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.
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)
Richness and Invasion (2010)

KR RELATIVE COVER VS. RICHNESS

richness 0-4 - $R^2 = .173$, $p = .001$
richness 1-4 - $R^2 = .021$, $p = .289$
Establishment and Invasion (2010)

**Graph:**

- **Title:** KR Relative Cover vs. Plot Basal Area of Restored Species
- **Graph Type:** Scatter plot with linear and quadratic regression lines.
- **Linear Regression:***
  - \( r^2 = 0.297 \)
  - \( p < 0.0001 \)
- **Quadratic Regression:***
  - \( r^2 = 0.303 \)
  - \( p < 0.0001 \)

**Axes:**
- **Y-axis:** KR Relative Percent Cover
- **X-axis:** Total Plot Basal Area of Restored Species

The scatter plot shows a negative correlation between KR relative cover and total plot basal area of restored species, with both linear and quadratic regression lines indicating significant relationships.
Complementarity and Invasion

**KR RELATIVE COVER VS. OVERYIELDING**

- Linear: $r^2 = 0.297$, $p = <0.0001$
- Quadratic: $r^2 = 0.304$, $p = <0.0001$
Restored Species Establishment
Fall 2012 (post-drought)
<table>
<thead>
<tr>
<th>Factor</th>
<th>F</th>
<th>p</th>
<th>R²</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>
</tr>
</tbody>
</table>
Species and Richness Treatment and Invasion (2012)

KR Cover as a Function of Species Treatment

Species and Richness Treatment

KR Percent Cover

-control  bbs  lbs  sbs  sog  yig  bbs  lbs  sbs  sog  yig  bbs  lbs  sbs  sog  yig  bbs  lbs  sbs  sog  yig  bbs  lbs  sbs  sog  yig

Species and Richness Treatment
Richness and Invasion (post-drought)

Plots with SOG (Dominant)

All Plots

linear: $R^2 = 0.002; p = 0.807$
quadratic: $R^2 = 0.137; p = 0.118$

linear: $R^2 = 0.295; p = 0.175$
quadratic: $R^2 = 0.068; p = 0.043$
Mass Ratio and BD-EF Living in Harmony?

Lolium

treatments with competitive dominant

A - total above ground weight (g)

$r^2 = 0.028, p = 0.716$

$r^2 = 0.110, p = 0.066$

B - total above ground weight (g)

$r^2 = 0.068, p = 0.020$

$r^2 = 0.054, p = 0.067$

treatments without competitive dominant

C - estimated total number of fruits

$r^2 = 0.028, p = 0.173$

$r^2 = 0.491, p < 0.0001$

D - estimated total number of fruits

$r^2 = 0.107, p = 0.005$

$r^2 = 0.107, p = 0.011$
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
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 the number of regrowing tillers per plot by date and treatment.]
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.
Acknowledgements

- 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

United States Department of Agriculture
National Institute of Food and Agriculture
Cost Calculations - Seed vs. Plug

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

<table>
<thead>
<tr>
<th>Seed (seed only)</th>
<th>Establishment Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 = $415</td>
<td>20%</td>
</tr>
<tr>
<td>Year 2 = $415</td>
<td>25%</td>
</tr>
<tr>
<td>Total = $830</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plug (seeds, plugs, labor)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 = $1760</td>
<td>60%</td>
</tr>
<tr>
<td>Year 2 = $920</td>
<td>80%</td>
</tr>
<tr>
<td>Total = $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>
</tbody>
</table>
Results – Establishment, Species x Richness
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: $p = .062$
sp x richness: $p = .016$

BASAL AREA (CM$^2$)

SPECIES

BBS  LBS  SOG  YIG
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 x richness: $p = 0.5463$

KR RELATIVE COVER

BBS  LBS  SOG  YIG

SPECIES

RICHNESS 1  RICHNESS 2  RICHNESS 3  RICHNESS 4
Results – Species in Mixtures and Invasion

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
Results – Intra- vs. Interspecific Competition

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

\[ \text{RY}_{ij} = \frac{Y_{ij}}{\frac{Y_i}{n_j}} \]

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.