Managing Invasive Range Plants in Beef-Cattle Grazing Systems: 
The Tale of Sericea Lespedeza in Native Tallgrass Prairie

KC Olson
Department of Animal Sciences & Industry
Kansas State University
Tallgrass Prairie in North America

- Covered 165 million acres prior to European settlement
  - 6.2 million acres (4%) remains

- The remnant is home to more than:
  - 500 plant species
  - 700 insect species
  - 185 bird species
  - 40 mammal species

- More ecologically diverse than rain forest ecosystems

- Provides an array of ecosystem services including carbon sequestration and water recycling

- Fire return intervals of 2 to 4 years
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Tallgrass Prairie in North America

- Dominated by C4 native grasses
  - Leguminous native forbs fix N
  - Capable of producing ~ 4,000 kg DM per ha without agronomic inputs
  - Supports yearling cattle gains that exceed 1 kg per day during summer

- Annually home to:
  - ~ 1.3 million transient stocker cattle
  - ~ 500,000 beef cows

- Provides sustainable income for many families and rural communities

- Susceptible to invasion by exotic plants
Sericea Lespedeza: An Ecological Transformer

“About 10% of invasive plants that change the character, condition, form, or nature of ecosystems over substantial areas may be termed transformers.”

- Richardson et al. (2001) Diversity & Distributions 6:93-107
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- Tolerant of poor soils
- Deeply-rooted perennial
- Robust canopy
- Resistant to grazing
- High in condensed tannins
- Prolific seed production
- Extended seed dormancy
- Treatment with specialty herbicides is common
  - Herbicide treatment results in collateral damage to non-target native plants, insects, and wildlife
Where to begin? Start with basic questions.
How does [CT] fluctuate over time?

Effect of harvest date on concentration and protein-binding capacity* of CT in sericea lespedeza (DM basis)

<table>
<thead>
<tr>
<th>Sampling date</th>
<th>Growth stage</th>
<th>[CT], g/kg</th>
<th>Protein-binding [CT], g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 1</td>
<td>Single-stem</td>
<td>103.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>July 1</td>
<td>Multiple-stem</td>
<td>151.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>68.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>August 1</td>
<td>Budding</td>
<td>191.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>94.0&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>September 1</td>
<td>Flowering</td>
<td>169.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>88.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>October 1</td>
<td>Mature</td>
<td>145.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>69.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SEM</td>
<td>-</td>
<td>5.02</td>
<td>1.05</td>
</tr>
</tbody>
</table>

* Total phenolic compounds which precipitated proteins.

<sup>a, b, c, d</sup> Within a column, means without a common superscript differ ($P < 0.01$).

Preedy et al., 2013
How much will experienced cattle eat?

Relative abundance of sericea lespedeza in diets of beef cows grazing native range in the Kansas Flint Hills

<table>
<thead>
<tr>
<th>Date</th>
<th>1-Jun</th>
<th>1-Jul</th>
<th>1-Aug</th>
<th>1-Sep</th>
<th>1-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative abundance, % of diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Preedy et al., 2013

a, b, c, d Means without a common superscript differ ($P < 0.01$).
How much will naive cattle eat?

Relative abundance of sericea lespedeza in diets of yearling beef steers grazing native range in the Kansas Flint Hills

![Graph showing relative abundance of sericea lespedeza in diets of yearling beef steers over time.](image-url)

Sowers et al., 2019
Can ruminal microbes adapt to a high CT diet?

Effects of Culture Substrate and Prior Tannin Exposure on Total VFA Concentration

Hoehn et al., 2018

a, b, c, d Means with unlike superscripts differ ($P < 0.001$).
e, f High CT or tannin-free substrate.
g, h Adapted to high CT or tannin-free substrate for 21 d.
Effects of sericea lespedeza contamination* on intake of tallgrass prairie hay by beef cows

Can we study intake in confinement?

