Climate change effects on rangeland resources: using the past to predict the future with population models

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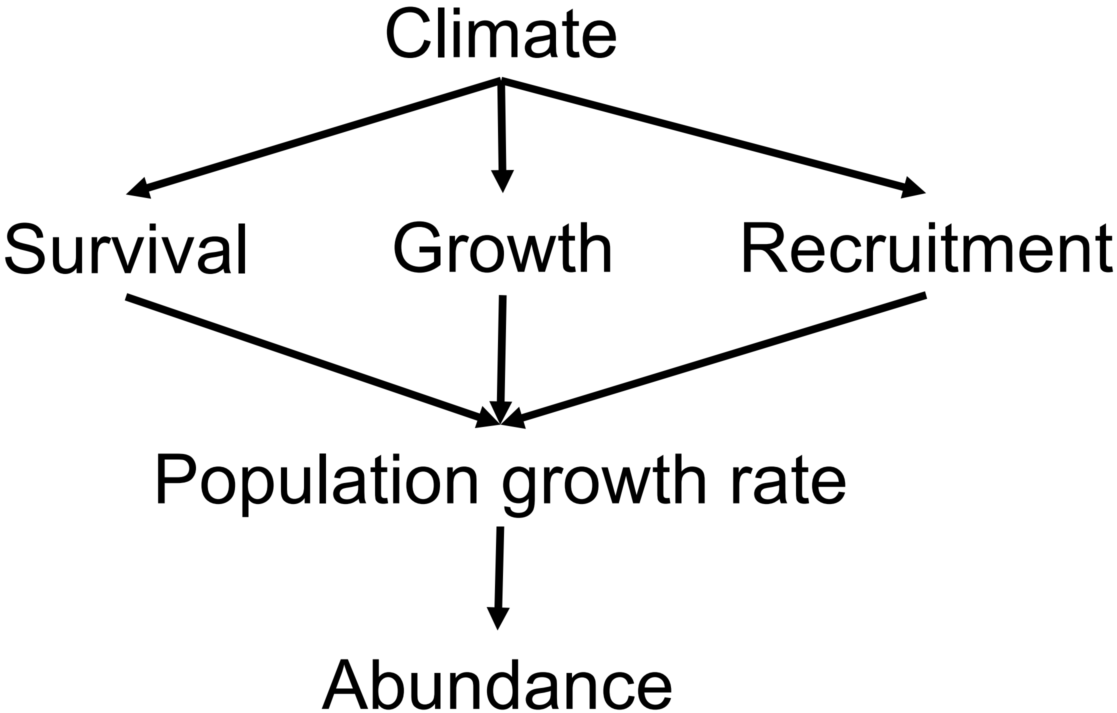
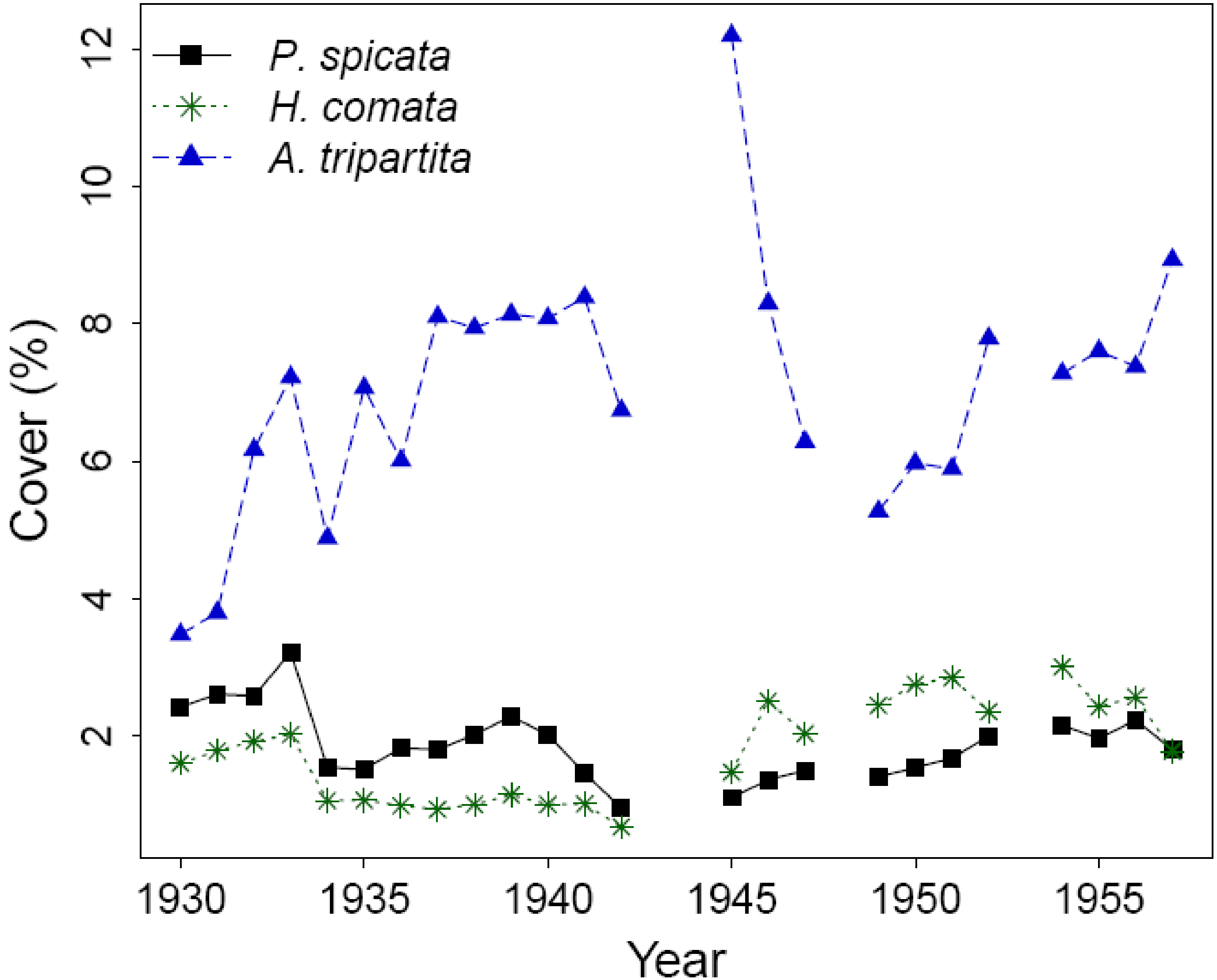
Population dynamics approach

