f}\right)$$

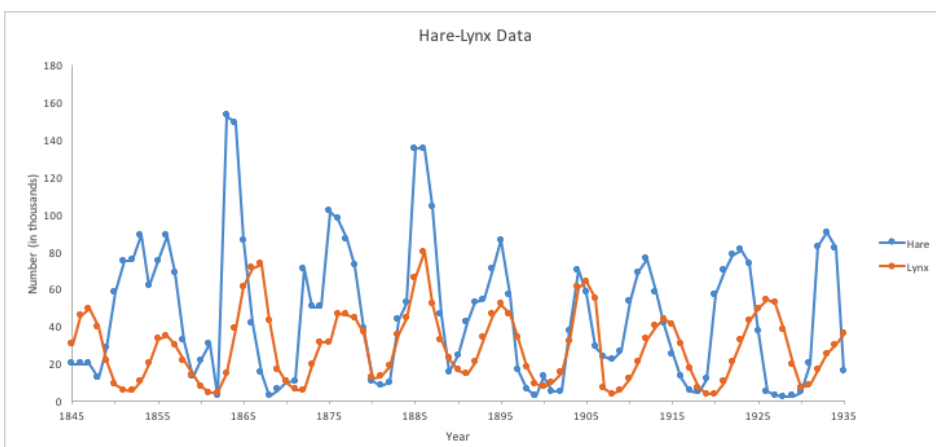
contains carrying capacities AND interactions



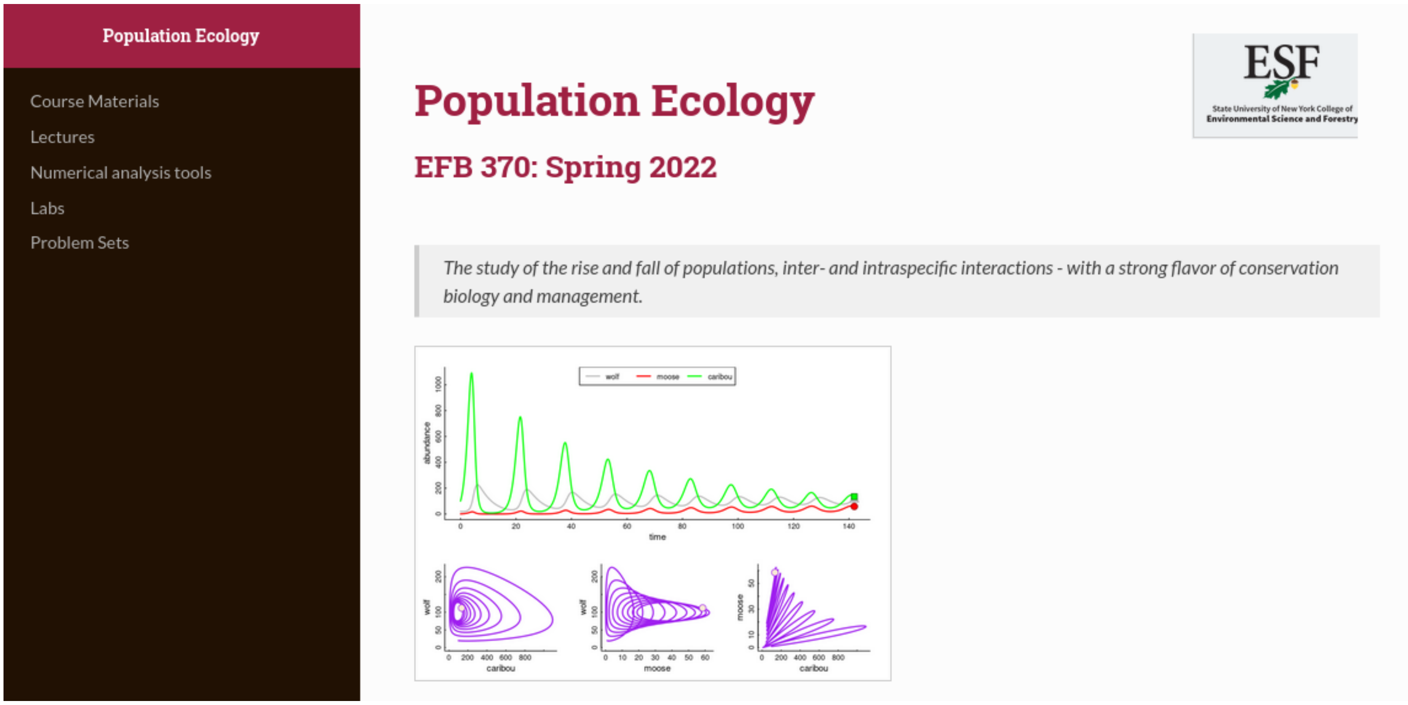
Predator-Prey Model

$$\frac{dP}{dt} = -qP + \gamma VP$$

$$\frac{dV}{dt} = rV - \sigma VP$$



To learn more ...



