

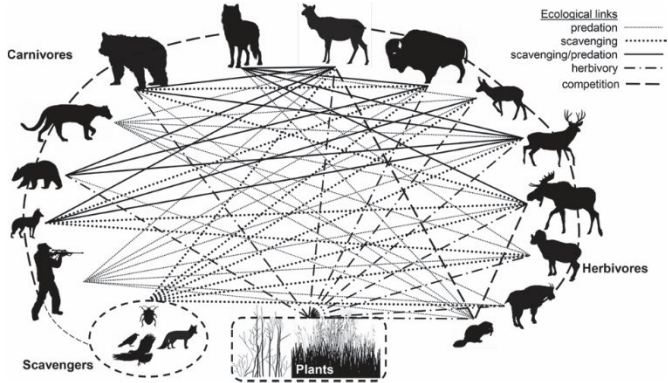
Quantifying trophic cascades Lessons from a North American system

Willem Bonnaffé¹, Marti Muraro¹, William Goulding², & Tim Coulson¹

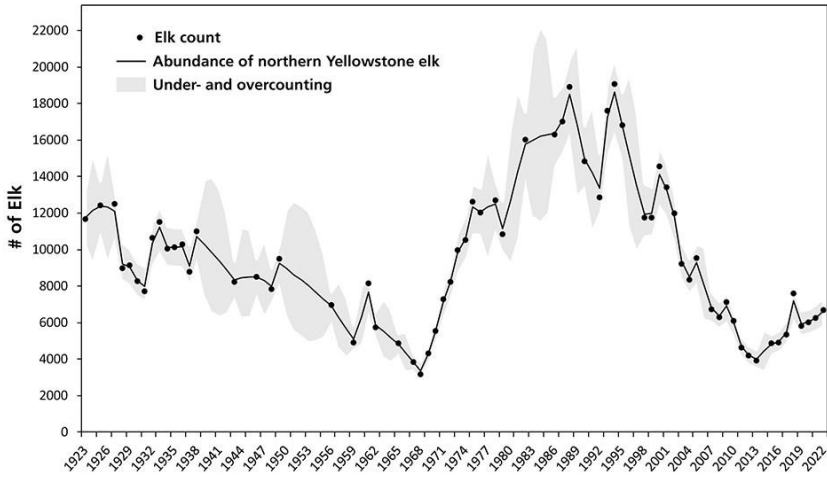
¹Department of Biology, University of Oxford, Oxford, UK

²Centre for Planetary Health and Food Security, Griffith University, Brisbane, Australia

