Mechanisms of Competition with KR Bluestem (*Bothriochloa ischaemum*)

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KR Bluestem (*Bothriochloa ischaemum*)

- Perennial, C4 bunchgrass

- Management of C4 in C4 grassland
Project Goals

• Increase presence and productivity of high-value forage species
• Increase native grass diversity for wildlife
Mediating Competition Through Management

- Restoration as Biocontrol
- Mycorrhizal Fungi Addition
- Prescribed Fire
Can rangeland restoration serve as biocontrol?

Which species?
How many species?
What combinations of species?
Experimental Design

- Four perennial grass species of high forage value.

- Richness: 1, 2, 3, 4 with all possible combinations at 2 and 3.

- Randomized, complete block design.

- 16 individuals per plot, substitutive design.

KR Removal – Prescribed Burn, Growing-Season, October 2009
Restored Species – Diversity Study

- Big bluestem (BBS, *Andropogon gerardii*)
- Little bluestem (LBS, *Schizachyrium scoparium*)
- Sideoats grama (SOG, *Bouteloua curtipendula*)
- Yellow Indian grass (YIG, *Sorghastrum nutans*)
Other Restored Species - Monoculture only

- Green sprangletop (GST, *Leptochloa dubia*)
- Purple threeawn (P3A, *Aristida purpurea*)
- Silver bluestem (SBS, *Bothriochloa laguroides*)
Restored Species Establishment
Summer 2010 (pre-drought)

PLUG ESTABLISHMENT BY SPECIES

PERCENT ESTABLISHMENT

SPECIES

BBS LBS SOG YIG GST P3A SBS
Richness and Invasion (2010)
Establishment and Invasion (2010)

![Graph showing the relationship between KR relative cover and plot basal area of restored species. The graph includes linear and quadratic regression analyses with corresponding R-squared values and p-values.]
Complementarity and Invasion

KR RELATIVE COVER VS. OVERYIELDING

linear - $r^2 = .297$, $p = <.0001$
quadratic - $r^2 = .304$, $p = <.0001$
Restored Species Establishment
Fall 2012 (post-drought)
<table>
<thead>
<tr>
<th>Factor</th>
<th>F</th>
<th>( p )</th>
<th>( R^2 )</th>
<th>direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restored grass cover</td>
<td>22.24</td>
<td>&lt;0.0001</td>
<td>0.222</td>
<td>-</td>
</tr>
<tr>
<td>Resident grass cover</td>
<td>0.58</td>
<td>0.449</td>
<td>0.007</td>
<td>-</td>
</tr>
<tr>
<td>All grass cover</td>
<td>30.81</td>
<td>&lt;0.0001</td>
<td>0.279</td>
<td>-</td>
</tr>
<tr>
<td>BBS</td>
<td>0.733</td>
<td>0.424</td>
<td>0.109</td>
<td>-</td>
</tr>
<tr>
<td>LBS</td>
<td>0.241</td>
<td>0.637</td>
<td>0.029</td>
<td>-</td>
</tr>
<tr>
<td>SOG</td>
<td>13.43</td>
<td>0.0009</td>
<td>0.302</td>
<td>-</td>
</tr>
<tr>
<td>YIG</td>
<td>0.104</td>
<td>0.752</td>
<td>0.007</td>
<td>0</td>
</tr>
<tr>
<td>P3A</td>
<td>4.68</td>
<td>0.275</td>
<td>0.824</td>
<td>+</td>
</tr>
<tr>
<td>SBS</td>
<td>3.02</td>
<td>0.224</td>
<td>0.602</td>
<td>-</td>
</tr>
<tr>
<td>TWG</td>
<td>1.03</td>
<td>0.348</td>
<td>0.147</td>
<td>+</td>
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</tbody>
</table>
Species and Richness Treatment and Invasion (2012)

KR Cover as a Function of Species Treatment
Richness and Invasion (post-drought)

Plots with SOG (Dominant)

All Plots

- Linear:
  - Plots with SOG: $R^2 = 0.002; p = 0.807$
  - All Plots: $R^2 = 0.295; p = 0.175$

- Quadratic:
  - Plots with SOG: $R^2 = 0.137; p = 0.118$
  - All Plots: $R^2 = 0.068; p = 0.043$
Mass Ratio and BD-EF Living in Harmony?

**Lolium**

**A - total above ground weight (g)**

- treatments with competitive dominant
- $r^2 = -0.028, p = 0.716$
- $r^2 = 0.110, p = 0.066$

**B - total above ground weight (g)**

- treatments without competitive dominant
- $r^2 = 0.068, p = 0.020$
- $r^2 = 0.054, p = 0.067$

**C - estimated total number of fruits**

- treatments with competitive dominant
- $r^2 = 0.028, p = 0.173$
- $r^2 = 0.491, p < 0.0001$

**D - estimated total number of fruits**

- treatments without competitive dominant
- $r^2 = 0.107, p = 0.005$
- $r^2 = 0.107, p = 0.011$
Mediating Competition Through Management

- Restoration as Biocontrol
- Mycorrhizal Fungi Addition
- Prescribed Fire
KR and Restored Species Re-establishment Following Burn as a Function of Mycorrhizal Fungi Addition

Commercial inoculant of mycorrhizal fungi:
- *Glomus mosseae*
- *Glomus aggregatum*
- *Glomus intraradices*
- *Pisolithus spp.*
- *Rhizopogon spp.*
KR and Native Species Competition as a Function of Mycorrhizal Fungi Addition

Positive values indicate increased biomass with added fungi

![Graph showing the difference in BGB (g) with and without fungi for different harvests.](chart.png)
Mediating Competition Through Management

- Restoration as Biocontrol
- Mycorrhizal Fungi Addition
- Prescribed Fire
Season, Phenology, and Prescribed Fire
Season, Phenology, and Prescribed Fire
Season, Phenology, and Prescribed Fire
in collaboration with Scott Havill and Susan Schwinning, TX State Univ.

