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

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Population dynamics approach

Population growth rate

Abundance

Climate
Survival
Growth
Recruitment
Historical data

- **P. spicata**
- **H. comata**
- **A. tripartita**

Cover (%) over the years from 1930 to 1955.
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

1935

1936
Survival, recruitment, and growth 1935 1936
Survival and growth functions

**survival**

- Probability of survival vs. \( \log(\text{Size } t) \)

**growth**

- \( \log(\text{Size } t+1) \) vs. \( \log(\text{Size } t) \)
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  \quad Growth  \quad Recruitment  \quad Number of size \( x \) at time \( t \)

Stochastic: vital rates vary each time step

26 quadrats, 22 years (1926-1956)
Outline

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## Growth rates and elasticities

<table>
<thead>
<tr>
<th>Species</th>
<th>$\lambda$</th>
<th>Surv./Growth elasticity</th>
<th>Recruitment elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. spicata</em></td>
<td>1.03</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td><em>H. comata</em></td>
<td>1.07</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td><em>A. tripartita</em></td>
<td>1.14</td>
<td>89%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Outline

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# Climate variables

<table>
<thead>
<tr>
<th>Precipitation</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter (Jan – Mar)</td>
<td>Winter mean</td>
</tr>
<tr>
<td>Spring (Apr – June)</td>
<td>Spring mean</td>
</tr>
<tr>
<td>Summer (July – Sept)</td>
<td>Summer mean</td>
</tr>
<tr>
<td>Fall (Oct – Dec)</td>
<td>Fall mean</td>
</tr>
<tr>
<td>Annual (July – June)</td>
<td>Annual mean</td>
</tr>
<tr>
<td>Previous annual</td>
<td></td>
</tr>
<tr>
<td>Feb + Mar Snow (superior to annual snow)</td>
<td></td>
</tr>
</tbody>
</table>
Correlations between random effects and climate

Correlation parameters:

- **P. spicata**
  - February + March Snow: $P = 0.002$, $\rho = 0.66$

- **H. comata**
  - February + March Snow: $P = 0.07$, $\rho = 0.42$

- **A. tripartita**
  - Lag precip.: $P = 0.002$, $\rho = -0.70$
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