Survival and reproduction underpin changes in population size



Ecological interactions determine the survival and reproduction of individuals



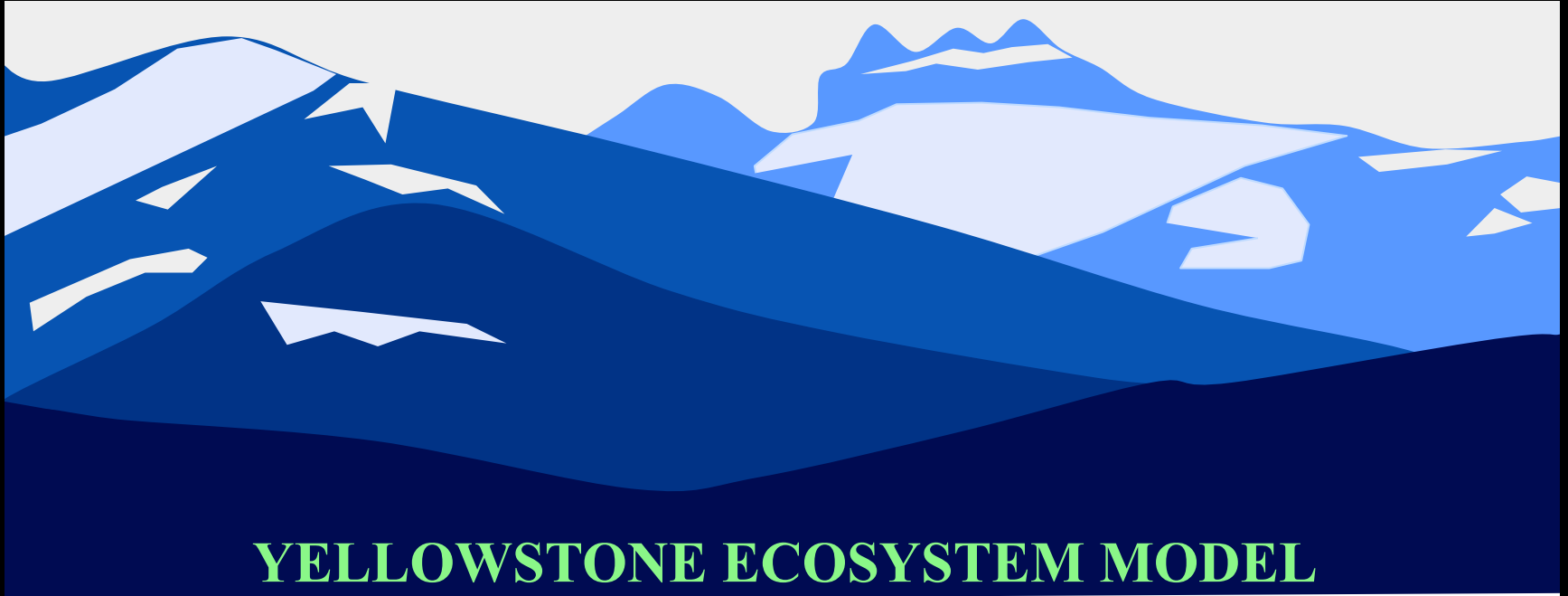




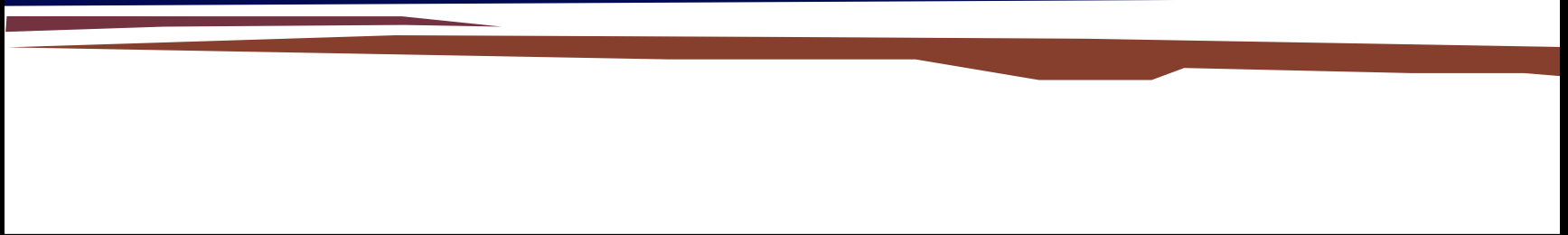








YELLOWSTONE ECOSYSTEM MODEL



$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

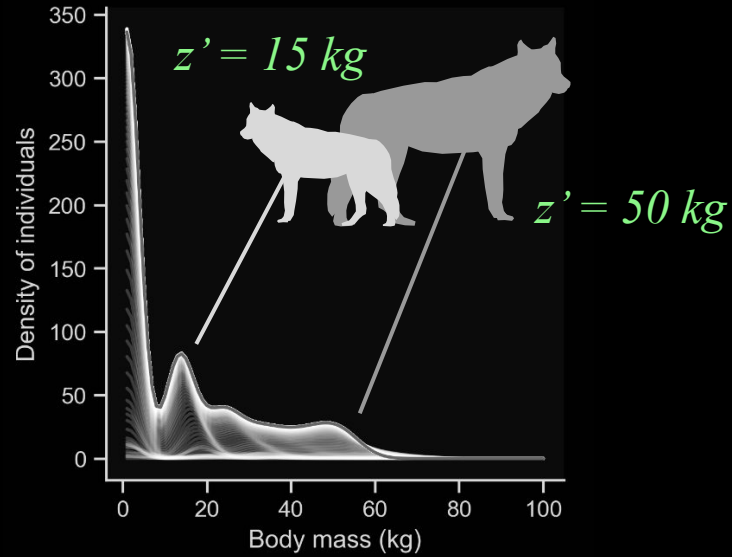
Phenotype
distribution at $t + 1$

Phenotype
distribution at t

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

Phenotype
distribution at t

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z') p_s(z') N(z', t)) dz'$$

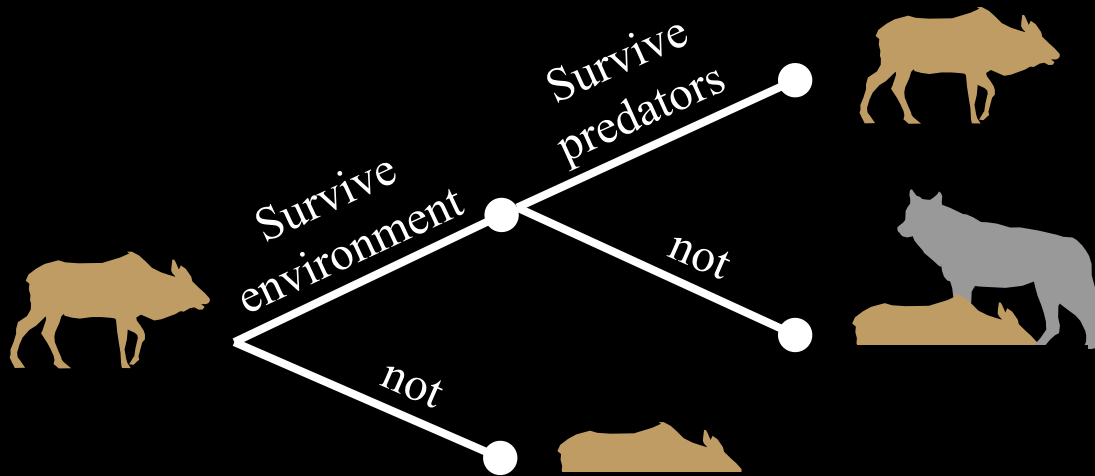


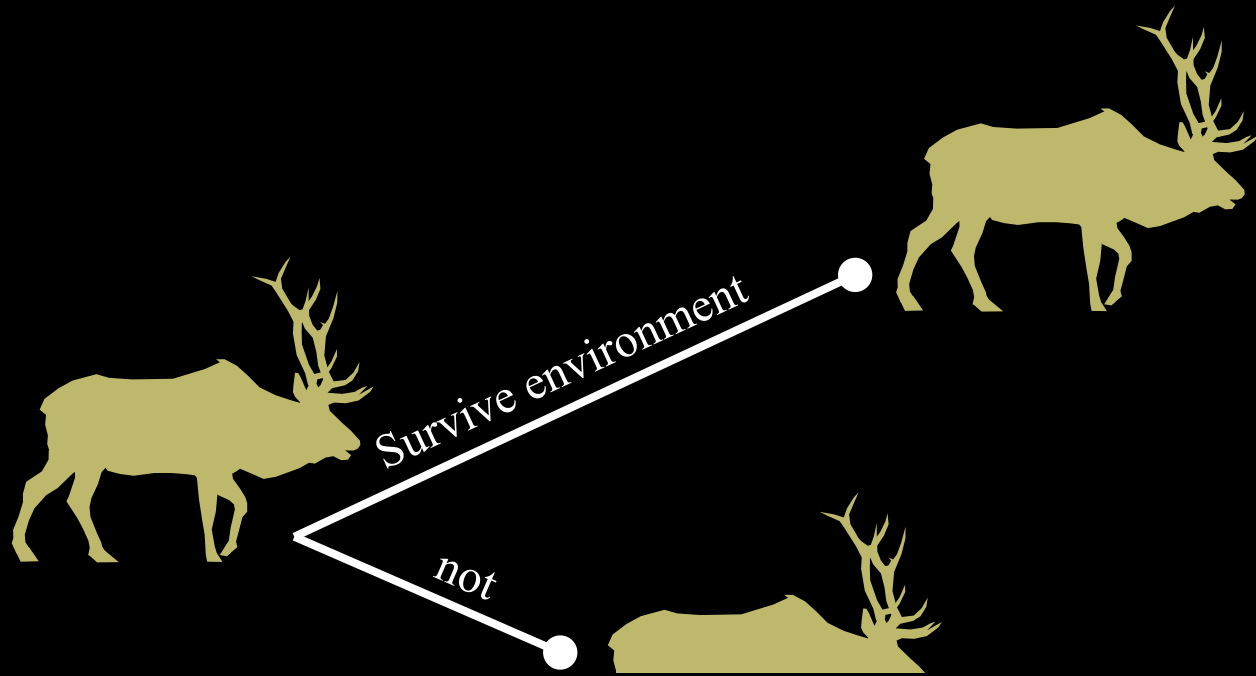
Phenotype
distribution at t

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

Probability of
Survival

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$



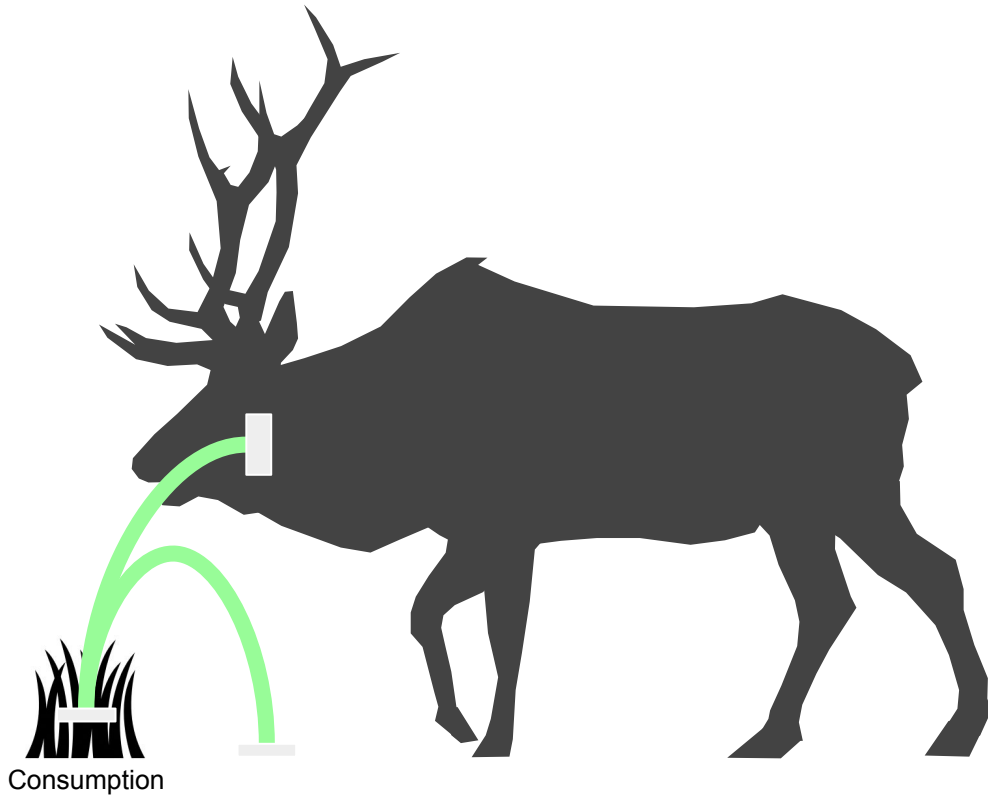


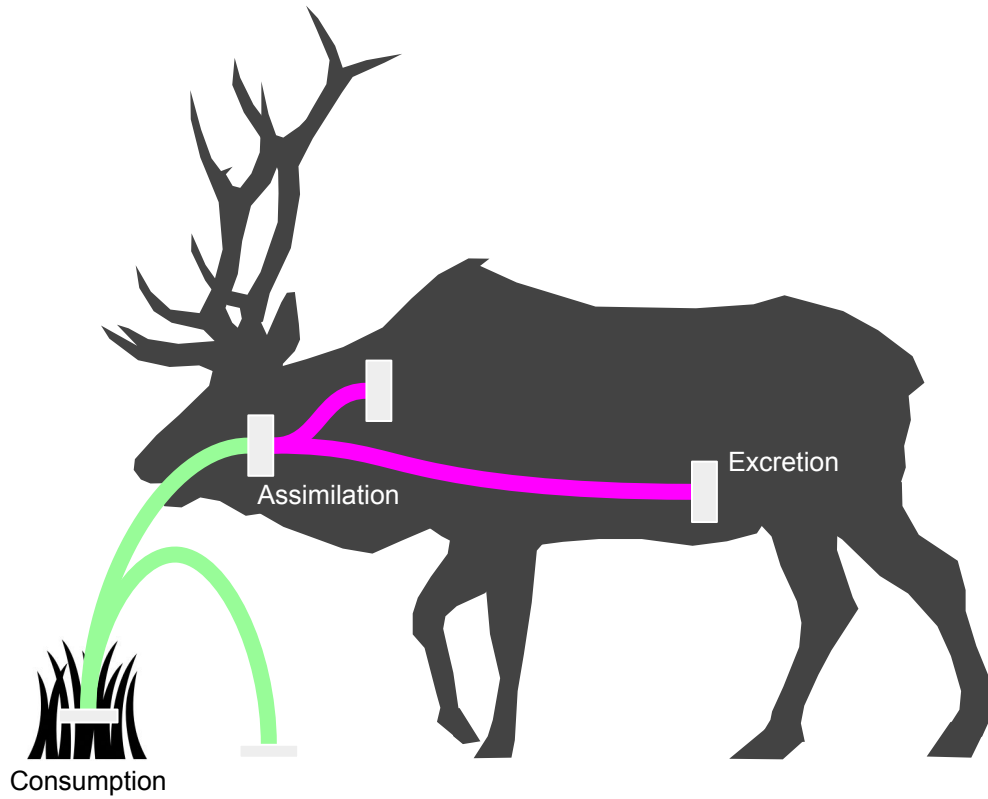
Probability of
Survival

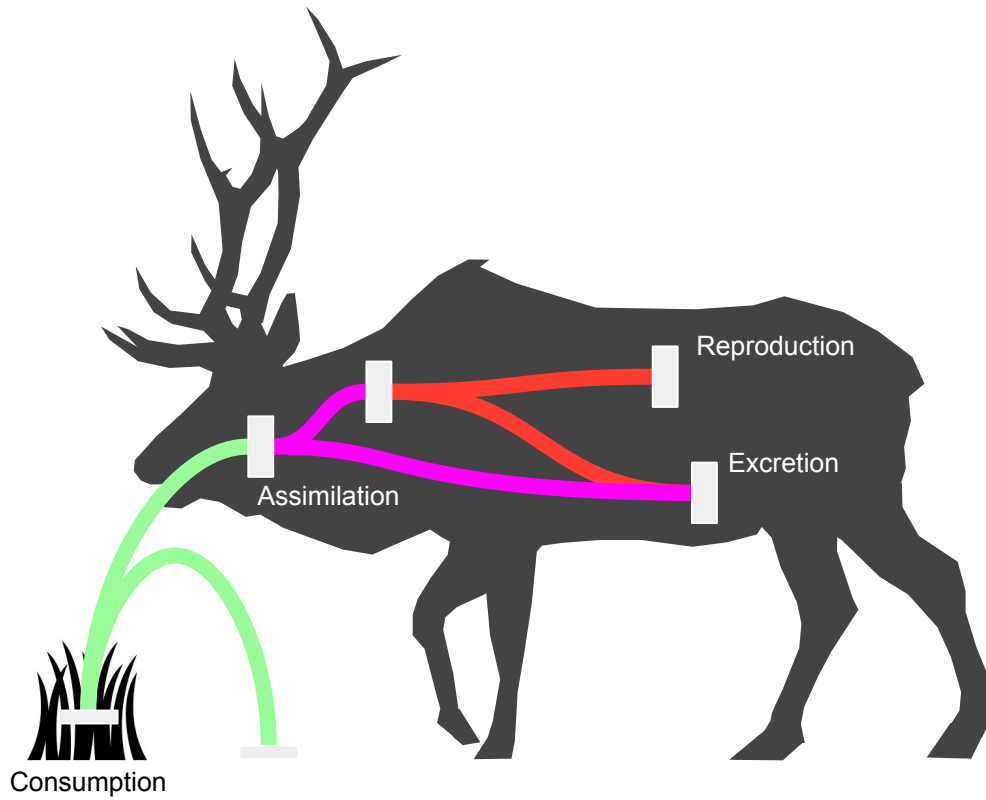
$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

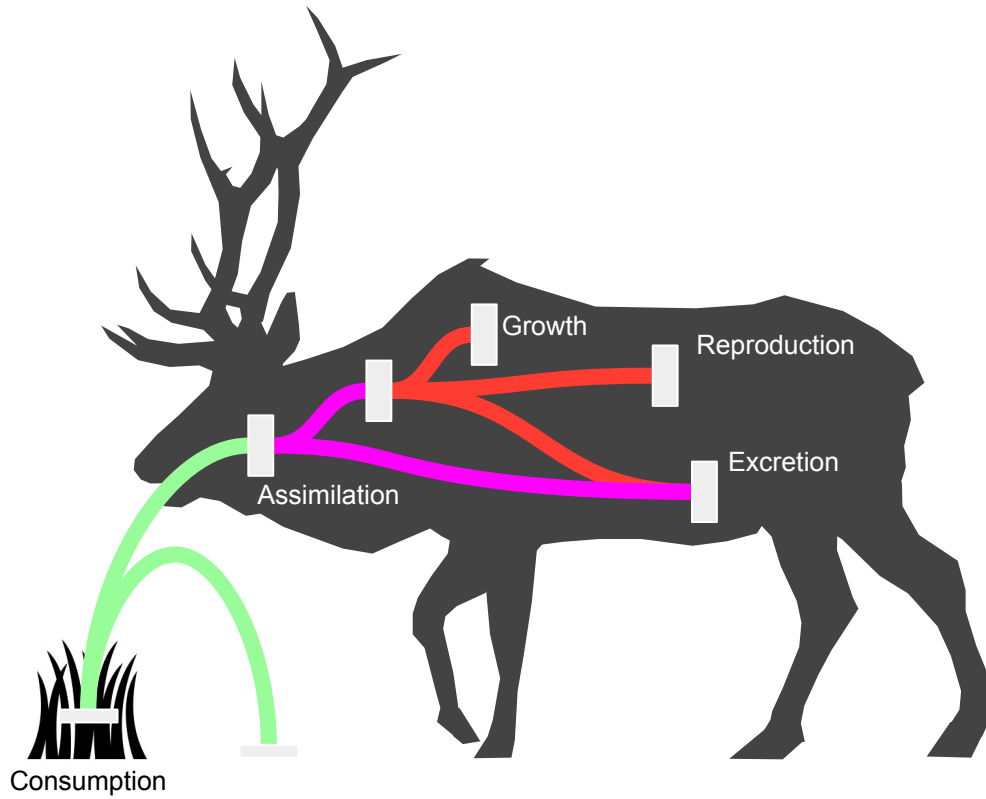
Growth
kernel

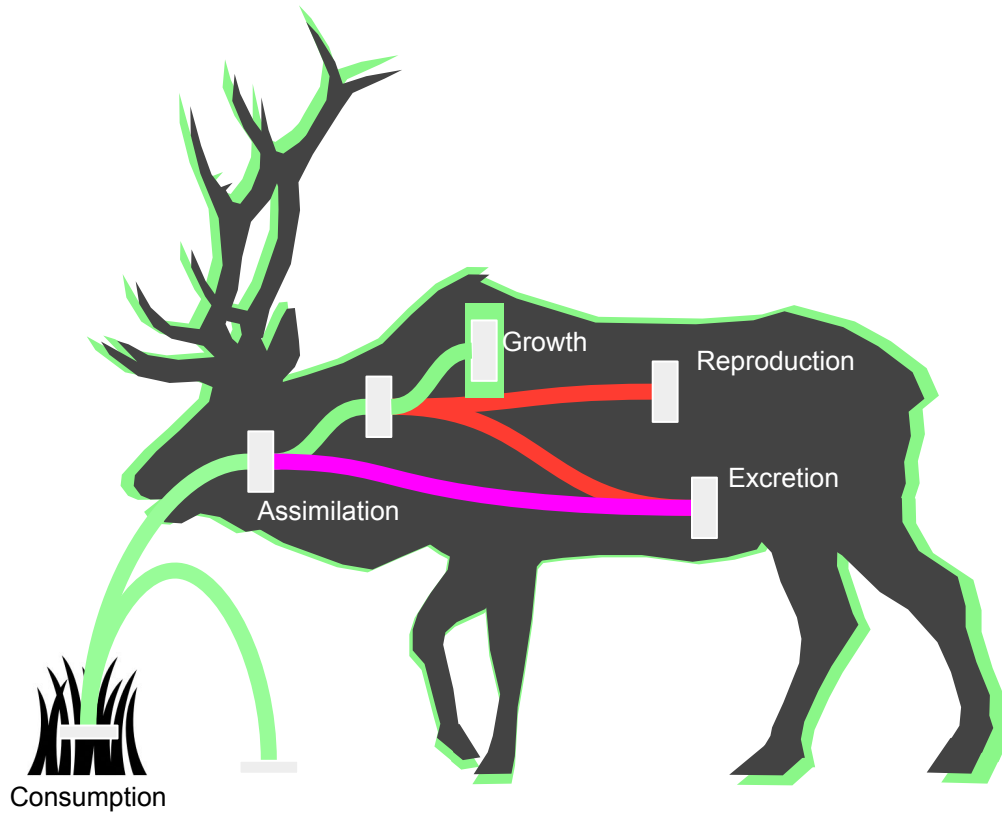
$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$











Growth
kernel

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

Reproduction kernel

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

Reproduction
kernel

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z') p_s(z')) N(z', t) dz'$$

Probability of
breeding

Reproduction
kernel

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

Number of
offspring

Reproduction
kernel

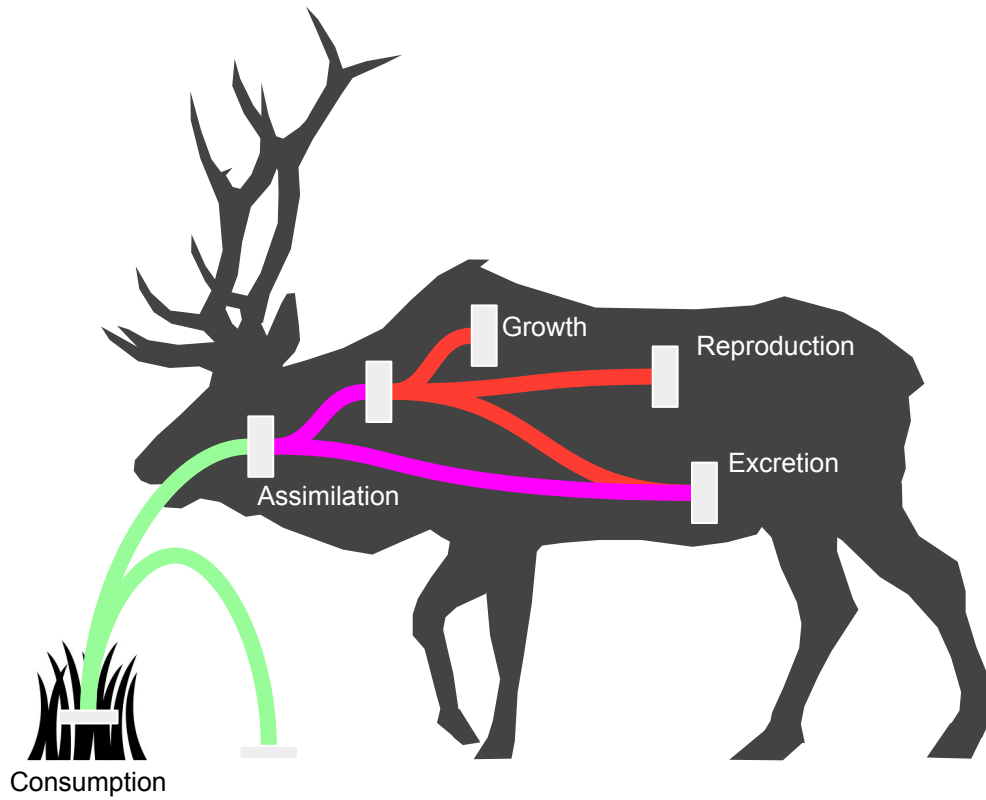
$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