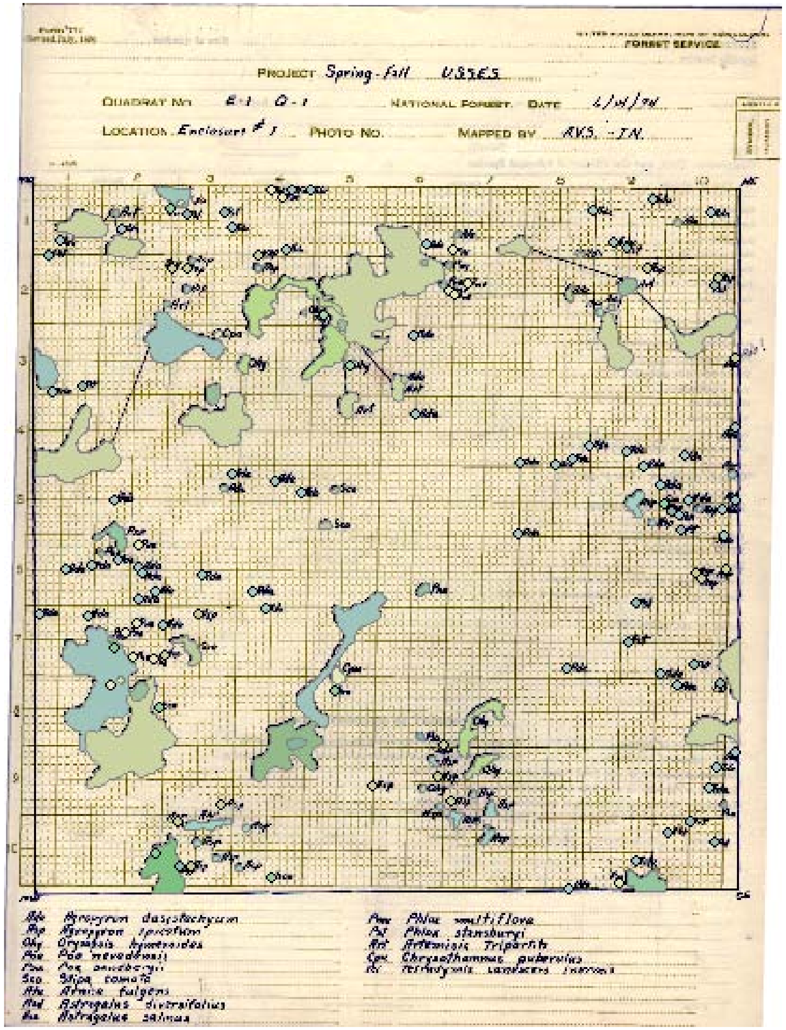


Historical data



Historical data

Most quadrats located in exclosures



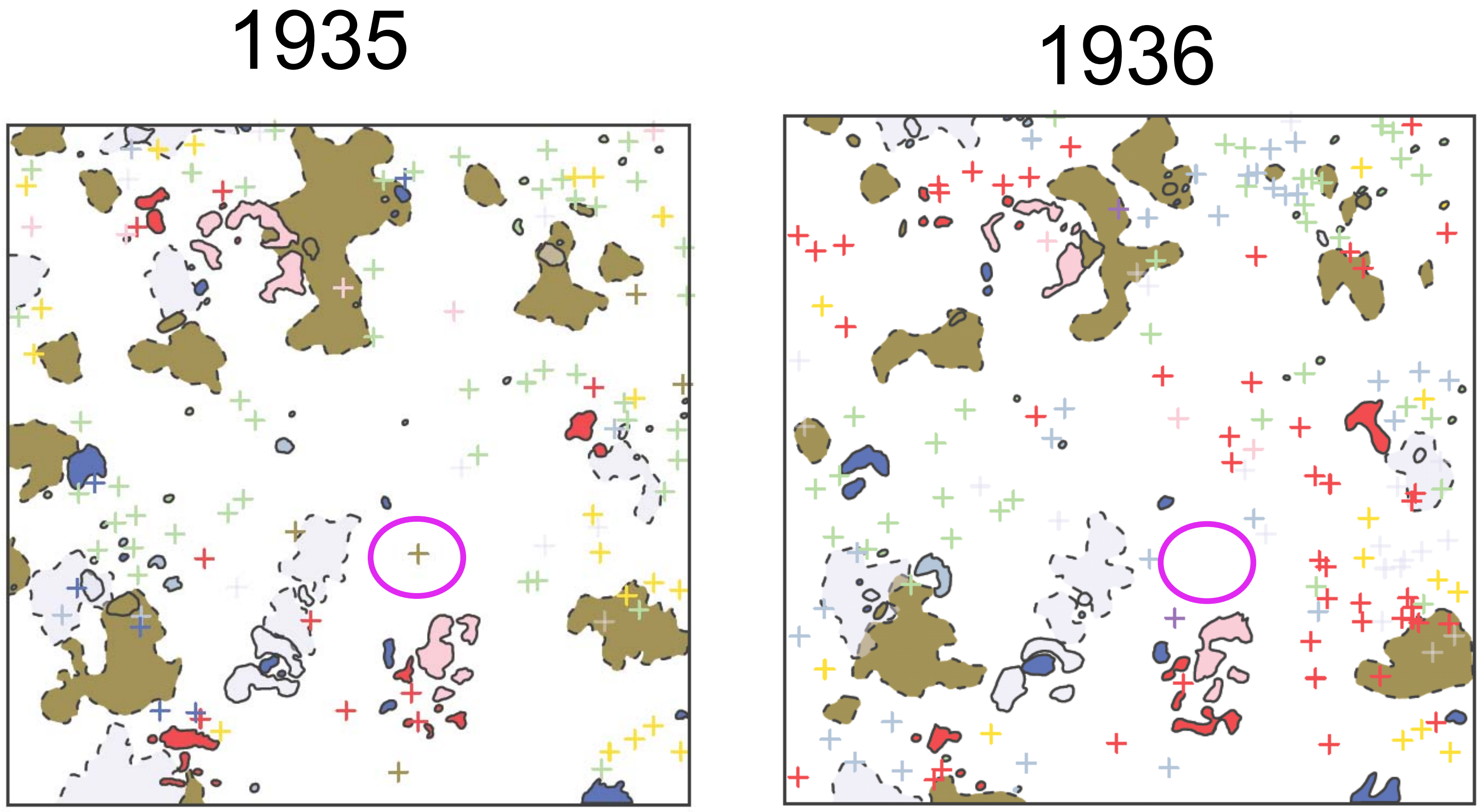
Research questions

- What are the growth rates and key vital rates?
  - Survival important for long-lived species.
  - Recruitment important for short-lived species.
- How do climate variables affect abundance?
  - Temperatures expected to increase
  - Annual precipitation expected to increase slightly
  - Shift from snow to rain?