Drilling into structure of Birth and Death

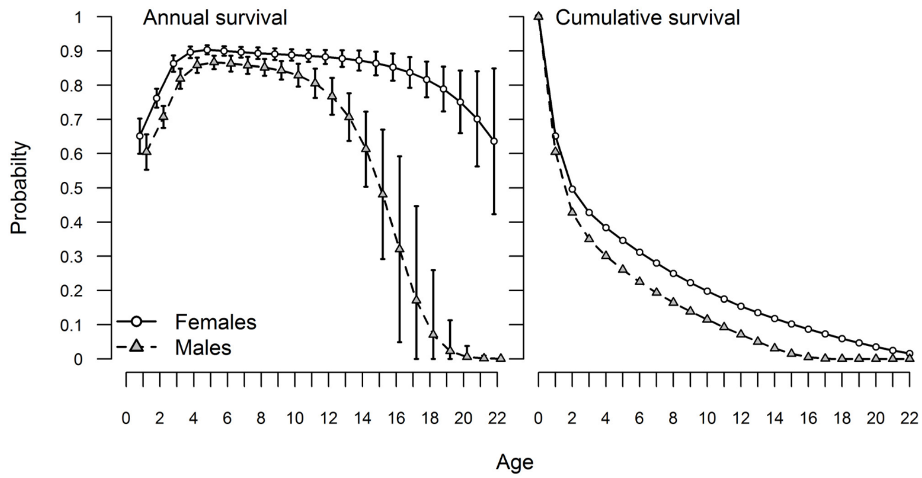
$$N_t = N_{t-1} + B_t - D_t$$

- **B** = Births
- **Fecundity** = # births / female / unit time

(*unit time* can be any unit of time, but is - ususally - year)

- **D** = Deaths
- **Mortality (rate)** = probability of death / unit time
- **Survival (rate)** = 1 - Mortality rate

Basic fact of life I: Survival varies with age!



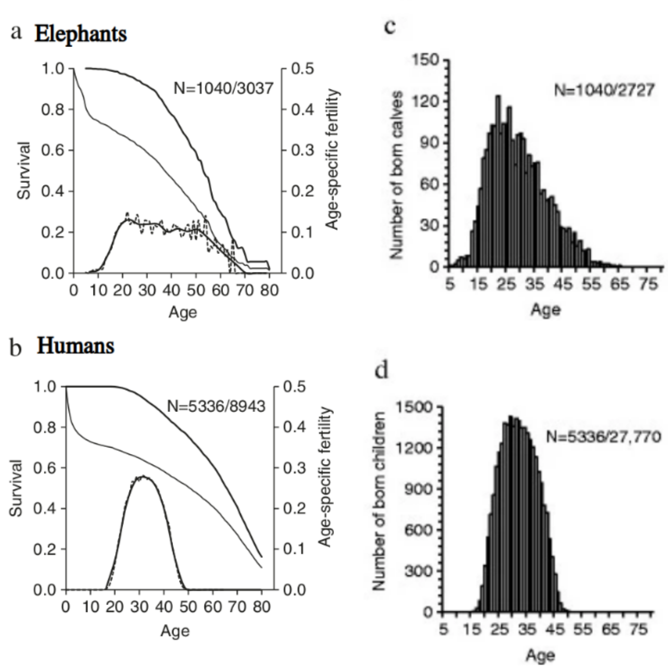
- **Survival Probability** ($S_0, S_1, S_2, \dots$) always between 0 and 1.
- **Cumulative Survival** ($1, S_0, S_0 S_1, S_0 S_1 S_2, \dots$) always starts at 1 and goes to 0

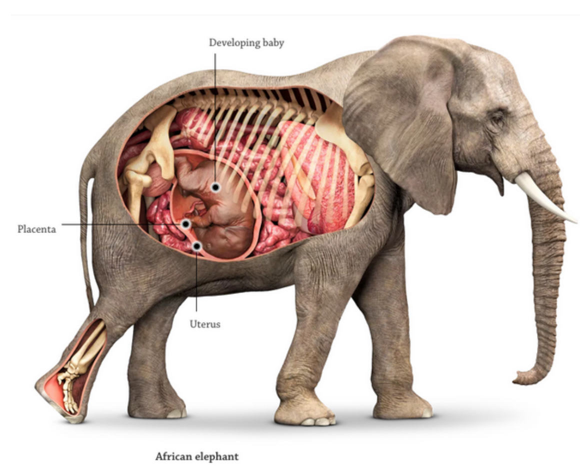
Steller sea lions (*Eumetopias jubatus*)