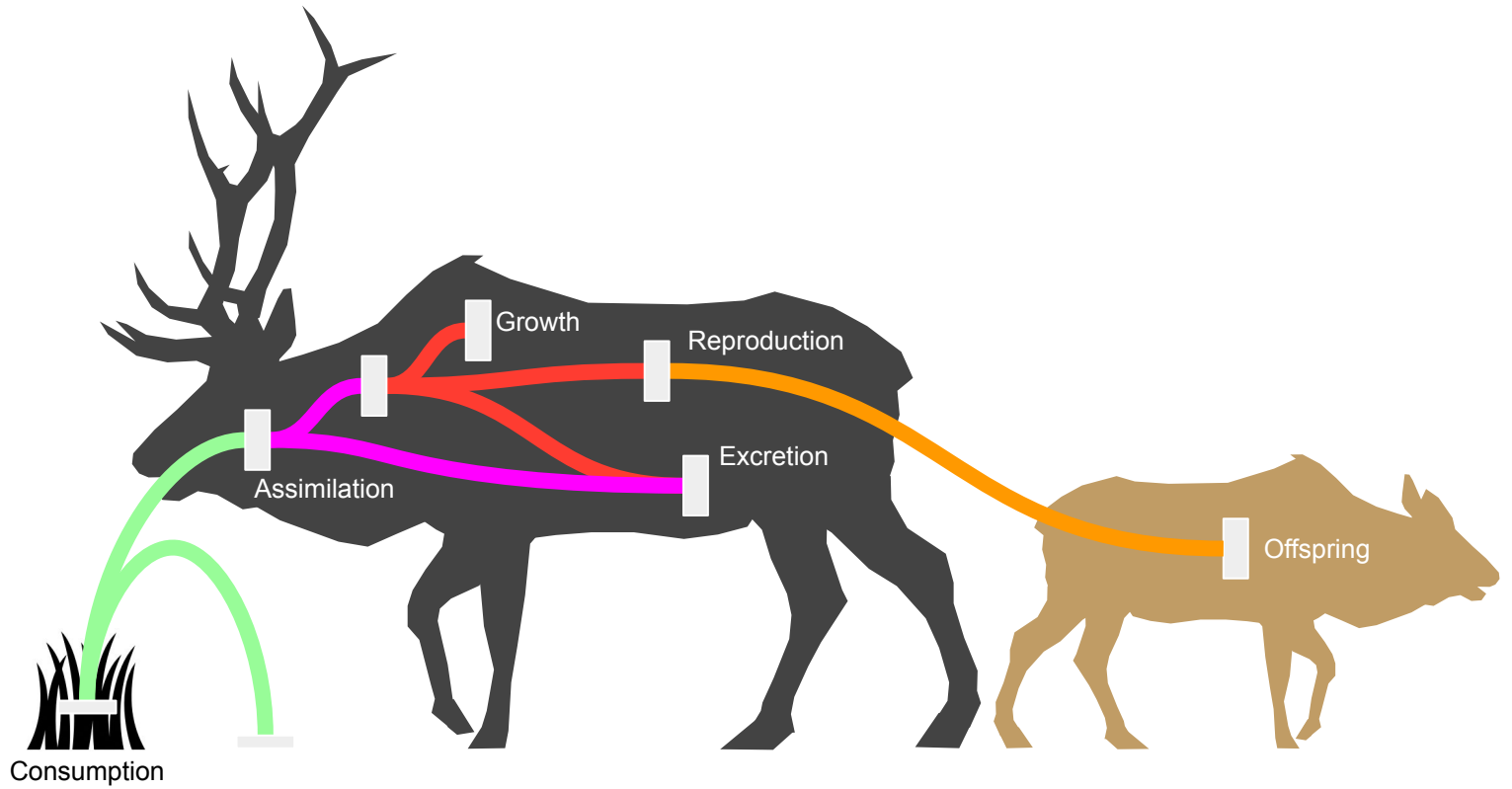
Probability of
recruitment

Reproduction
kernel

$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z') p_s(z')) N(z', t) dz'$$

Inheritance
kernel





Reproduction
kernel

Growth
kernel

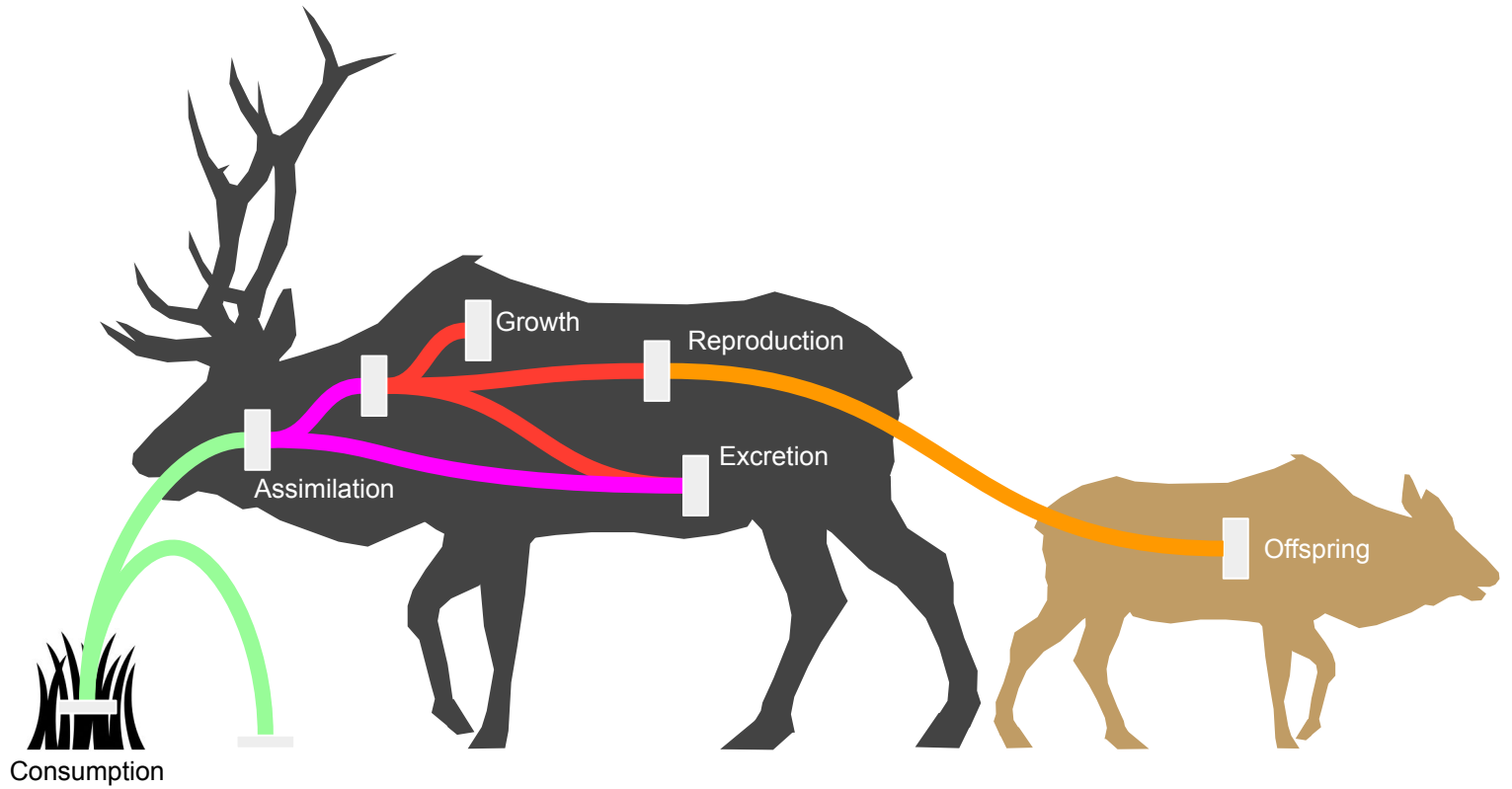
$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z') p_s(z')) N(z', t) dz'$$