Outline

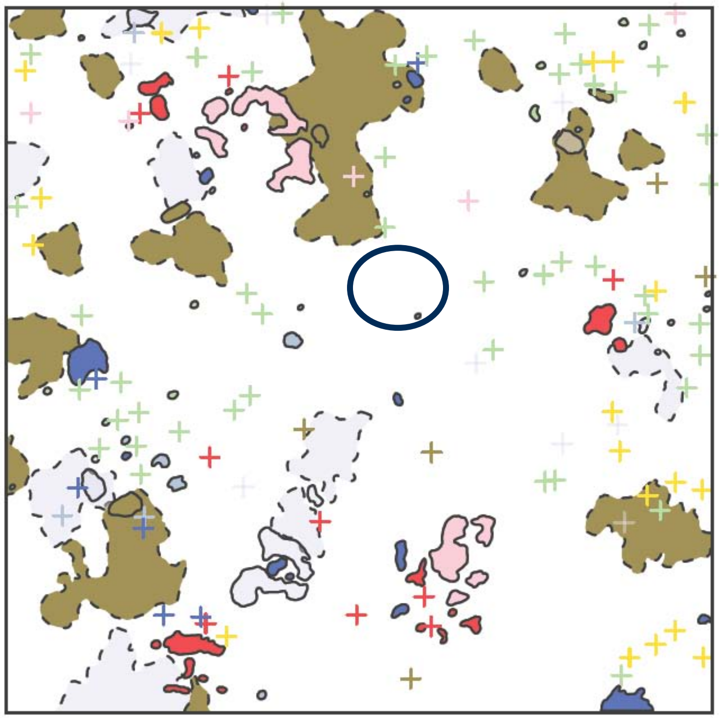
- Methods
  - Statistical models for survival, growth, recruitment
  - Population models
- Important vital rates?
- Important climate variables?
  - Correlations with vital rates
  - Effects on population growth

