ESTIMATING CARRYING CAPACITY OF ROOSEVELT ELK HERDS USING STATE-SPACE MODELS AND VARIATION IN STRENGTH OF DENSITY DEPENDENCE

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SETTING

July

January
Benign Climate ➔ Little Density Independent Influences

$\text{Annual precipitation}_t (\text{cm})$

$$r_{\text{correlation}} = 0.19$$

$\text{Winter low temperature}_t (\text{C})$

$$r_{\text{correlation}} = -0.21$$

STABLE LANDSCAPE
PREDATORS
FOOD

ELK

Abundance

Year

$K$ carrying capacity

[Image of elk grazing in a field with a graph showing population growth with $K$ as the carrying capacity]
ESTIMATE $K$ CARRYING CAPACITY

![Graph showing the growth of abundance over time, approaching $K$ carrying capacity.](image-url)
Variation K ➔ AFFECT POPULATION DYNAMICS

- Abundance vs. Time

- $K$ carrying capacity
STATE-SPACE FORMULATION

- **Gompertz**: 
  \[ N_{t+1} = N_t e^{r_{max} \left(1 - \frac{\ln(N_t + 1)}{\ln(K + 1)}\right)} \]

- **Ricker**: 
  \[ N_{t+1} = N_t e^{r_{max} \left(1 - \frac{N_t}{K}\right)} \]

- **θ-Logistic**: 
  \[ N_{t+1} = N_t e^{r_{max} \left(1 - \left(\frac{N_t}{K}\right)^{\theta}\right)} \]

**Observer Error**: Count \( \sim \) Poisson(\( \lambda \))
BALD HILLS

- Gompertz
- Θ-logistic
- Ricker
$N_{t+1} = N_t e^{r_{max}(1 - \frac{N_t}{K})}$

$N_{t+1} = N_t e^{r_{max}(1 - (\frac{N_t}{K})^\theta)}$

**Model**

- **Ricker**
- **Theta-logistic**
\[ r = \ln \left( \frac{N_{t+1}}{N_t} \right) \]
\[ r = \ln\left(\frac{N_{t+1}}{N_t}\right) \]
January 2017

Elk forage hrs vs. Forage biomass (kg)

\[ r^2 = 0.79, \ P = 0.0014 \]

$r = \ln\left(\frac{N_{t+1}}{N_t}\right)$
Thank you
Lower Redwood – Prairie Creek
Juveniles:female_{t+2}

Females, juveniles and sub-adult males_{t}

PLACEHOLDER_1

DECLINE

LOWER K
Intrinsic growth rate ($r$)
Gompertz

\[ N_{t+1} = N_t e^{r_{max} \left(1 - \frac{N_t}{K}\right)} \]

Ricker

\[ N_{t+1} = N_t e^{r_{max} \left(1 - \left(\frac{N_t}{K}\right)\theta\right)} \]

\[ N_{t+1} = N_t e^{r_{max} \left(1 - \left(\frac{\ln N_t + 1}{\ln K + 1}\right)\theta\right)} \]

\[ r = r_{max} \left(1 - \frac{N_t}{K}\right) \]

\[ r = r_{max} \left(1 - \left(\frac{N_t}{K}\right)^\theta\right) \]

\[ r = r_{max} \left(1 - \frac{\ln(N_t + 1)}{\ln(K + 1)}\right) \]