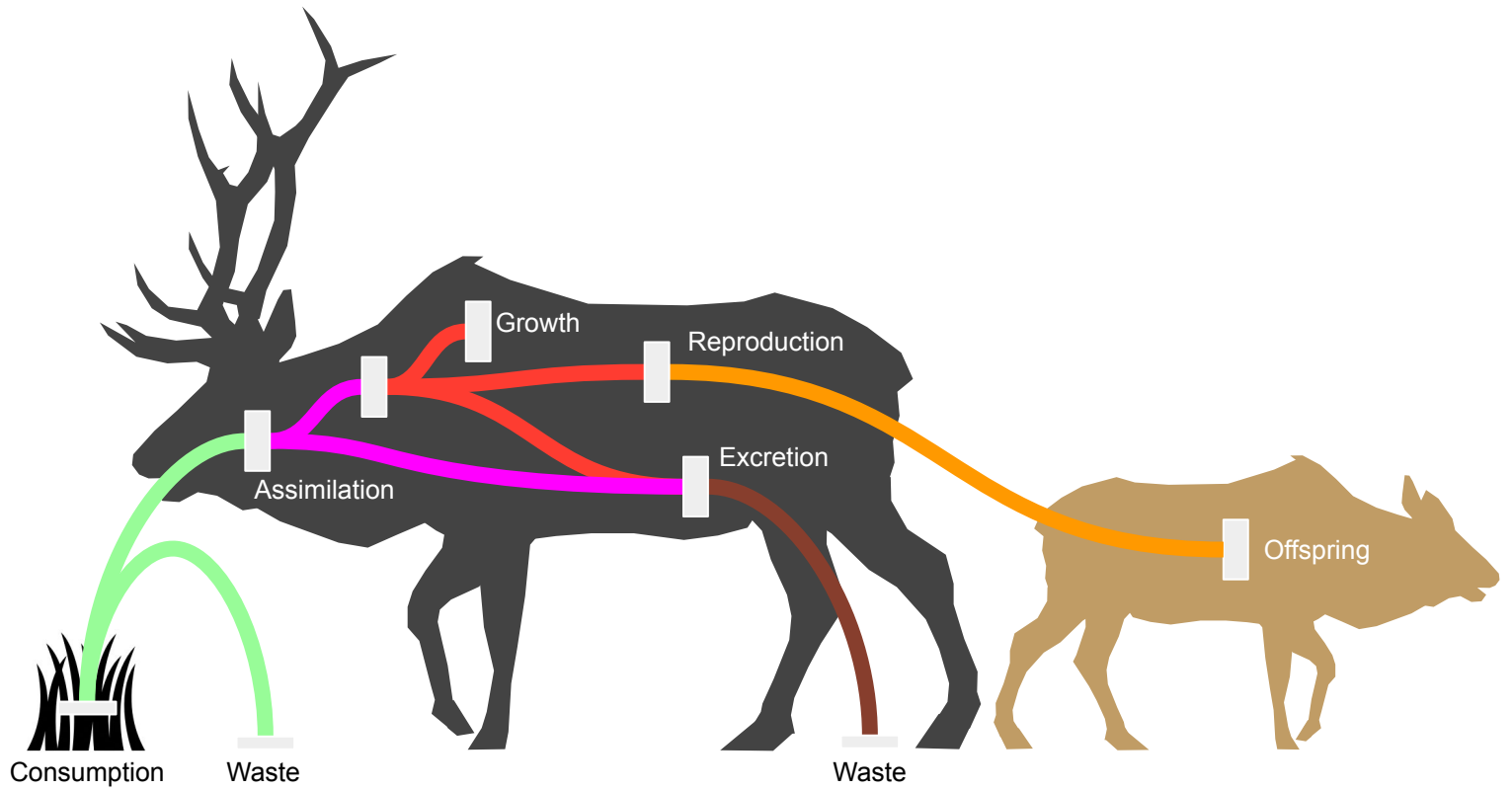
Probability of
Survival

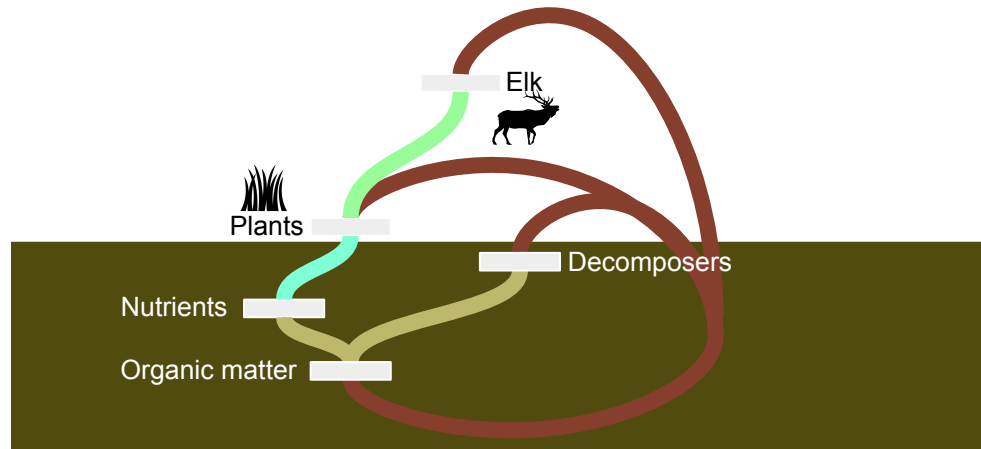
Phenotype
distribution at $t + 1$

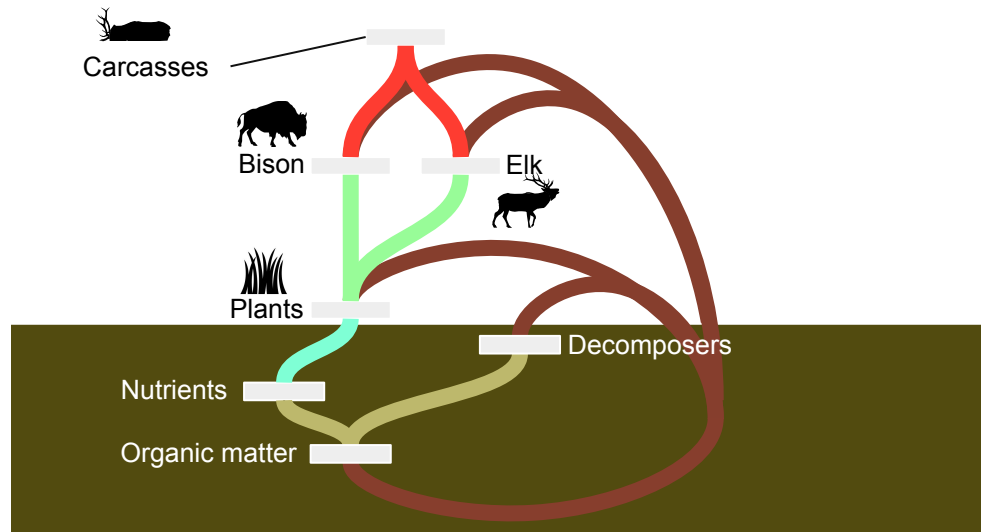
Phenotype
distribution at t

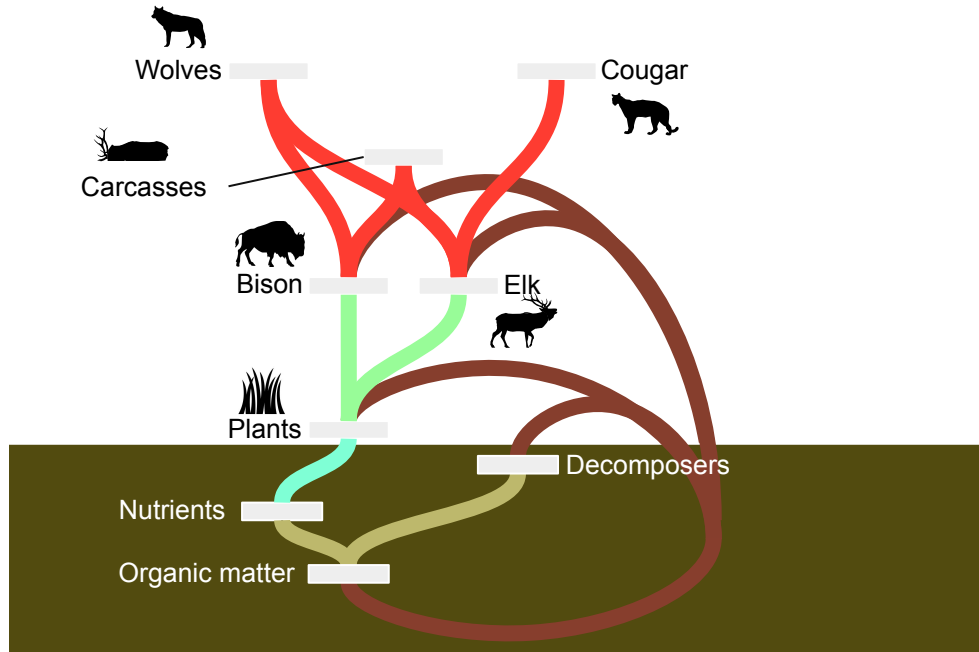
$$N(z, t+1) = \int (f_r(z|z') p_r(z') n_o(z') p_b(z') + f_s(z|z')) p_s(z') N(z', t) dz'$$

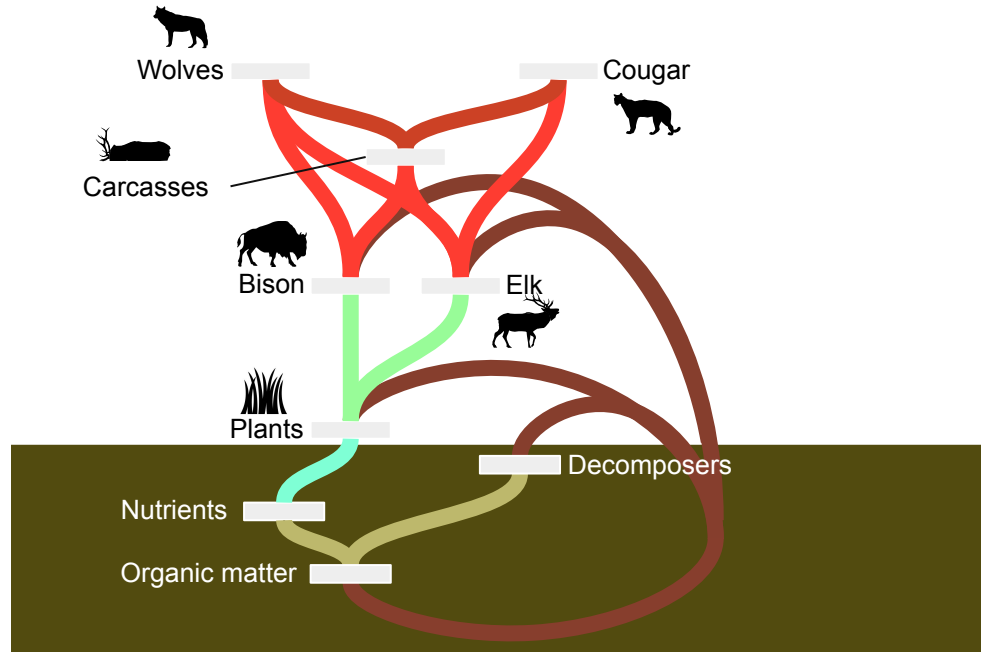


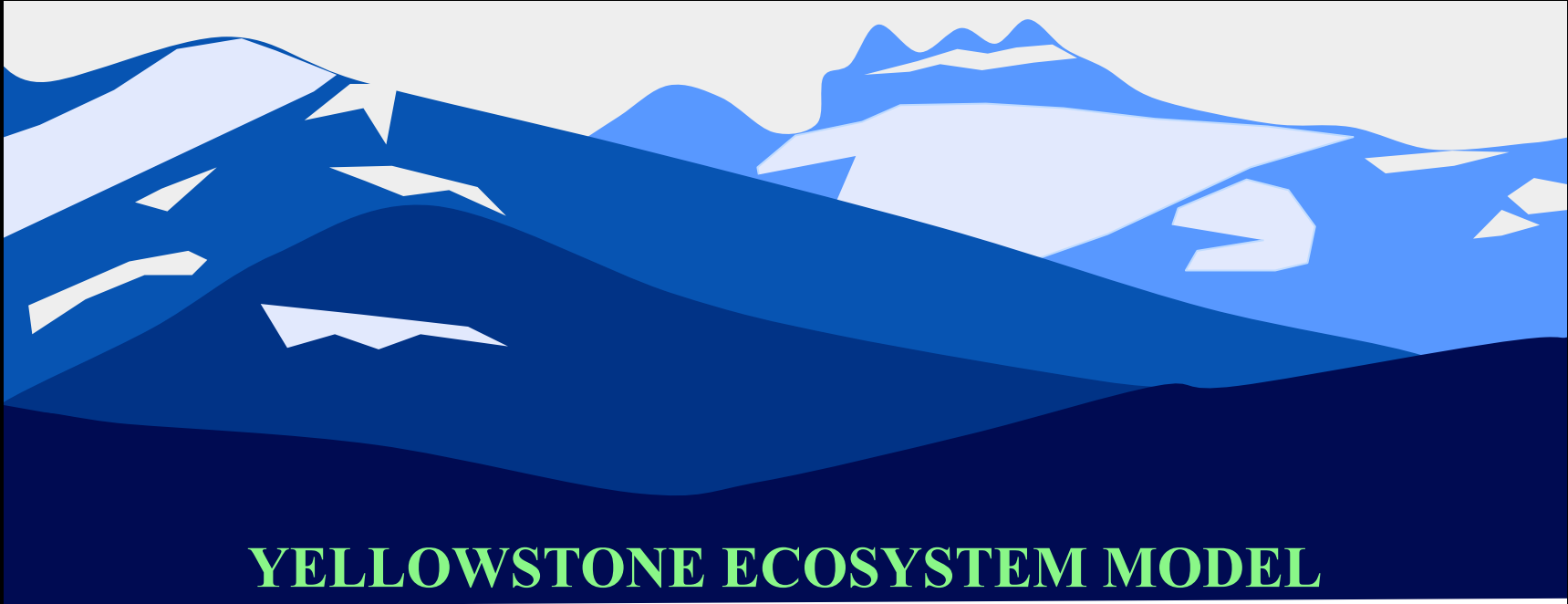




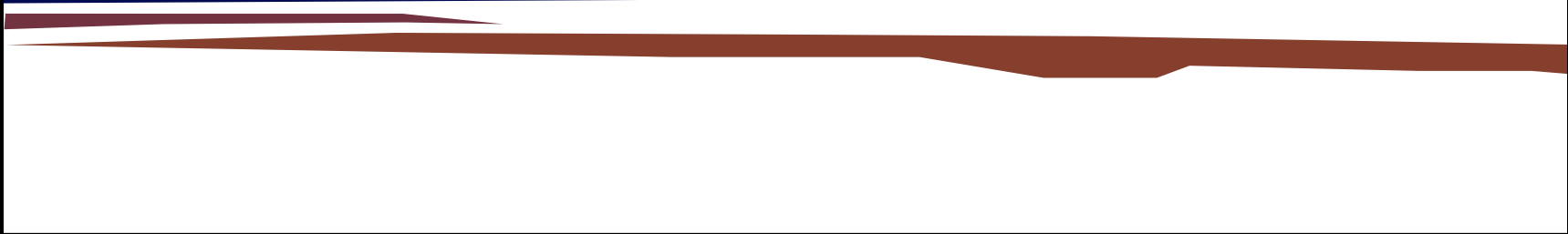






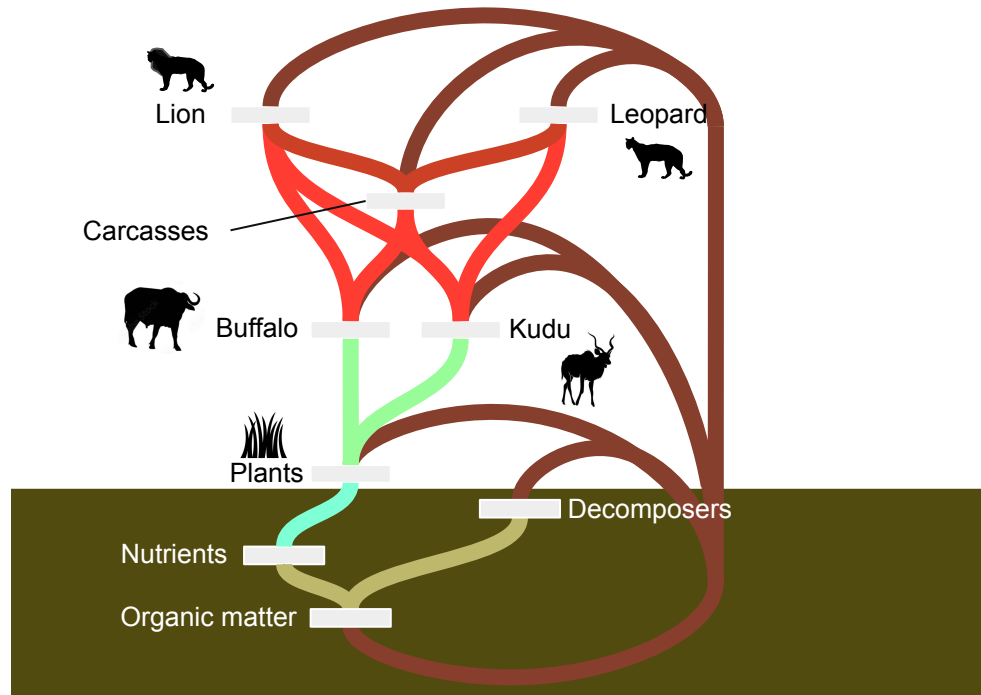


YELLOWSTONE ECOSYSTEM MODEL



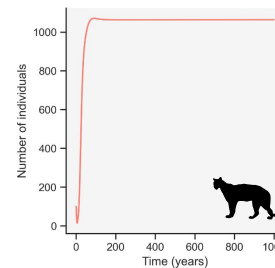
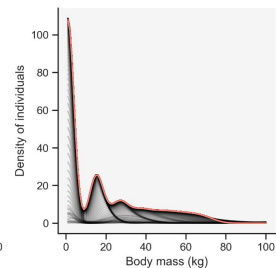
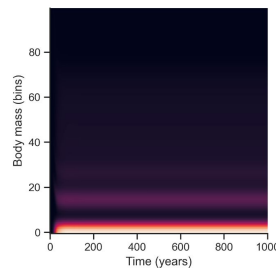
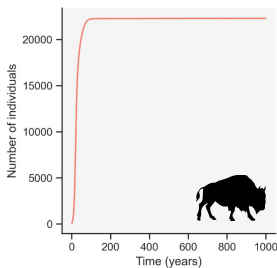
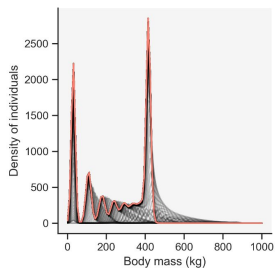
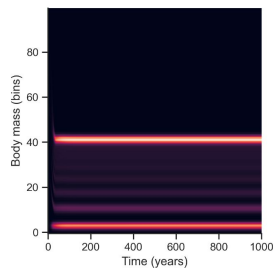
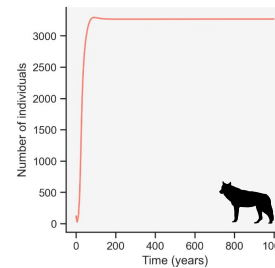
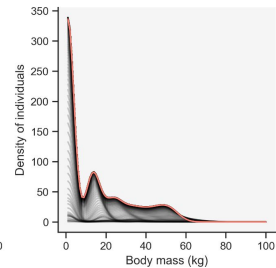
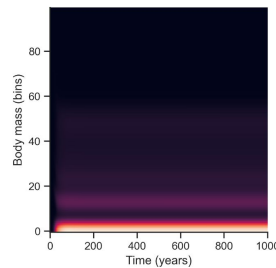
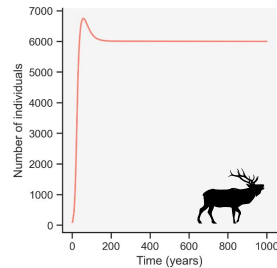
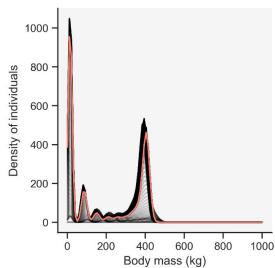
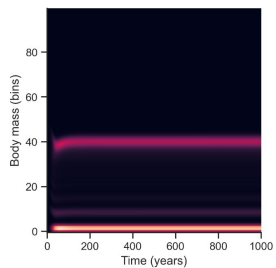
The background is a stylized landscape illustration. It features several layers of mountains and hills in various shades of red, orange, and brown. In the foreground, there is a wide, flat area that could represent a river or a plain, also rendered in warm tones. The overall aesthetic is minimalist and graphic, using solid colors and simple shapes to create a sense of depth and atmosphere.