Survival, recruitment, and growth

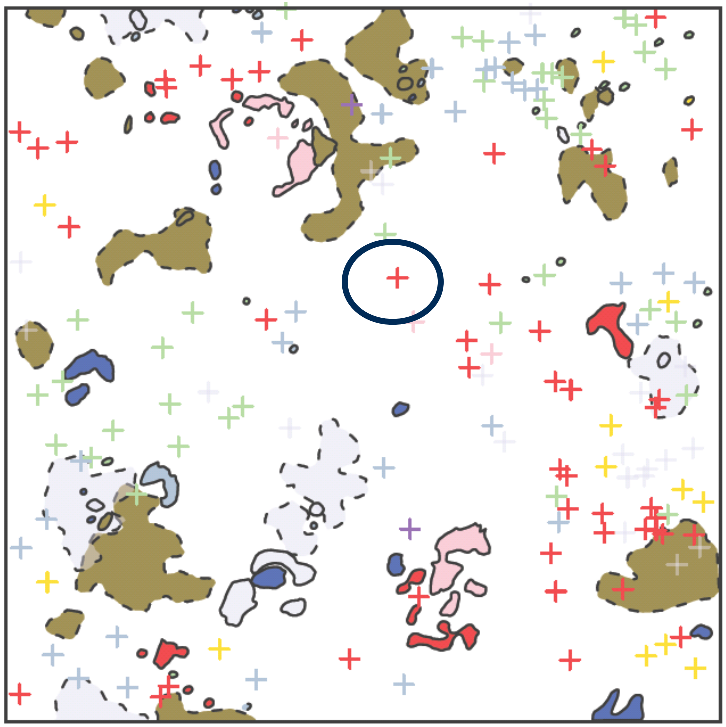


Survival, recruitment, and growth

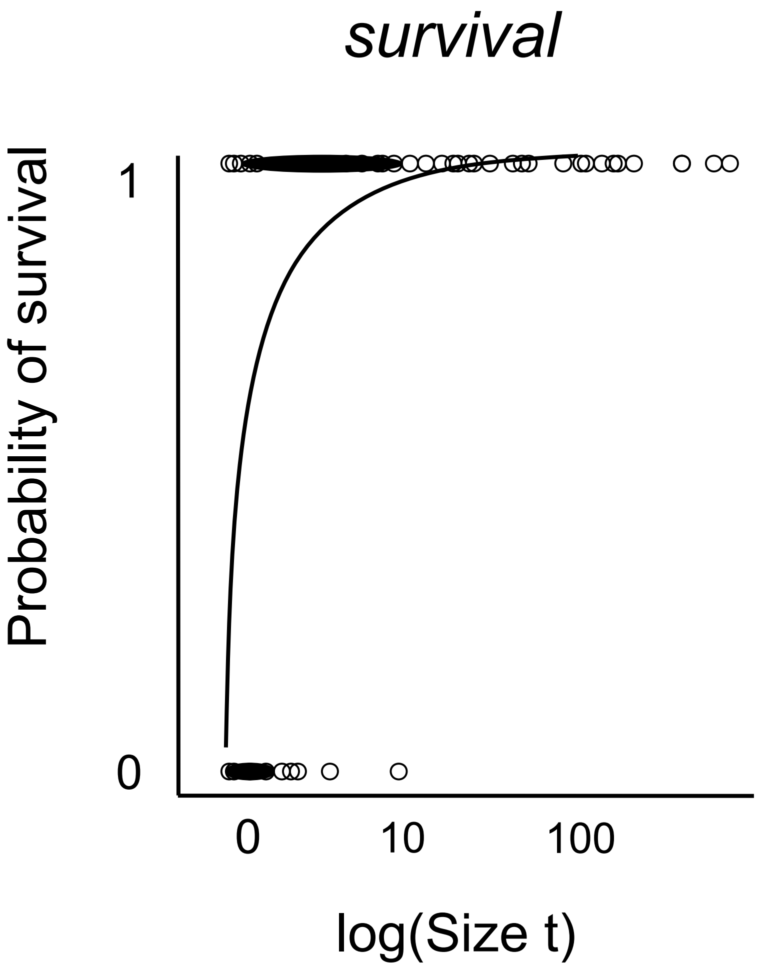
1935

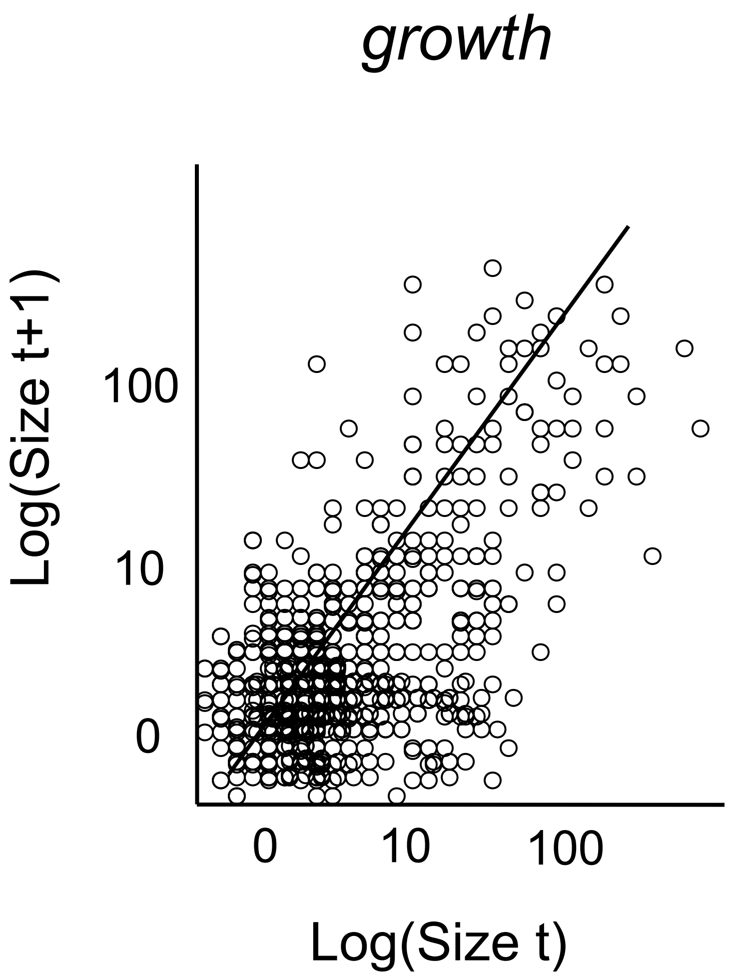


1936



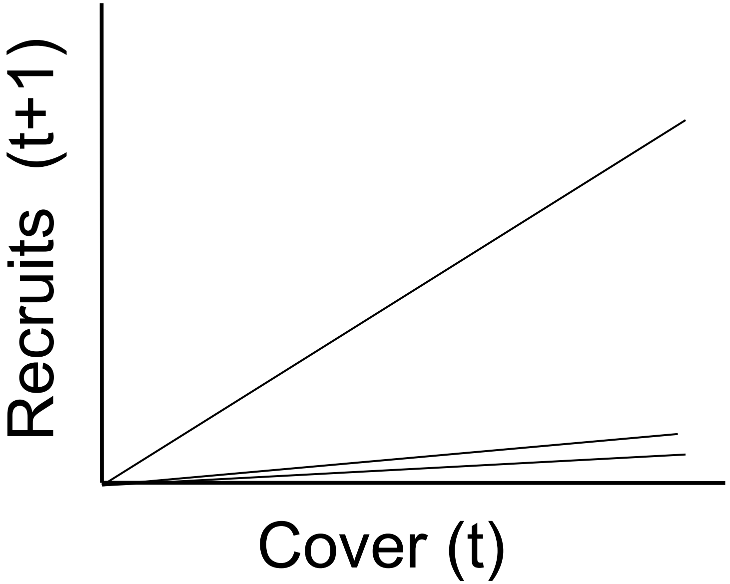
Survival and growth functions





Recruitment function

- Number of recruits distributed as a negative binomial
- Our model predicts the mean of that distribution in each year



Integral Projection Model (IPM)

$$n(y, t+1) = \int [S(y,x)G(y,x) + R(y,x)]\, v(x,t)\, dx$$

Survival   Growth   Recruitment   Number of size x at time t

Stochastic: vital rates vary each time step

26 quadrats, 22 years (1926-1956)

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Growth rates and elasticities