[Graph showing data on regrowing tillers per plot for KR and LB treated with burn and clip.]
Mediating Competition Through Management

- Restoration as Biocontrol
- Prescribed Fire
- Soil Microbe Adjustments
Conclusions

- **Restoration as Biocontrol** – something is better than nothing; competitive, rapidly establishing species (e.g., sideoats grama) provide resistance to re-invasion under drought

- **Mycorrhizal Fungi Addition** – favor KR in field and greenhouse studies

- **Fire** – KR is overall more sensitive to fire than little bluestem; season, environmental conditions, and phenology matter
• David and Patricia Davidson
• The Nature Conservancy, Texas, USA
• Students: Jonathan Loos, Katie Banick, Claire Afflerbach, Mario Miranda, Ryan Rabat, Rohit Goswamy, Kristen Schulz, Erin Tansey, Kara Schoenenmann, Elizabeth Van Horn, Cade Bradshaw
Cost Calculations - Seed vs. Plug

On a 1 hectare plot (100 m x 100 m)

**Seed (seed only)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>$415</td>
<td>20%</td>
</tr>
<tr>
<td>Year 2</td>
<td>$415</td>
<td>25%</td>
</tr>
<tr>
<td>Total</td>
<td>$830</td>
<td></td>
</tr>
</tbody>
</table>

**Plug (seeds, plugs, labor)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>$1760</td>
<td>60%</td>
</tr>
<tr>
<td>Year 2</td>
<td>$920</td>
<td>80%</td>
</tr>
<tr>
<td>Total</td>
<td>$2680</td>
<td></td>
</tr>
</tbody>
</table>
Results – Soil Available Nutrients

No differences among species in soil nutrient use.

<table>
<thead>
<tr>
<th>Factor*</th>
<th>KR Percent Cover</th>
<th>Native Herbaceous Species Cover</th>
<th>KR Cover as a Proportion of Native Herb Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2$</td>
<td>$P$</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.100</td>
<td>0.316+</td>
<td>0.006</td>
</tr>
<tr>
<td>Ammonium</td>
<td>0.150</td>
<td>0.213+</td>
<td>0.824</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.190</td>
<td>0.154+</td>
<td>0.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor*</th>
<th>Nitrate</th>
<th>Ammonium</th>
<th>Phosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F$</td>
<td>$P$</td>
<td>$F$</td>
</tr>
<tr>
<td>Mycorrhizal Fungi Addition</td>
<td>7.280</td>
<td>0.014(-)</td>
<td>0.730</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.135</td>
</tr>
</tbody>
</table>
Results – Establishment, Species x Richness

SPECIES TOTAL PLOT BASAL AREA BY RICHNESS

TOTAL PLOT BASAL AREA (CM²)

BBS  LBS  SOG  YIG  GST  P3A  SBS

SPECIES

RICHNESS 1
RICHNESS 2
RICHNESS 3
RICHNESS 4
Results – Restored Species Effects on Plot Productivity

**PLOT BASAL AREA OF RESTORED SPECIES VS. SPECIES PRESENCE AND RICHNESS**

- **Model:** $p < .001$
- **Species:** $p < .001$
- **Richness:** $p = .062$
- **Species x Richness:** $p = .016$

![Bar chart showing differences in plot basal area among restored species with varying richness levels.](chart.png)

- **Species:** BBS, LBS, SOG, YIG
- **Richness Levels:**
  - RICHNESS 1
  - RICHNESS 2
  - RICHNESS 3
  - RICHNESS 4
Results – Species Effects on Invasion

KR RELATIVE COVER VS. SPECIES PRESENCE AND RICHNESS

- Model: $p = 0.049$
- Species: $p = 0.057$
- Richness: $p = 0.030$
- $sp \times$ richness: $p = 0.5463$

Species: BBS, LBS, SOG, YIG

Y-axis: KR relative percent cover
X-axis: Species
The better a species performs in a mixture, the greater its potential for suppression of KR.
Results – Monospecific Vs. Mixture Performance

COMPLEMENTARITY

Overyielding (OY)

= ave. yield of monocultures – plot yield

OY > 0 = mixture performs better than average of monocultures.

Hector et al. 2009
Results – Monospecific Vs. Mixture Performance

COMPLEMENTARITY

Transgressive Overyielding (TOY) = yield highest performing monoculture – plot yield.

TOY > 0 = mixture performs better than highest performing monoculture.

Hector et al. 2009

![Graph showing transgressive overyielding vs. richness](image)
Results – Intra- vs. Interspecific Competition

Relative Yield (RY):
Measure of individual species performance in mixtures relative to their average performance in the monocultures.

$\text{RY}_{ij} = \frac{Y_{ij}}{(Y_i/n_j)}$, where $Y_{ij}$ is the yield of species $i$ in mixture $j$, $Y_i$ is the yield of species $i$ in monoculture (here the average), and $n_j$ is the number of species in mixture $j$.

e.g., Dukes 2001
Results – Intra- Vs. Interspecific Competition

RYij > 1 = species performs better in mixture than monoculture.
Conclusions

• Native species establish at high rates from plugs.

• Richness trends positively with higher productivity and complementarity (basal area, OY and TOY).

• Some species are more limited by intraspecific (LBS) than interspecific (BBS, SOG, YIG) competition.

• Something is better than nothing (0 vs. 1 richness).

• KR cover is significantly negatively correlated with richness and restored species basal area.

• KR cover is significantly negatively correlated with OY and TOY = plots containing competitive species with high complementarity are more effective for invasive species control in this system.

• No differences among species in soil nutrient use.