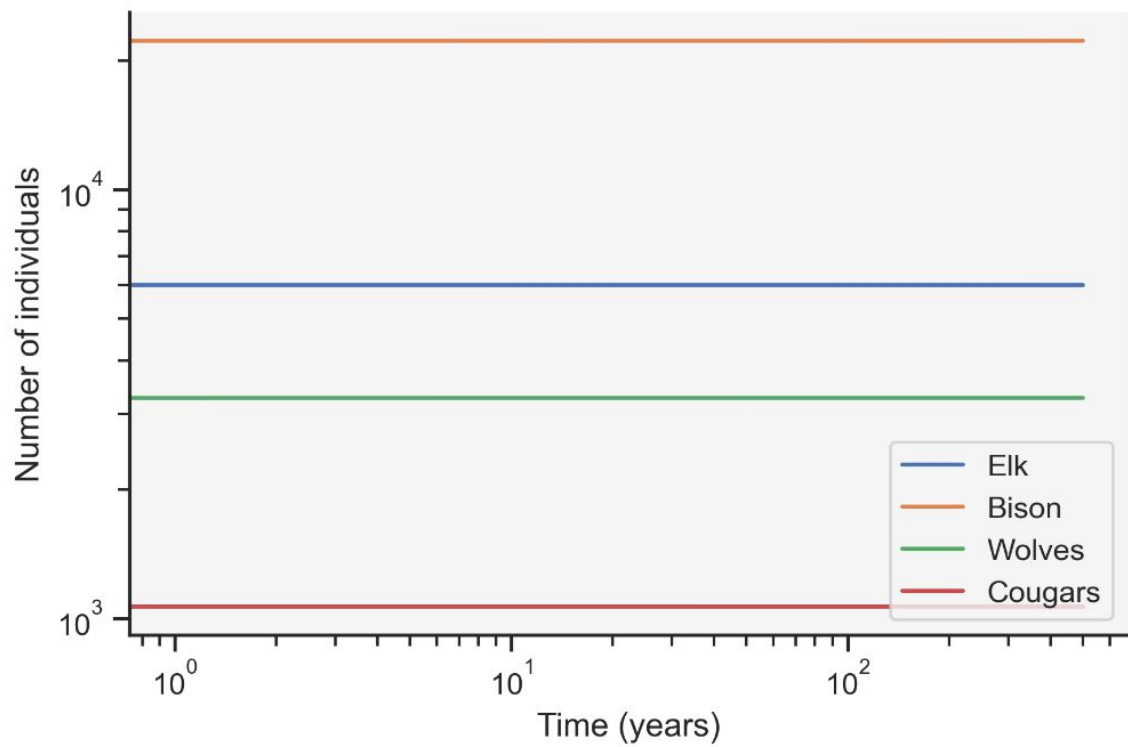
KRUGER ECOSYSTEM MODEL



A stylized illustration of a mountain range. The mountains are rendered in various shades of blue, from light to dark, creating a sense of depth and layering. The peaks are jagged and angular. The foreground consists of a dark blue, undulating shape representing a valley or a low ridge. Below this, there is a thin, dark brown horizontal line, and the bottom of the image is a solid white background.

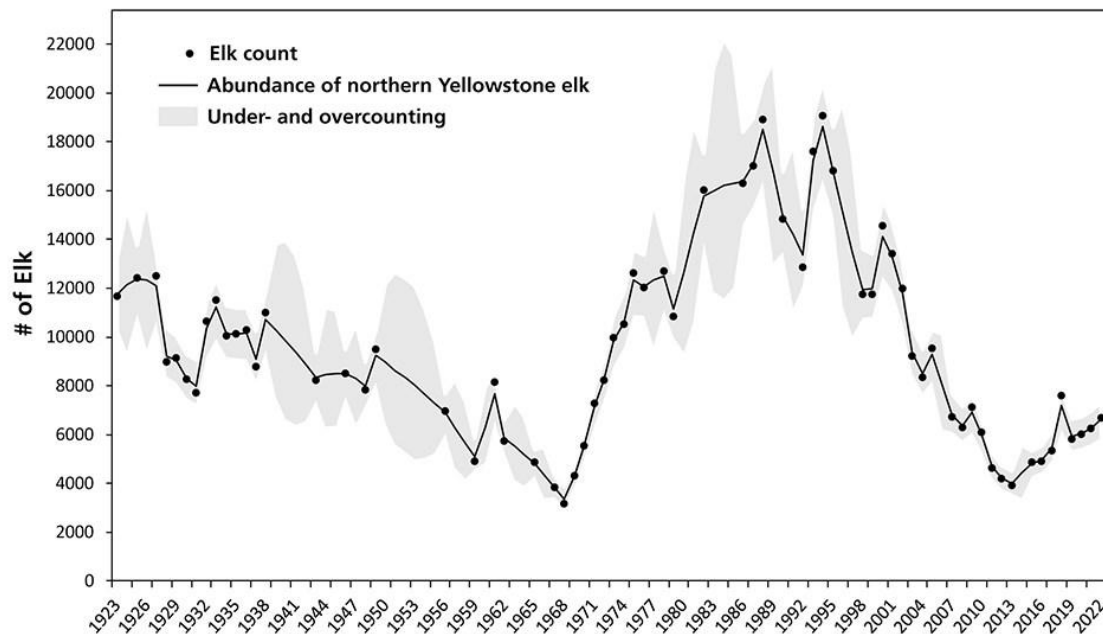
DYNAMICS





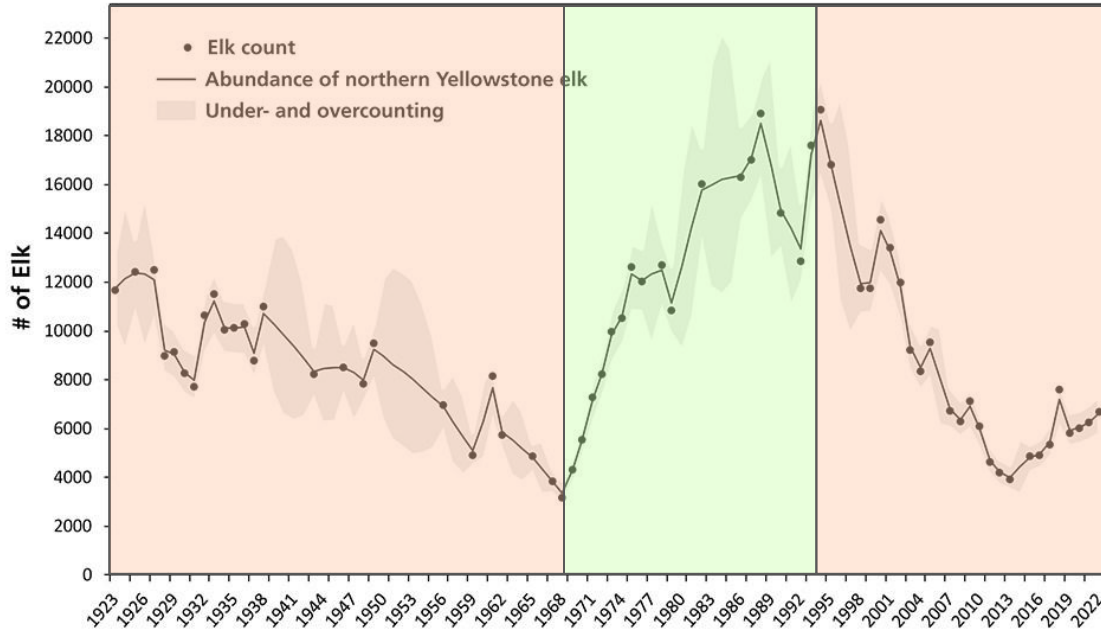
A stylized illustration of a mountain range. The mountains are rendered in various shades of blue, from light to dark, creating a sense of depth and distance. The peaks are jagged and layered, with some appearing closer and more detailed than others. The overall style is graphic and minimalist.