Age Specific Survival Rates of Steller Sea Lions at Rookeries with Divergent Population Trends in the Russian Far East

Alexey V. Altukhov, Russel D. Andrews, Donald G. Calkins, Thomas S. Gelatt, Eliezer D. Gurarie, Thomas R. Loughlin, Evgeny G. Mamaev, Victor S. Nikulin, Peter A. Permyakov, Sergey D. Ryazanov, Vladimir V. Vertyankin, Vladimir N. Burkanov

Basic fact of life II: Fecundity varies with age!





Research | Open Access | Published: 12 August 2014

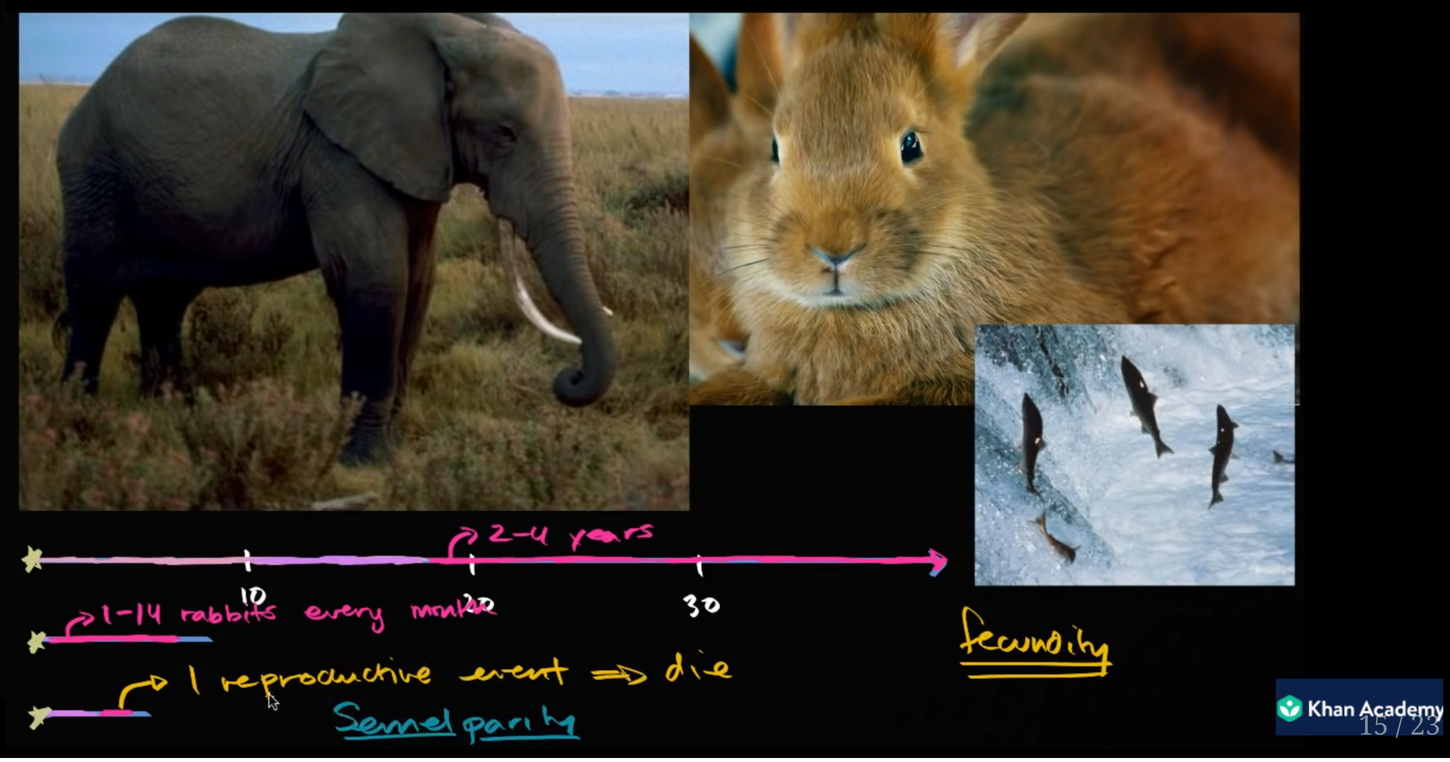
Reproductive cessation and post-reproductive lifespan in Asian elephants and pre-industrial humans