Eckerle et al., 2011a

* Contaminated prairie hay = 5.5% CP, 41% ADF
* Uncontaminated hay = 5.4% CP, 40% ADF
Can the effects of CT on ruminal N availability be managed?

## Binding affinity of condensed tannins for bovine serum albumin (BSA) in the presence of polyethylene glycol (PEG) or corn steep liquor (CSL)*

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mitigator</th>
<th>Mitigator Dose(^a)</th>
<th>True Protein Availability(^b) (%)</th>
<th>CT-Bound Protein(^c) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannin + BSA</td>
<td>None</td>
<td>0</td>
<td>42.7</td>
<td>57.3</td>
</tr>
<tr>
<td>Tannin + BSA</td>
<td>PEG</td>
<td>16</td>
<td>59.0</td>
<td>41.0</td>
</tr>
<tr>
<td>Tannin + BSA</td>
<td>CSL</td>
<td>16</td>
<td>155.7</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^a\) Mitigator dose is expressed as mg/mg BSA in the original sample.

\(^b\) True protein availability was expressed as % BSA protein in the original sample.

\(^c\) CT-bound protein was expressed as the inverse of true protein availability.

* CSL = 45.1% DM, 34.4% CP (DM basis).
Can the effects of CT on ruminal N availability be managed?

Effects of increasing dose of corn steep liquor (CSL) on intake and digestion of tallgrass prairie hay contaminated by sericea lespedeza

<table>
<thead>
<tr>
<th></th>
<th>Corn steep liquor intake, (kg DM /d)</th>
<th>Item</th>
<th>0</th>
<th>0.6</th>
<th>1.2</th>
<th>1.8</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage DMI, g/kg BW^{0.75}</td>
<td>69.9^{a}</td>
<td>80.7^{b}</td>
<td>80.9^{b}</td>
<td>84.6^{b}</td>
<td>3.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total-tract DM Digestibility, %</td>
<td>52.6^{a}</td>
<td>55.6^{a}</td>
<td>65.6^{b}</td>
<td>66.3^{b}</td>
<td>2.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total-tract N digestibility, %</td>
<td>-1.5^{a}</td>
<td>18.6^{b}</td>
<td>51.7^{c}</td>
<td>52.3^{c}</td>
<td>1.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total digestible DMI, g/kg BW^{0.75}</td>
<td>40.9^{a}</td>
<td>55.0^{ab}</td>
<td>75.2^{bc}</td>
<td>87.6^{c}</td>
<td>2.14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eckerle et al., 2011b

a, b, c Means within a row lacking common superscripts differ (P > 0.05).
Can CT mitigation influence diet selection?

Effects of low-level CSL supplementation on forage intake and total tract digestion

<table>
<thead>
<tr>
<th>Item</th>
<th>CSL intake, (kg DM/d)</th>
<th>0</th>
<th>0.6</th>
<th>SEM</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontaminated forage DMI, g/kg BW(^{0.75})</td>
<td></td>
<td>43.6</td>
<td>41.6</td>
<td>3.10</td>
<td>0.65</td>
</tr>
<tr>
<td>Contaminated forage DMI, g/kg BW(^{0.75})</td>
<td></td>
<td>50.3</td>
<td>63.0</td>
<td>2.48</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Total forage DMI, g/kg BW(^{0.75})</td>
<td></td>
<td>93.9</td>
<td>104.7</td>
<td>3.90</td>
<td>0.05</td>
</tr>
<tr>
<td>Total-tract DM digestibility, %</td>
<td></td>
<td>50.5</td>
<td>53.9</td>
<td>1.66</td>
<td>0.17</td>
</tr>
<tr>
<td>Total digestible DMI, g/kg BW(^{0.75})</td>
<td></td>
<td>48.7</td>
<td>63.7</td>
<td>3.49</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Eckerle et al., 2011c
Effects of corn steep liquor supplementation on the abundance of sericea lespedeza in diets of grazing beef cows

Preedy et al., 2013

** Treatments differ within month ($P < 0.01$)
Can targeted grazing by small ruminants be used to control sericea lespedeza?