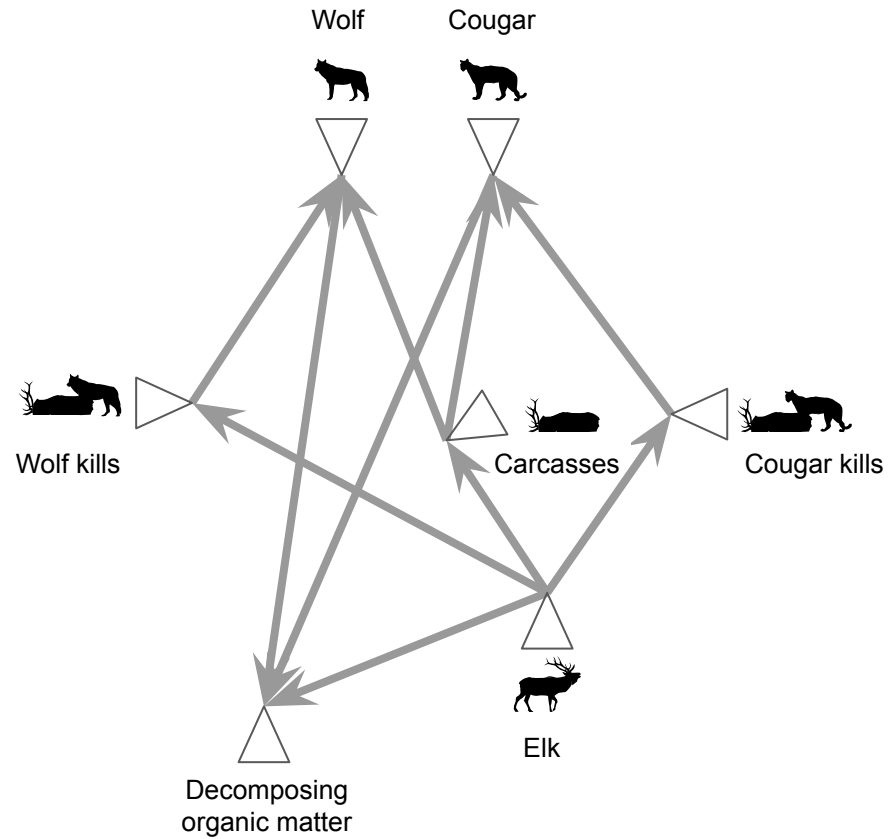
IMPACT OF HERBIVORES

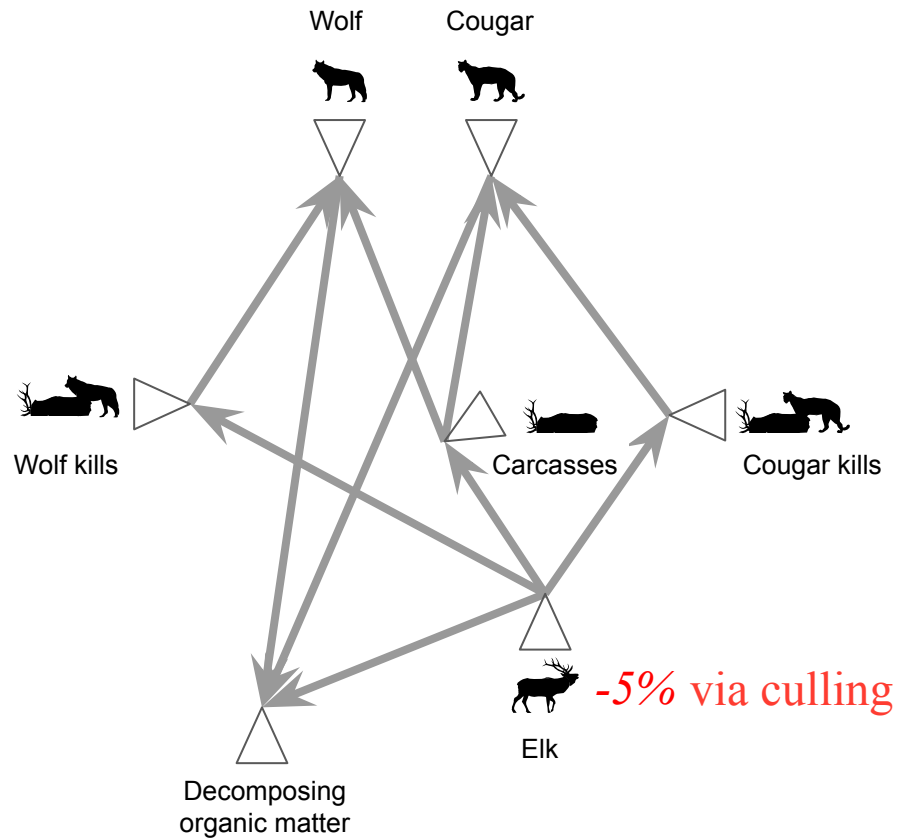


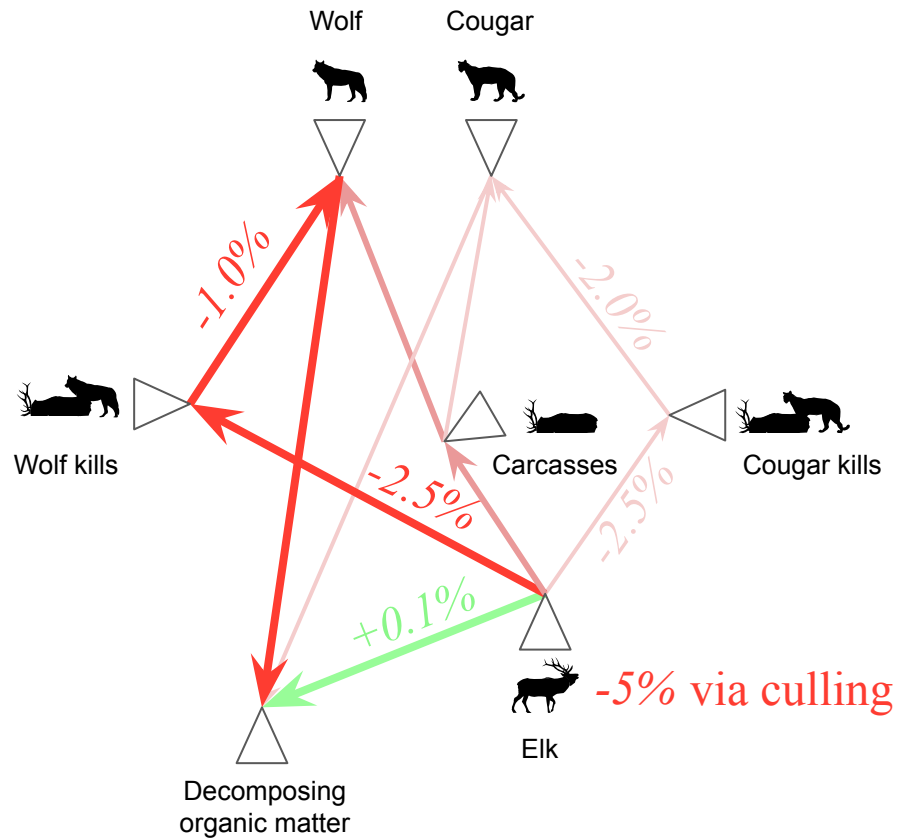
Culling

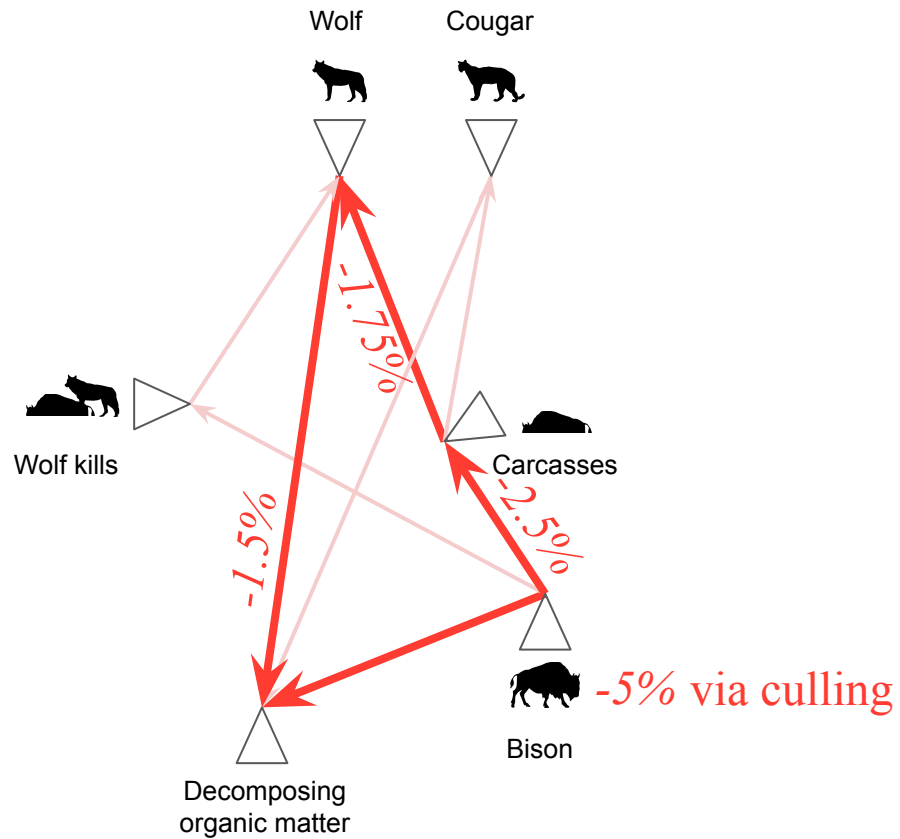
Culling





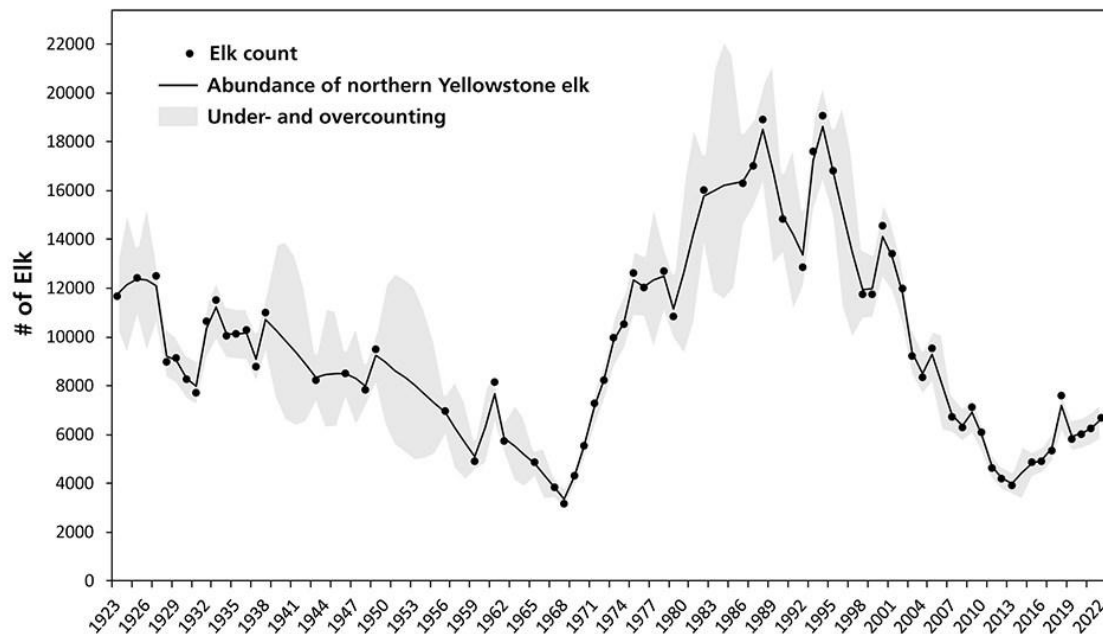






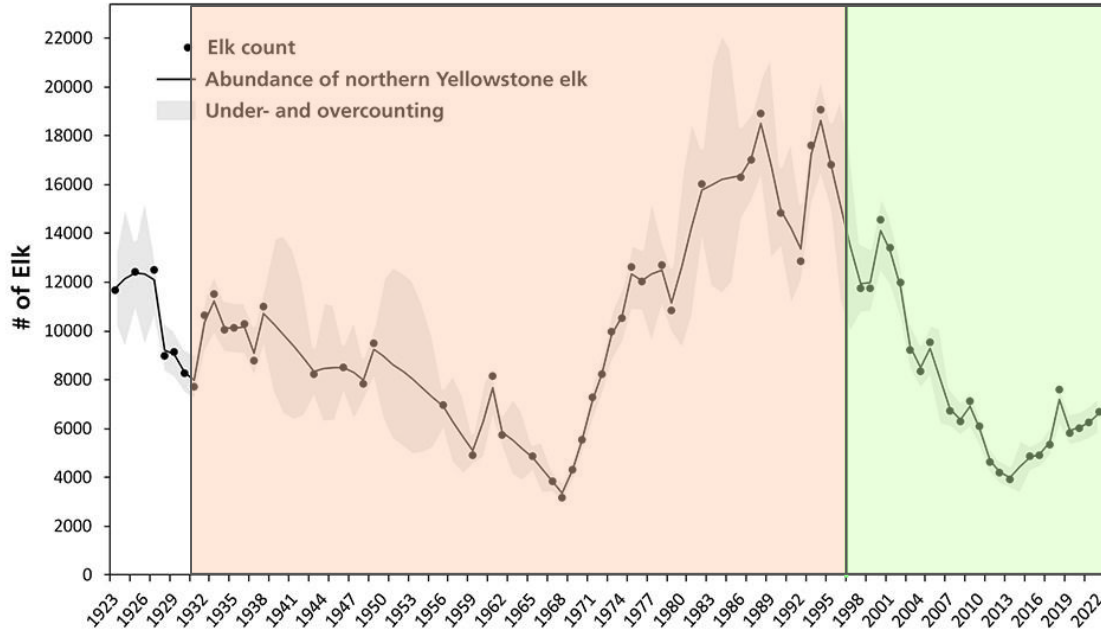
A stylized illustration of a mountain range. The mountains are rendered in various shades of blue, from light to dark, creating a sense of depth and layering. The peaks are jagged and angular. The foreground is a dark blue, and the sky is a light, pale blue. The overall style is graphic and minimalist.