	λ	Surv./Growth elasticity	Recruitment elasticity
P. spicata	1.03	90%	10%
H. comata	1.07	86%	14%
A. tripartita	1.14	89%	11%

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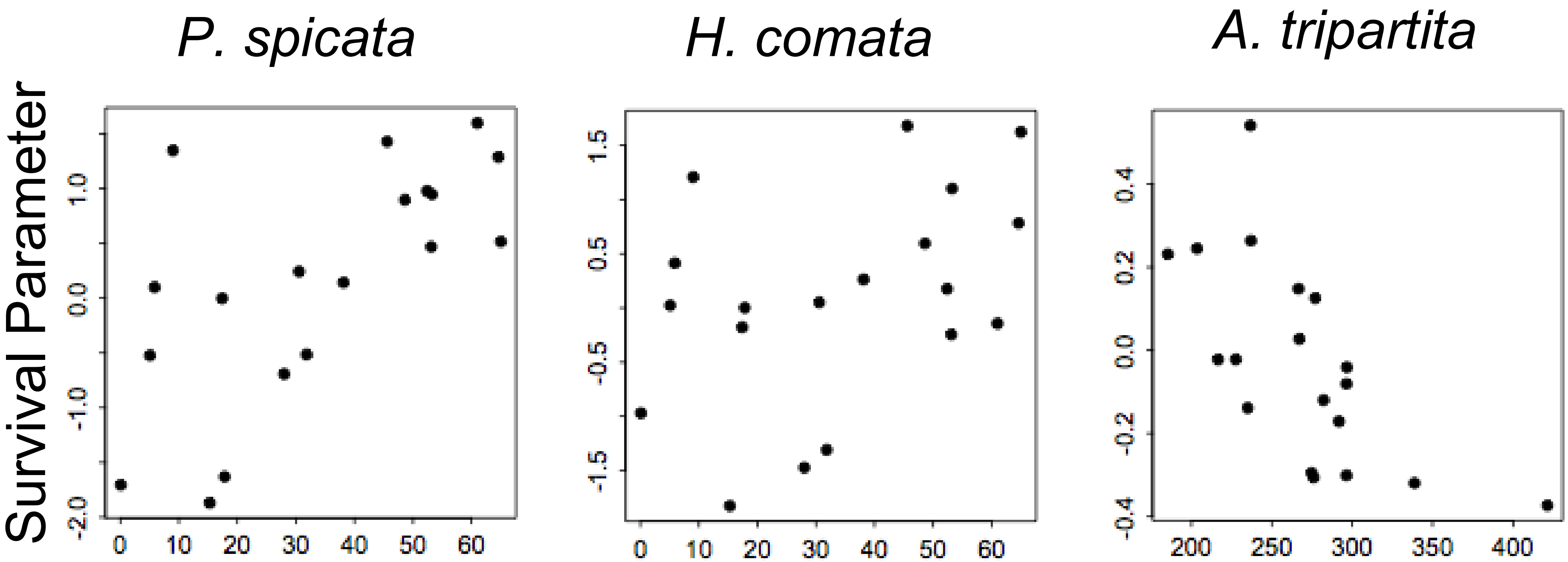
Climate variables

Precipitation	Temperature
Winter (Jan – Mar)	Winter mean
Spring (Apr – June)	Spring mean
Summer (July – Sept)	Summer mean
Fall (Oct – Dec)	Fall mean
Annual (July – June)	Annual mean
Previous annual	
Feb + Mar Snow (superior to annual snow)	

Correlations between random effects and climate



February + March Snow

Lag precip.