**Effect of late-season grazing by sheep on weekly herbivory of sericea lespedeza**

- Steers only
- Steers + Sheep

SEM = 3.10

Wk 1: Steers only = 10, Steers + Sheep = 10
Wk 2: Steers only = ns, Steers + Sheep = 10
Wk 3: Steers only = 10, Steers + Sheep = 20
Wk 4: Steers only = 20, Steers + Sheep = 20
Wk 5: Steers only = 20, Steers + Sheep = 20
Wk 6: Steers only = 20, Steers + Sheep = 20
Wk 7: Steers only = 20, Steers + Sheep = 20
Wk 8: Steers only = ns, Steers + Sheep = 40
Wk 9: Steers only = ns, Steers + Sheep = 80

* Treatments differ within week (P < 0.01)

Lemmon et al., 2017
Can targeted grazing by small ruminants be used to control sericea lespedeza?

Effect of late-season grazing by sheep on seed production by sericea lespedeza

Lemmon et al., 2017

Means with unlike superscripts differ ($P < 0.01$)
Can targeted grazing by small ruminants be used to control sericea lespedeza?

Lemmon et al., 2017
What if we slightly change something we already do?
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Fire timing and sericea lespedeza basal cover

What if we slightly change something we already do?

Sericea lespedeza, % basal cover

Early spring

Mid-summer

Late summer

SEM = 1.559

a, b Means w/ unlike superscripts differ ($P \leq 0.01$)
What if we slightly change something we already do?

Fire timing and sericea lespedeza whole-plant mass

Whole-plant DM weight, mg/plant

Early spring

Mid-summer

Late summer

SEM = 452.7

Alexander et al., 2019

a, b Means w/ unlike superscripts differ ($P \leq 0.01$)
What if we slightly change something we already do?

Fire timing and sericea lespedeza seed production

<table>
<thead>
<tr>
<th>Season</th>
<th>Seeds, no./stem</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early spring</td>
<td>800 (a)</td>
<td>139.4</td>
</tr>
<tr>
<td>Mid-summer</td>
<td>100 (b)</td>
<td></td>
</tr>
<tr>
<td>Late summer</td>
<td>100 (b)</td>
<td></td>
</tr>
</tbody>
</table>

Means w/ unlike superscripts differ ($P \leq 0.01$)

Alexander et al., 2019
<table>
<thead>
<tr>
<th>Pasture</th>
<th>Spring Burn 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture 5</td>
<td>27524.10 mg</td>
</tr>
<tr>
<td>Pasture 6</td>
<td>35719.20 mg</td>
</tr>
<tr>
<td>Pasture 9</td>
<td>25832.90 mg</td>
</tr>
<tr>
<td>Pasture 1</td>
<td>691.50 mg</td>
</tr>
<tr>
<td>Pasture 4</td>
<td>12.10 mg</td>
</tr>
<tr>
<td>Pasture 7</td>
<td>698.40 mg</td>
</tr>
<tr>
<td>Pasture 2</td>
<td>0 mg</td>
</tr>
<tr>
<td>Pasture 3</td>
<td>0 mg</td>
</tr>
<tr>
<td>Pasture 8</td>
<td>0 mg</td>
</tr>
</tbody>
</table>
So... what happened to everything else?
Fire timing and peak forage biomass

Standing biomass, kg DM / ha

<table>
<thead>
<tr>
<th></th>
<th>Early spring</th>
<th>Mid-summer</th>
<th>Late summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-July</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>P = 0.78</td>
<td>SEM = 360.2</td>
<td></td>
</tr>
</tbody>
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Kansas State University
Fire timing and graminoid cover, % of total basal cover