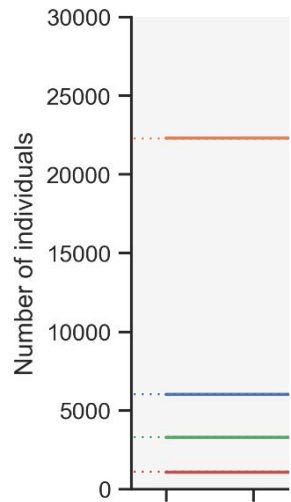
IMPACT OF CARNIVORES



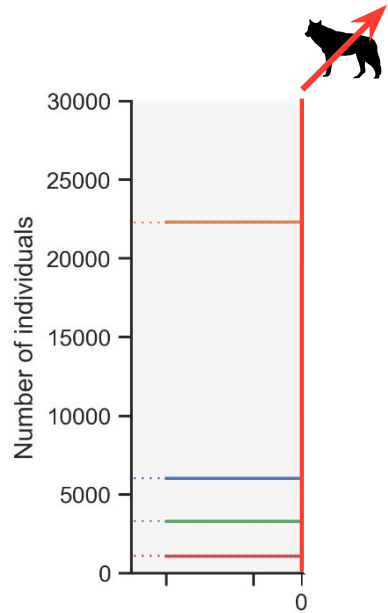
Wolf extirpation

Wolf reintroduction

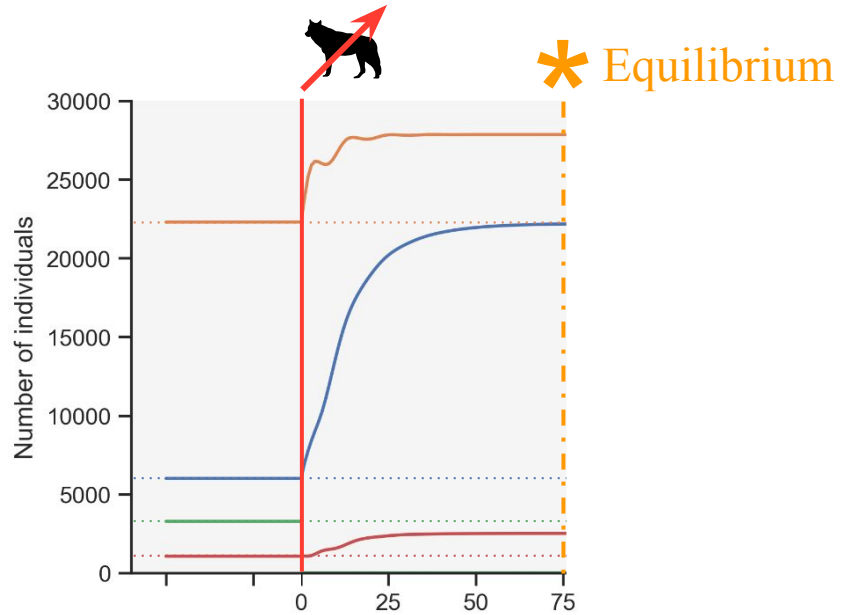




Extirpation

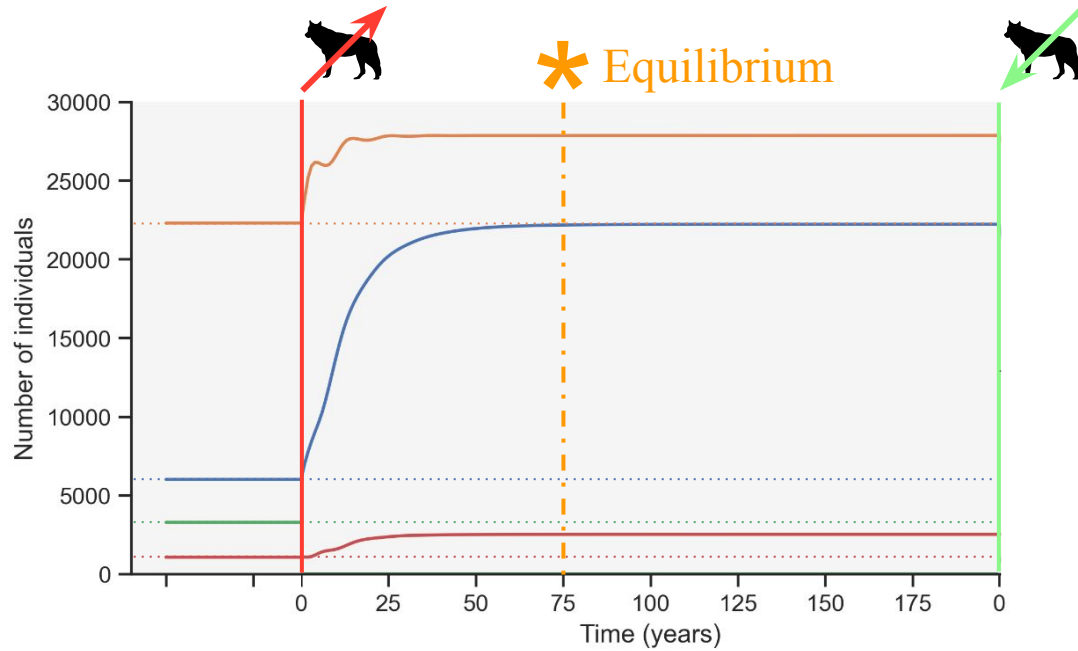


Extirpation



Extirpation

Reintroduction



Extirpation

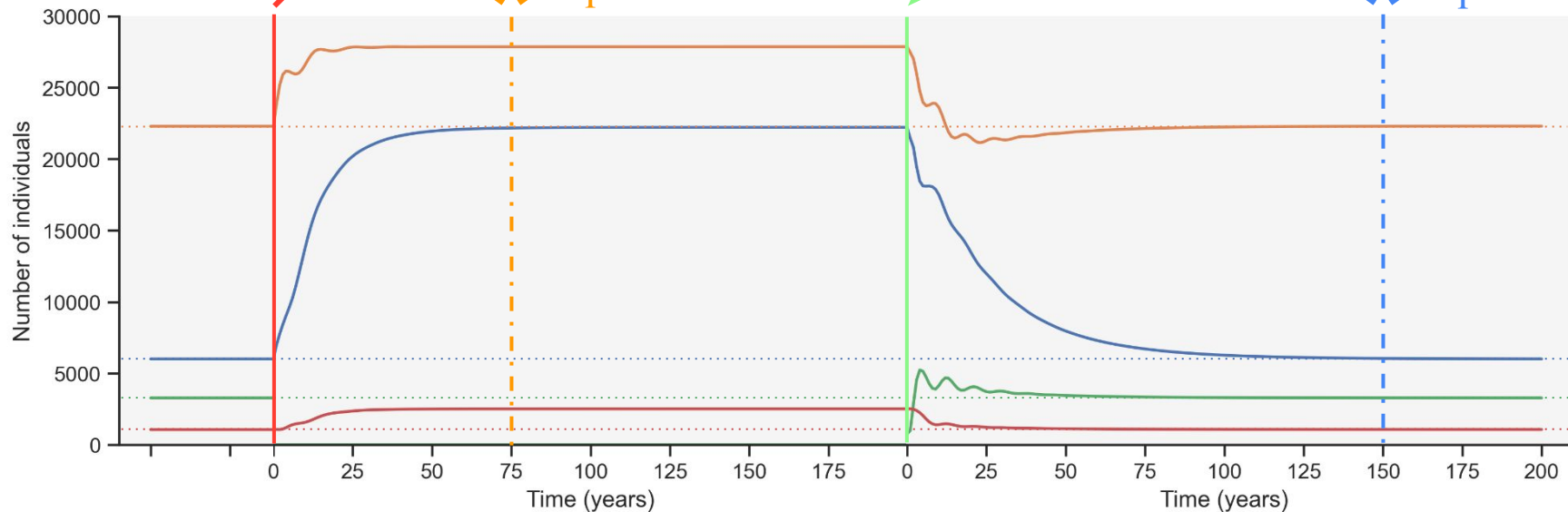


* Equilibrium

Reintroduction

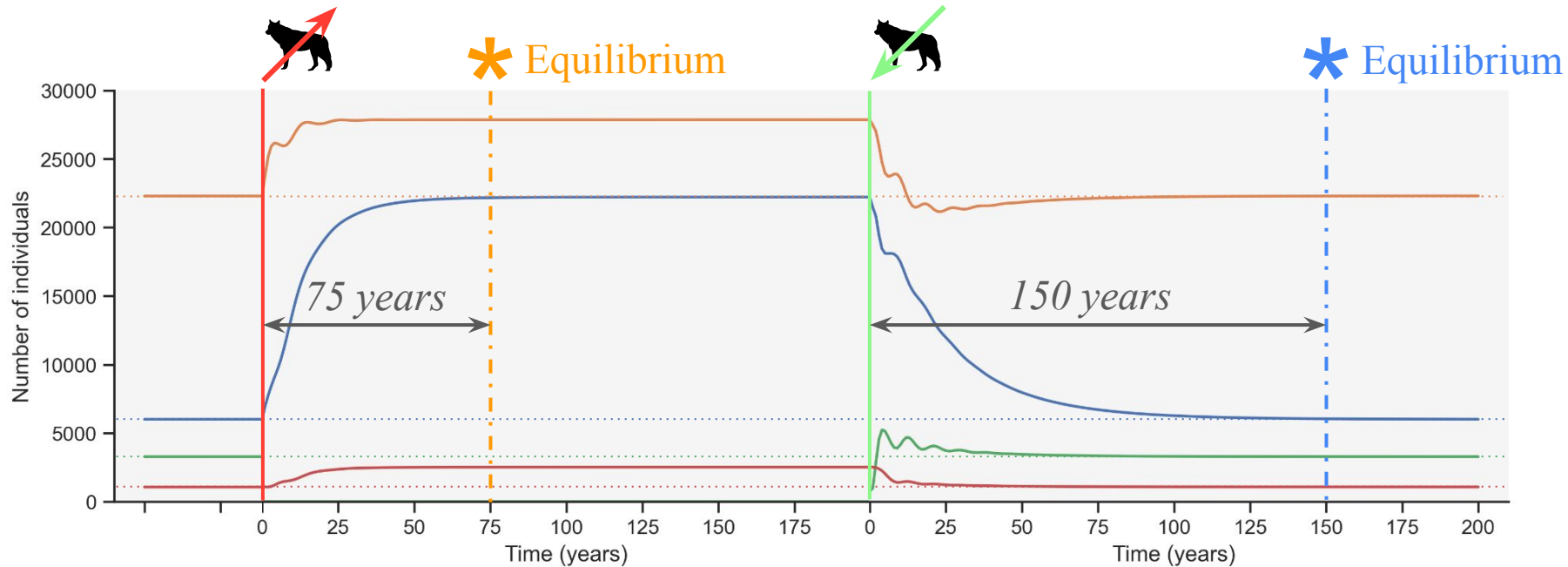


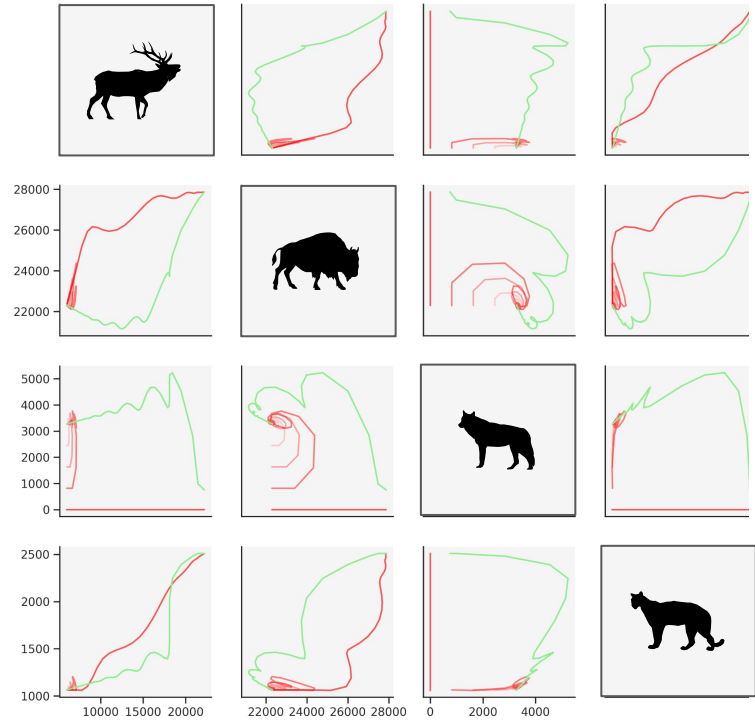
* Equilibrium

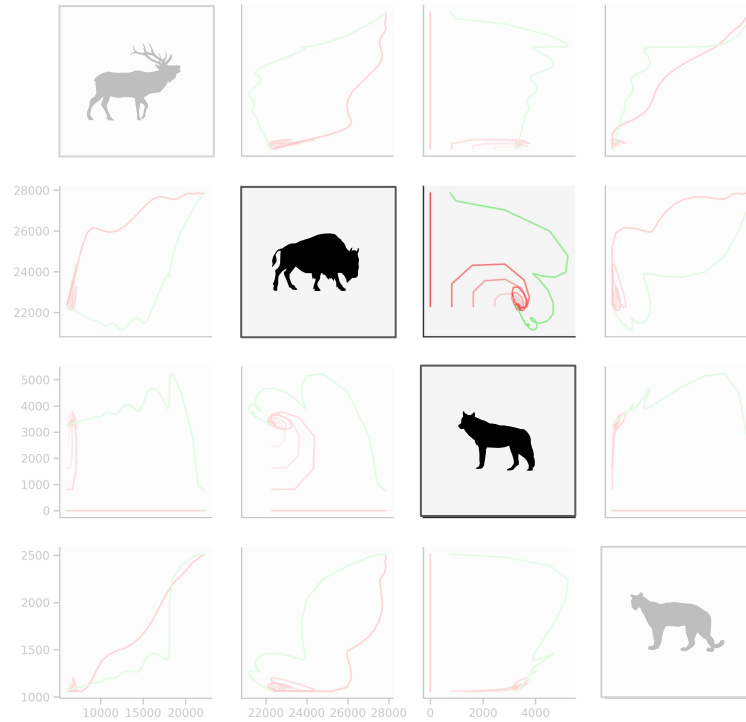


Extirpation

Reintroduction

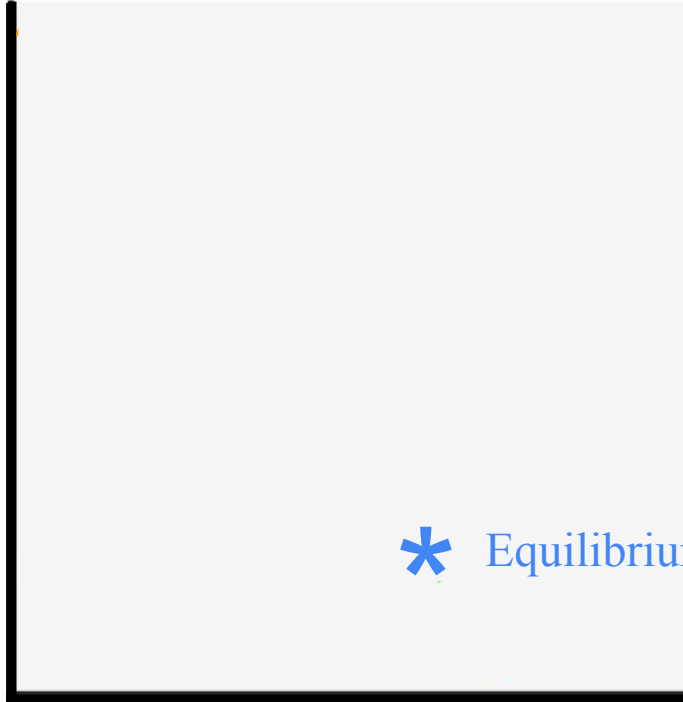








Bison density



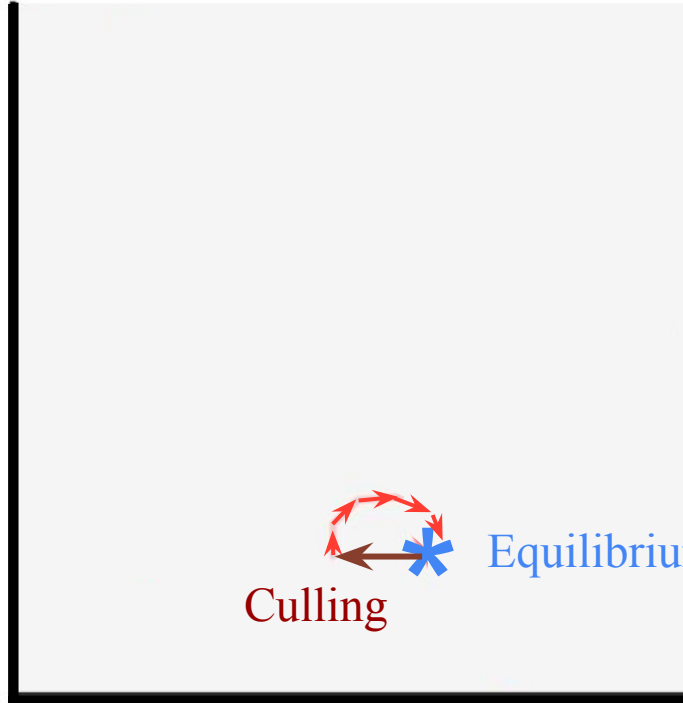
* Equilibrium

Wolf density





Bison density

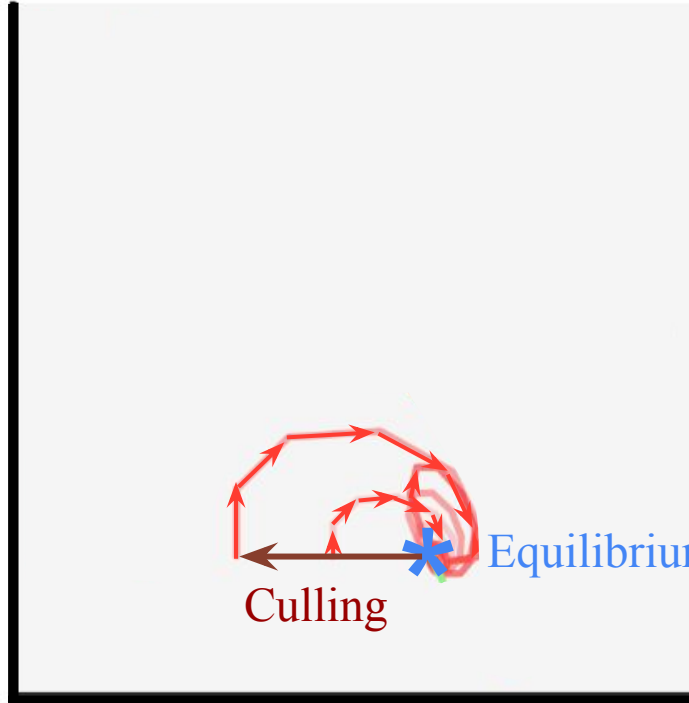


Wolf density





Bison density

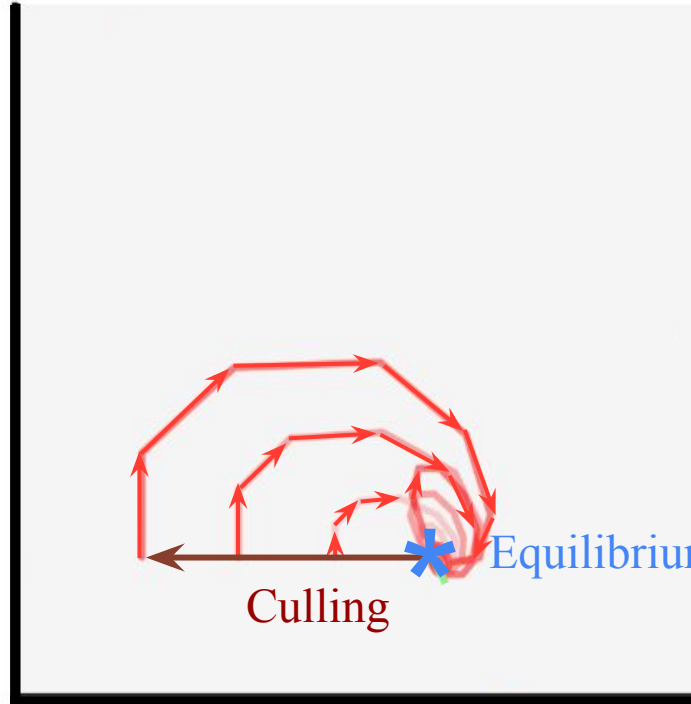


Wolf density





Bison density

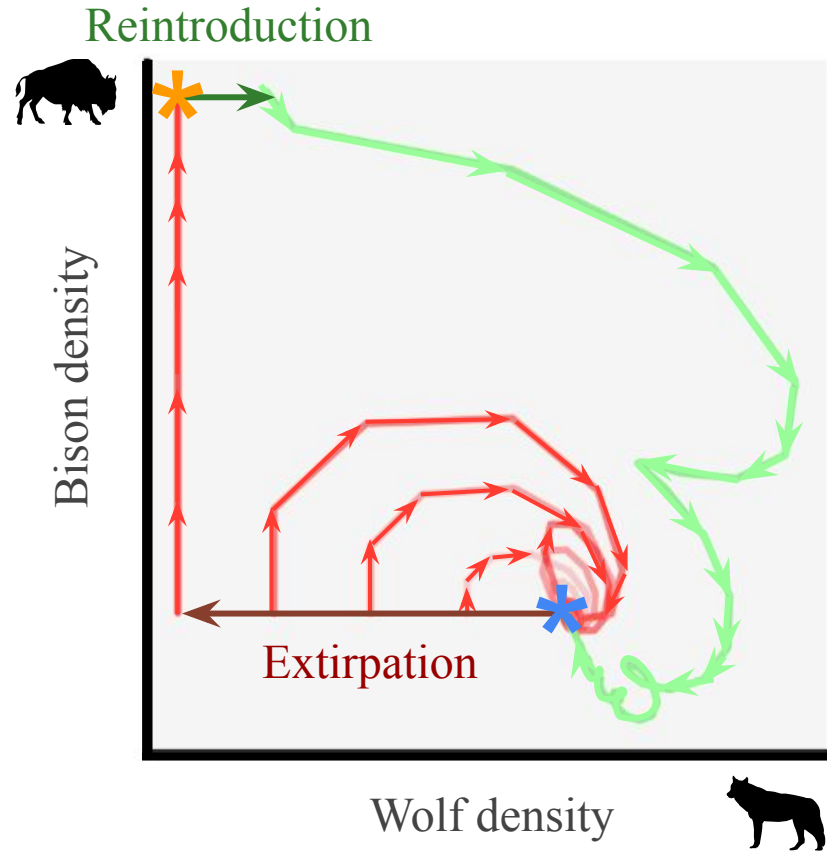


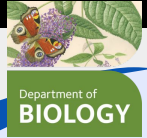