P = 0.002
ρ = 0.66

P = 0.07
ρ = 0.42

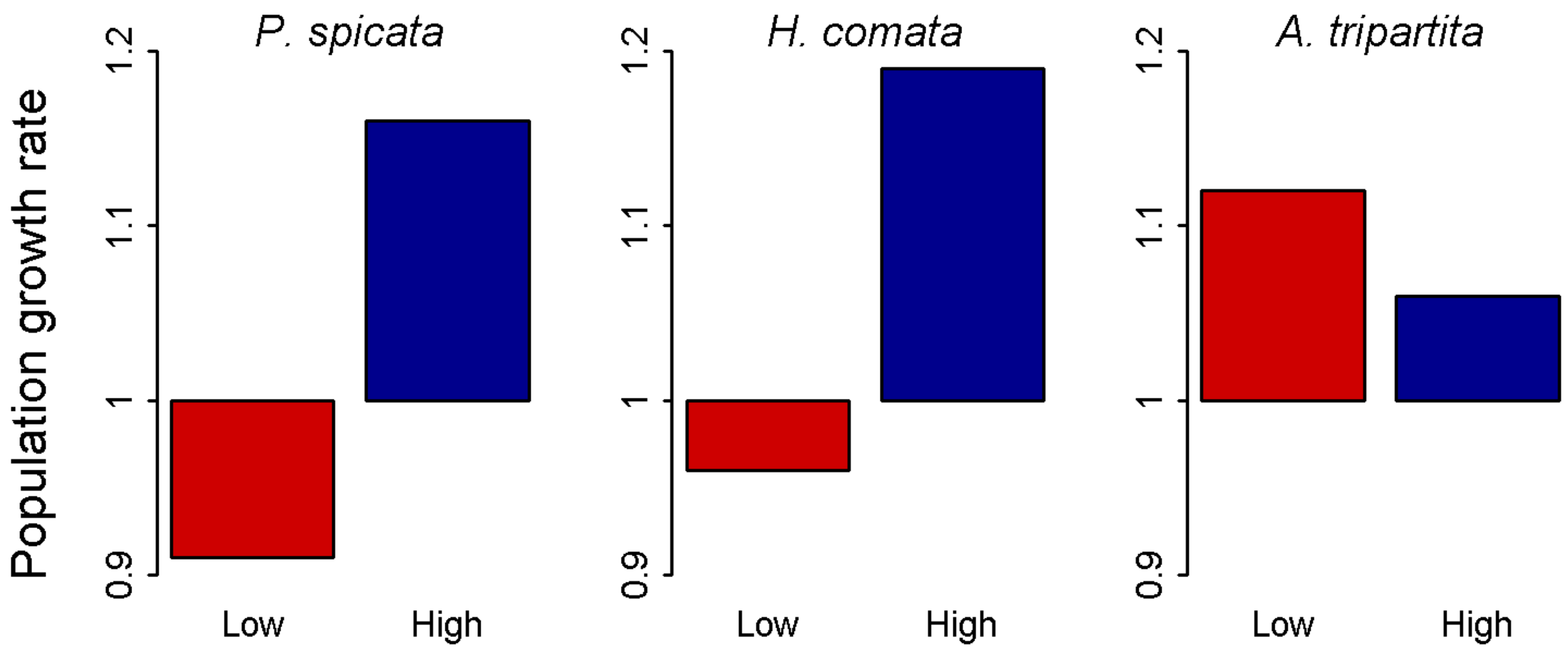
P = 0.002
ρ = -0.70

Summary of climate correlations

- Snow superior to precipitation in explaining bunchgrass performance
- Lag effects of climate affected all species
  - Precipitation in 1933-1934 affects survival from 1935-1936

Effects on population growth

- Simulate the long-term stochastic growth rate using
  - only below-average snow years
  - only above-average snow years