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<tr>
<th>Item</th>
<th>Early spring</th>
<th>Mid-summer</th>
<th>Late summer</th>
<th>SEM*</th>
<th>P-value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total grass cover, %</td>
<td>82.8</td>
<td>85.9</td>
<td>86.5</td>
<td>2.17</td>
<td>0.20</td>
</tr>
<tr>
<td>C4 grasses, %</td>
<td>67.7</td>
<td>65.9</td>
<td>64.8</td>
<td>3.40</td>
<td>0.70</td>
</tr>
<tr>
<td>C3 grasses and sedges, %</td>
<td>15.1</td>
<td>19.7</td>
<td>21.7</td>
<td>3.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Annual grasses, %</td>
<td>0.07</td>
<td>0.33</td>
<td>0</td>
<td>0.227</td>
<td>0.31</td>
</tr>
</tbody>
</table>

* Mixed-model SEM associated with comparison of treatment main effect means.
† Treatment main effect.
### Fire timing and forb cover, % of total basal cover

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<tbody>
<tr>
<td>Total forb cover, %</td>
<td>15.4</td>
<td>12.1</td>
<td>11.2</td>
<td>2.28</td>
<td>0.16</td>
</tr>
<tr>
<td>Perennial forbs, %</td>
<td>15.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.05</td>
<td>0.02</td>
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<tr>
<td>Sericea lespedeza, %</td>
<td>7.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.56</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Baldwin’s ironweed, %</td>
<td>0.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.16</td>
<td>0.01</td>
</tr>
<tr>
<td>Western ragweed, %</td>
<td>3.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.53</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Major wildflowers, %</td>
<td>0.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.9&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.28</td>
<td>0.03</td>
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* Mixed-model SEM associated with comparison of treatment main effect means.
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<sup>a, b</sup> Within row, means with unlike superscripts differ ($P \leq 0.05$).
## Fire timing and forb cover, % of total basal cover

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</tr>
<tr>
<td><strong>Major wildflowers</strong>&lt;sup&gt;‡&lt;/sup&gt;, %</td>
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<td>0.9&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.4&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>0.52</td>
<td>0.02</td>
</tr>
</tbody>
</table>

* Mixed-model SEM associated with comparison of treatment main effect means.
† Treatment main effect.
‡ Combined basal cover of catclaw sensitive briar, dotted gayfeather, heath aster, prairie coneflower, purple poppy-mallow, purple prairie-clover, round-headed prairie clover, and white prairie-clover.

<sup>a, b</sup> Within row, means with unlike superscripts differ (P ≤ 0.05).
## Fire timing and plant-species diversity

<table>
<thead>
<tr>
<th>Item</th>
<th>Early spring</th>
<th>Mid-summer</th>
<th>Late summer</th>
<th>SEM*</th>
<th>P-value\†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall species richness</td>
<td>22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.6</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Native species richness</td>
<td>21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.6</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Graminoid richness</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>0.6</td>
<td>0.46</td>
</tr>
<tr>
<td>Forb richness</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.2</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Forb evenness</td>
<td>0.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.039</td>
<td>0.02</td>
</tr>
<tr>
<td>Forb diversity</td>
<td>0.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.83&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.066</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

<sup>a, b</sup> Within row, means with unlike superscripts differ ($P \leq 0.05$).
Lessons Learned

• Most of the value of rangeland to society can’t be quantified by animal production or animal-based revenue

• Understanding the basic biology of invasive organisms is essential to find their Achilles’ Heel(s)

• For most invasive organisms, multi-faceted control mechanisms will likely be necessary to cover an inclusive range of land managers

• You won’t know all you need to know to find answers – learn it from colleagues and students

• Every location has enigmatic agricultural problems, related to invasive species or otherwise.
  • Some are shared with other regions. You own the rest. Don’t expect enthusiastic buy-in from “outside” funding sources.
  • Find ways to engage the stakeholder base.
  • Keep knocking on doors; eventually, somebody with a checkbook will respond.