Mirkka Lahdenperä, Khyne U Mar & Virpi Lummaa

Frontiers in Zoology **11**, Article number: 54 (2014) | Cite this article

8909 Accesses | **59** Citations | **45** Altmetric | Metrics

Life History is the reproduction / mortality pattern



Survival curves

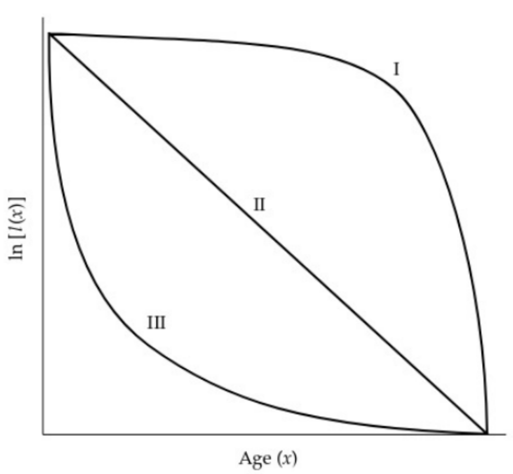


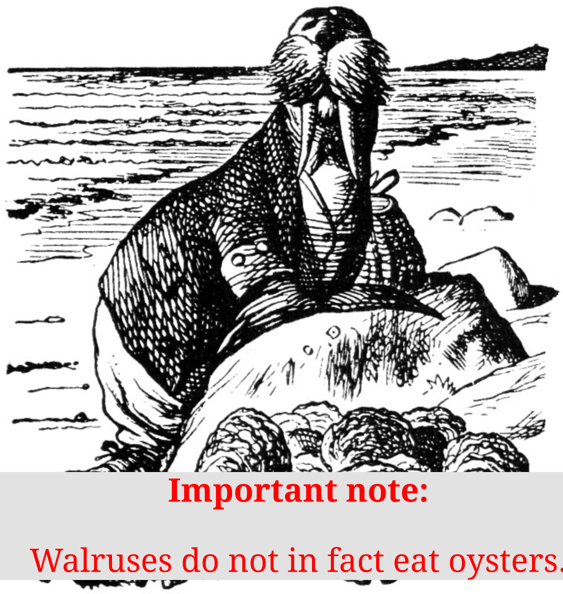
Figure 3.2 Type I, II, and III survivorship curves. Note the logarithmic transformation of the y axis.

- **TYPE I:** high survivorship for juveniles; most mortality late in life
- **TYPE II:** survivorship (or mortality) is relatively constant throughout life
- **TYPE III:** low survivorship for juveniles; survivorship high once older ages are reached

r (oysters) vs. K (walrus) strategy

r-selected species

- lots of offspring
- little or no parental investment
- low survivorship
- unstable environments
- small
- early maturity
- semelparous
- short life-expectancy
- Type III survivorship



K-selected species

- few offspring
- lots of parental investment
- high survivorship
- stable environments
- large
- late maturity
- iteroparous
- long life-expectancy
- Type I survivorship schedule

Important note:

Walruses do not in fact eat oysters.

Nice theory you've got there, but ...

- What about **trees**? They're big, they're long-lived (very **K**), but they produce and disperse a **heckload** of seeds (very, very **r**).
- What about **iteroparous** fish species (**K**) that are hedging their bets against high inter-annual variation in environmental conditions (very **r**)?

To learn more: Consider **EFB 370**

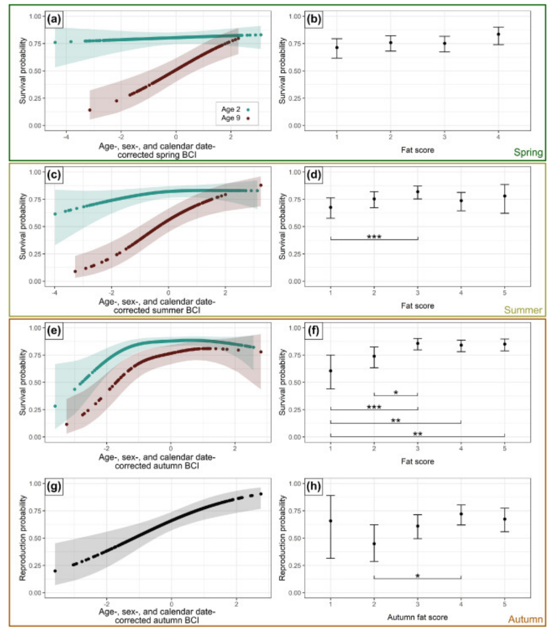
Body Condition and Physiology

Fecundity and **Survival** both depend very much on **body condition**.