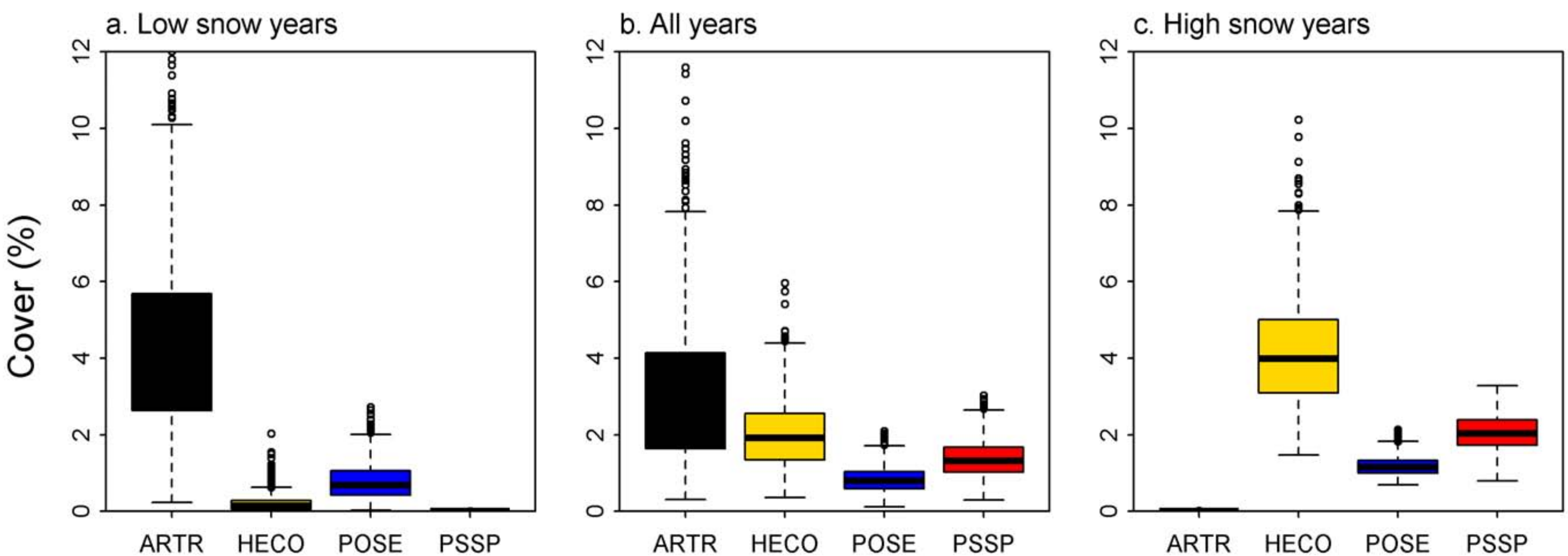


Conclusions

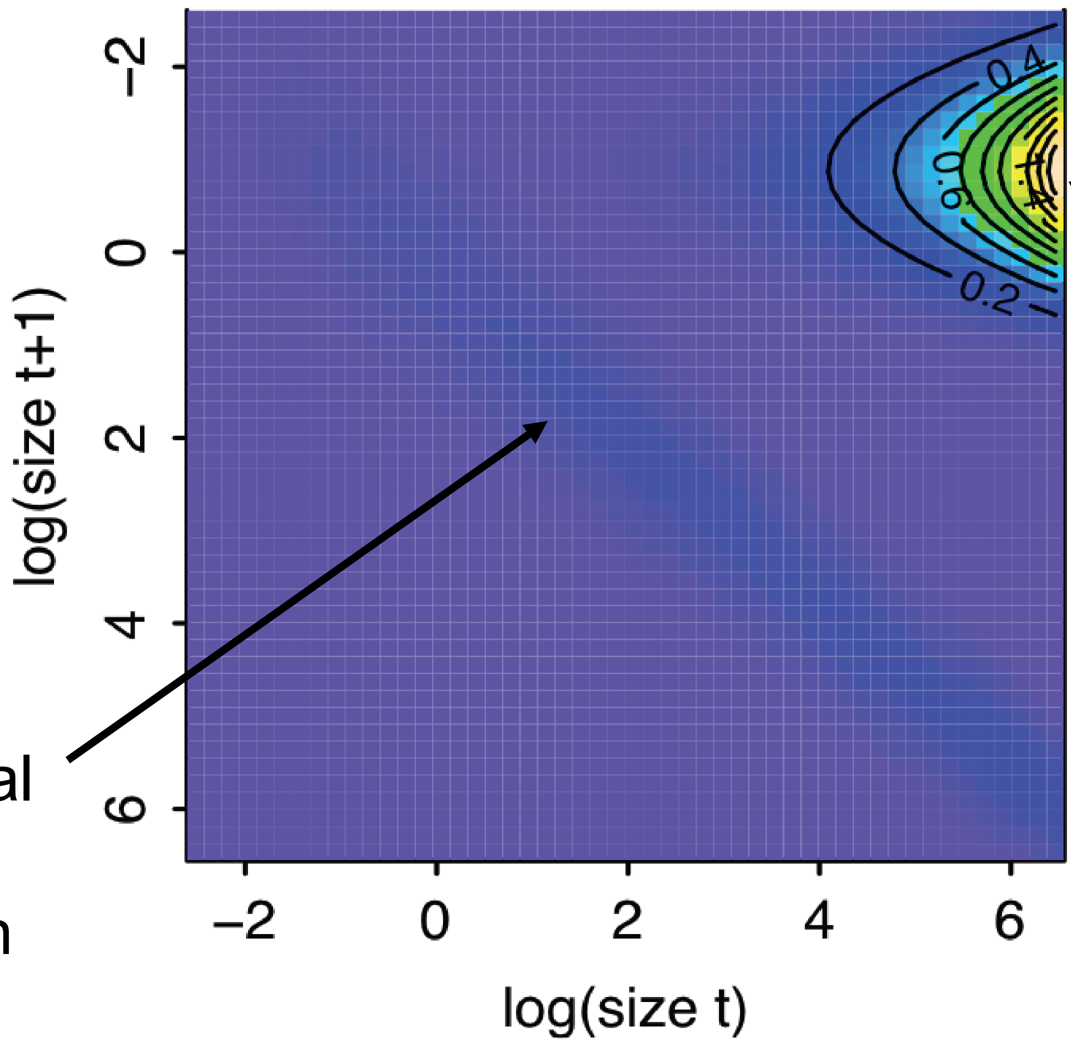
- Climate variables affecting survival are most important.
- Precipitation increases should favor grasses, hurt sagebrush.
- Shifts from snow to rain in February and March could decrease grass abundance.

- New question: Precipitation amount vs. type?

Next step: Experiments


a. Low snow years
b. All years
c. High snow years
Cover (%)
0
2
4
6
8
10
12
ARTR
HECO
POSE
PSSP

Kernel



Recruitment

Survival and Growth