Culling

Equilibrium

Wolf density

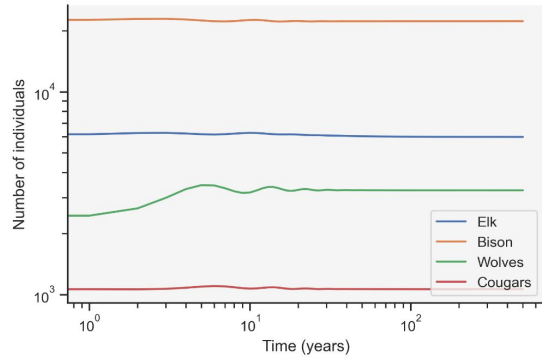




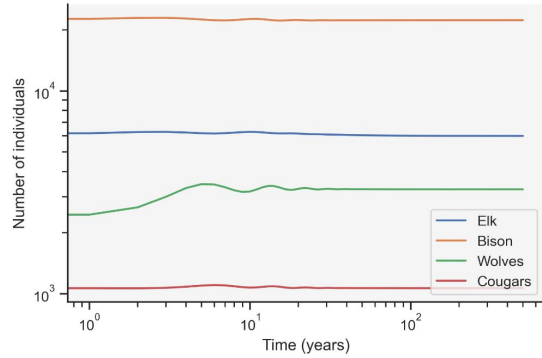


Thank you!

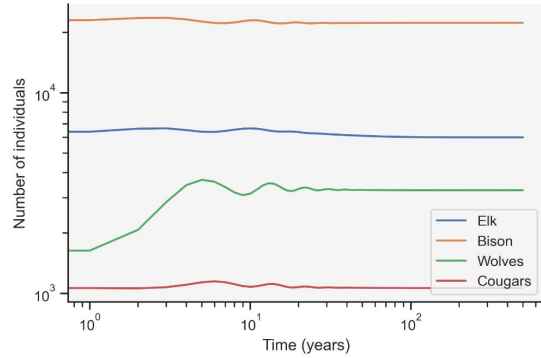
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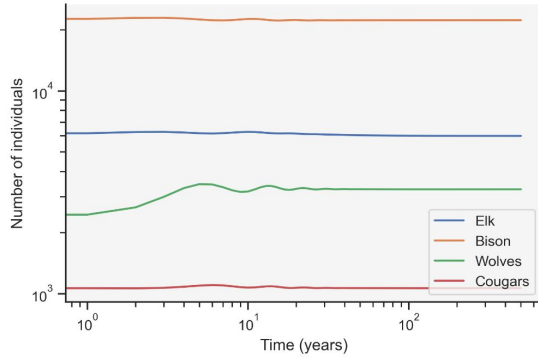
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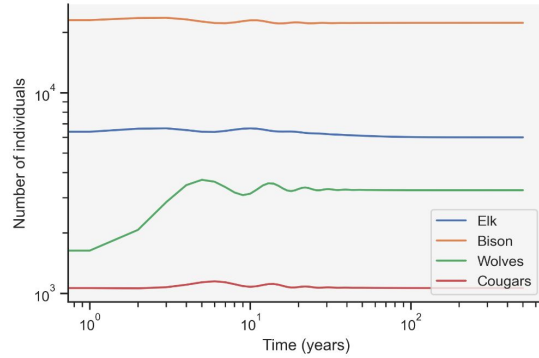
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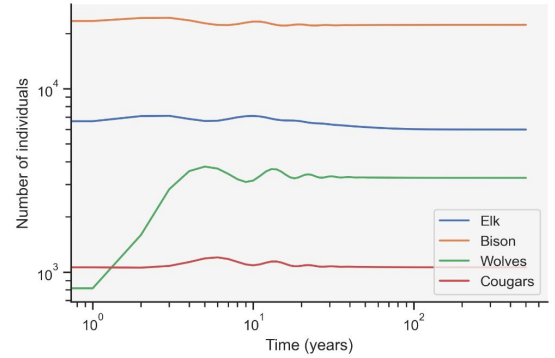
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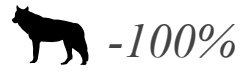


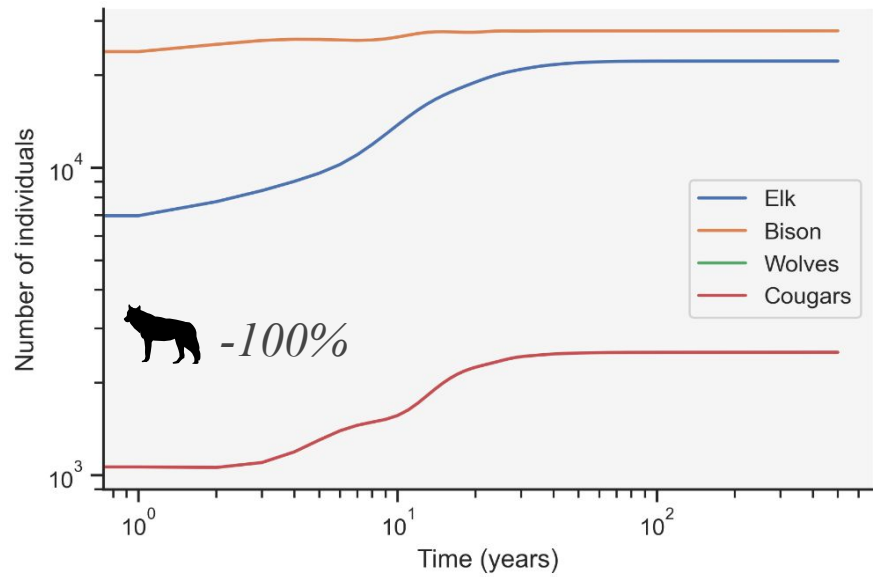
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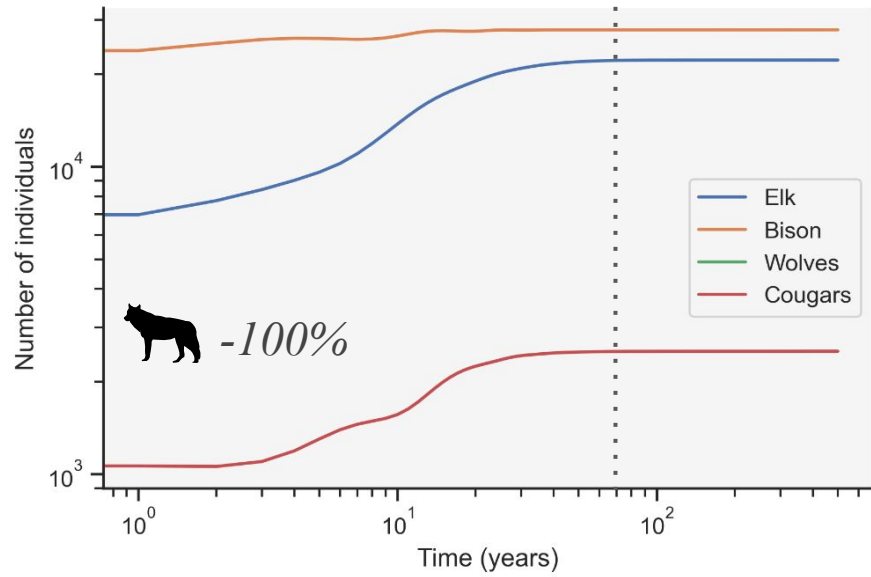
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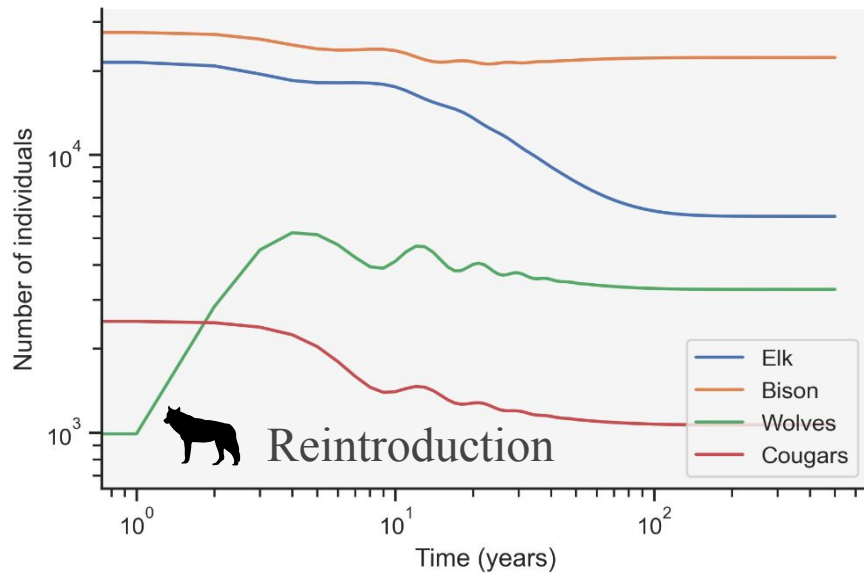
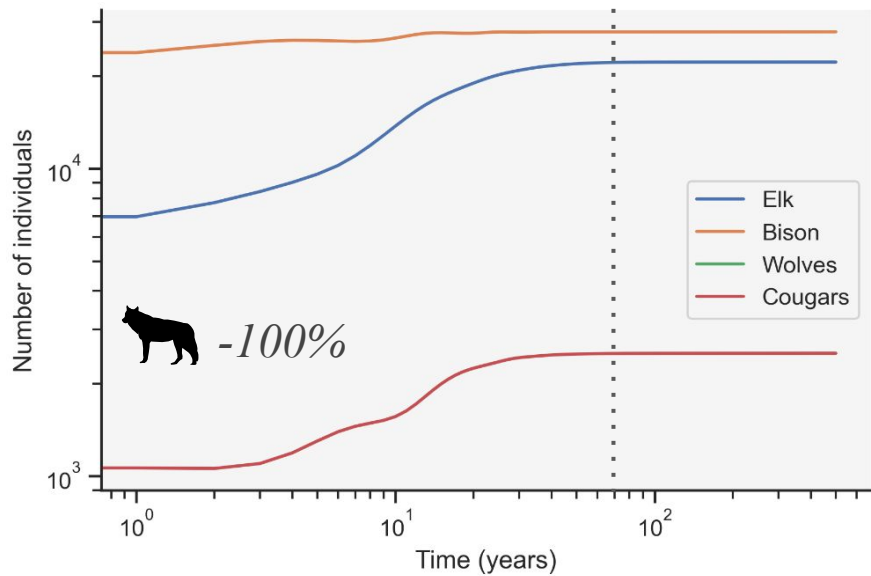




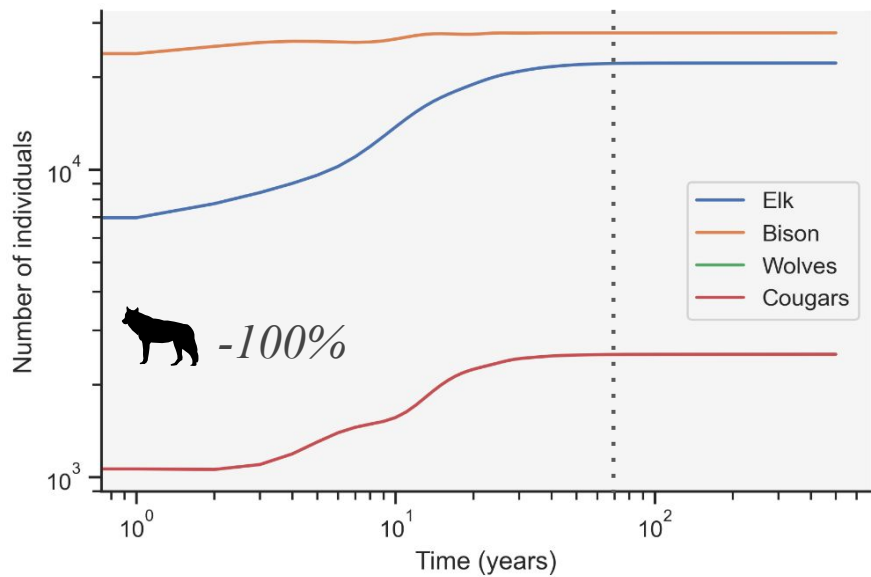
70 years



70 years



70 years



200 years