Body condition is measured in many ways, for example:.

> We analysed two metrics of body condition: i) a direct subcutaneous **fat score (categorical, 1-5)**, assessed by palpating the belly-loin, with the badger laterally recumbent, and ii) a **body condition index (BCI)** estimated using a ratio-based approach for each capture: log (body mass)/log (body length).

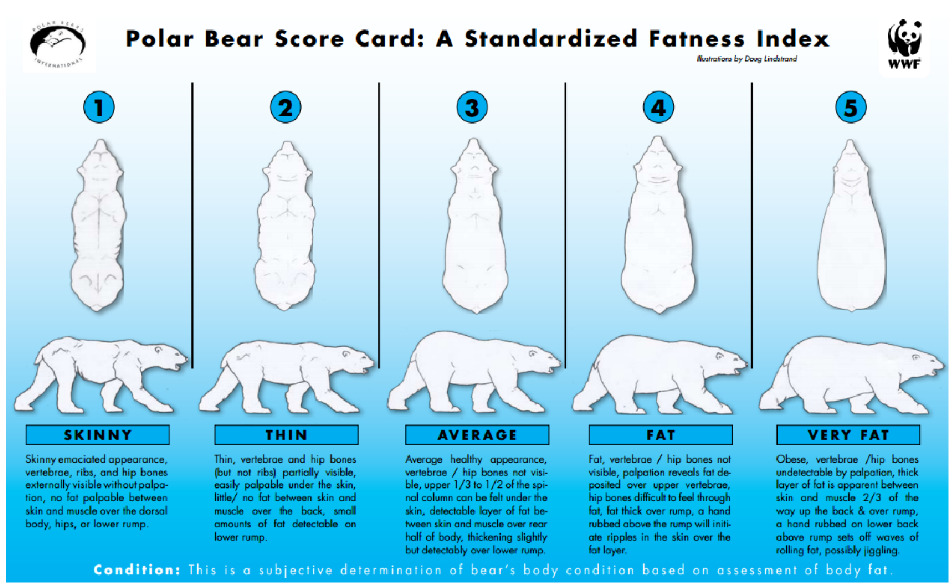
European badger (*Meles meles*):



(Ross et al. 2021)

Remote assessments of body condition

Field measurements made using categorical assessments.



Other measurements

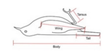
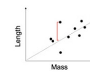
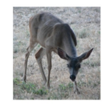
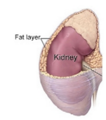
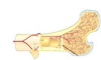
Note invasive measures

Kidney fat

- healthy mammals

Bone marrow fat

- informative for non-healthy mammals

	Condition quantification			External measure				
Condition metric	Qualitative	Raw quantitative	Adjusted quantitative	External	Invasive	Pros	Cons	Pictorial example
Mass (e.g. body mass)		●		●		Easy to measure; non-invasive	Can fluctuate rapidly; can differ with age, sex and reproductive status	
Length (e.g. body length)		●		●		Easy to measure; non-invasive	Can differ with age and sex; often does not change after reaching adult state	
Mass adjusted for body size (e.g. residuals of mass vs. length regression)			●	●		Controls for effect of body size on condition	Difficult to compare across populations; different mass and size measurements can result in equal scores	
Subjective score (e.g. body fat score)	●			●		Non-invasive; can be used for multiple age classes, sexes	Prone to interobserver variation; lipid stores might not reflect health or reproductive success	
Assessment of internal characteristics (e.g. kidney fat cover index)	●				●	May not require entire animal or can be provided by hunters	Lethal sampling; see above concerns about lipids	
Measurement of internal characteristics (e.g. % bone marrow fat)		●			●	May not require entire animal or can be provided by hunters	Lethal sampling; see above concerns about lipids	

(Sanchez et al. 2018)

Influences on body condition

- **Food availability** - including (often) high seasonal variation
  - These relationships make **Body Condition** a good proxy for **Habitat Quality**
- **Disease and parasite loads**
- **Stress** - from human, predator impacts, or social interactions

Consequences of (poor) body condition

- Lower **survival** & lower **fecundity**
  - Varies by age
  - Often - physiological energetic trade-offs between **survival** and **reproduction** (less gonadal growth, later maturation, skipped estrus)
- Population level impacts
  - mechanisms of **Density Dependence**

Introducing ...

Eaqan Chaudhry

- Wildlife physiologist
- Ph.D. candidate in Environmental Biology, SUNY-ESF with **Dr. Cynthia Downs**
- Pop wildlife quiz: **IS** or **IS NOT** holding a New England cottontail rabbit in the image to the right?