Restoring Wyoming Big Sagebrush to Annual Brome-Invaded Landscapes with Seeding and Herbicides

Authors: 1Emily Metier, 2Lisa Rew and 1Matt Rinella

Presenter: Gabe Johnson

1United States Department of Agriculture, Agricultural Research Service, Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana

2Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana

3Cloud Peak Energy, Spring Creek Coal Mine, Decker, Montana
Cloud Peak Energy Operations

2017 by the numbers:

- Approx. 1,300 employees in Wyoming, Montana and Colorado
- One of the largest U.S. coal producers
- Approx. 58 million tons produced
- Approx. 2 percent of U.S. electricity generation
- 4.2 million tons exported to Asia through British Columbia
Recognized for Health, Safety & Environmental Performance

2017 Office of Surface Mining (OSM) National Excellence in Surface Mining and Reclamation
  ■ Enhanced reclamation success through diversity of topography, soil and vegetation

2013 Rocky Mountain Coal Mining Institute Safety Award

2013 Mine Safety and Health Administration (MSHA) – Top 5 Sentinel’s of Safety

2012 Office of Surface Mining (OSM) Good Neighbor Award to all CPE operations
  ■ Reclamation & mining education outreach, flood responses

2011 Mine Safety and Health Administration (MSHA) – Sentinel’s of Safety

Office of Surface Mining – Excellence in Surface Mine Reclamation
  ■ 2009 - Voluntary plantings of rare mustard plant (woolly twinpod)
  ■ 2005 - Reclamation of the South Fork stream channel

2008 and 2005 MSHA Sentinel’s of Safety Runner-Up

2006 Rocky Mountain Coal Mining Institute Safety Award

ISO 14001 & OHSAS 18001 Environmental/Safety Management Systems
  ■ Initially certified in 2005
  ■ Recertification audits completed in 2017
Agenda

• Environmental Setting

• Reclamation Goals

• Problem (WEEDS!)

• Causes for WEEDS

• WEED Prevention Options

• WEED Repair Options

• USDA Test Plots Objectives & Test Results
Environmental Setting
Powder River Basin

Spring Creek Mine

Decker Mine
Tongue River Basin
South-Central MT
Elev. 3500’ (1,070 m)

Annual Precipitation 10.8” (27 CM)
~ Clay Loam Topsoil

3 Substrate Options:
Spoil, Scoria, Salvaged Topsoil
A = Top 6”
B ~ 12” below the A horizon
Reclamation Goals
• Establish Wildlife Habitat in 10 years
  – Mule Deer Winter Range
  – Core Sage-grouse Habitat

• **SMCRA 1977**

  REVEG. Diverse, Effective, Permanent

  Native SPP. Except Pastures

  ≥ Premine Cover and Productivity

  Control Erosion
10 Year Technical vegetation standards, SCM. Revegetation must meet 90% of the standards with 0.1 Type 1 error.

<table>
<thead>
<tr>
<th>PERFORMANCE PARAMETER</th>
<th>GRAZING LAND</th>
<th>WILDLIFE HABITAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOODY PLANT DENSITY</td>
<td>1,112/HA</td>
<td>5,740/HA</td>
</tr>
<tr>
<td></td>
<td>450/AC</td>
<td>2,322/AC</td>
</tr>
<tr>
<td>PERENNIAL COVER</td>
<td>50%</td>
<td>46%</td>
</tr>
<tr>
<td>PEAK STANDING CROP</td>
<td>775 KG/HA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>690 LBS/AC</td>
<td></td>
</tr>
</tbody>
</table>
• Desire a field full of a variety of woody plants and perennial grasses
The Problem
• Sometimes reclaimed fields either have an abundance of **WEEDS** and lack shrubs or they have an abundance of perennial grasses and lack shrubs.

• Today we’ll just focus on improving **WEEDY** fields
Richard Prodgess, “Give me revegetation in one sentence”. The answer is: “Matching plants to habitat”.
Causes for Weedy Fields
• #1 Direct haul topsoil which contains annual weeds

• Poor implementation of seeding plan,
  – seeding surface too rough
  – seed too deep
  – seed not deep enough
  – seed row plugged (not paying attention while seeding)
  – seeder not calibrated
  – bad seed (stored in hot location)

• Chance
  – hard rain (wash away)
  – windy (blows away)
  – long dry period after germination
Weedy Field Prevention
• Use Best substrate “*Vegetation is the soil map*”
  – Topsoil from stockpile, **not direct haul**
  – Suitable Spoil
  – Suitable Spoil with 6” of B Topsoil ontop (**ideal**)
  – Scoria (not too coarse)
PHOTO 2007

SODIC OVERBURDEN TEST PLOTS

TOPSOIL

SUITABLE SPOIL
• Seeding “Proper implementation”
  – Calibrate seeder and check seed cups while seeding
  – check seed depth
  – check seed quality
  – seed before majority of spring moisture...pray for nice steady rain with no wind...
### Drill, Sunflower 10' Wide Drill, 17 Hoses

<table>
<thead>
<tr>
<th>Mix</th>
<th>Type</th>
<th>&quot;A&quot; Driven (by meter)</th>
<th>&quot;B&quot; Main Drive (with small tire)</th>
<th>&quot;D&quot; Heavy Box Feeder</th>
<th>Exact Inches of Opening on Heavy Box</th>
<th>Chain Between &quot;A&quot; and &quot;C&quot;</th>
<th>Chain Between &quot;C&quot; and &quot;E &amp; F&quot;</th>
<th>&quot;E&quot; Light Box (bottom)</th>
<th>&quot;F&quot; Light Box (top)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13a (calibrated Fall '16 with Granite Seed)</td>
<td>Alternative Rows</td>
<td>21</td>
<td>10</td>
<td>35</td>
<td>6/16&quot; (right side of white mark)</td>
<td>Yellow</td>
<td>Green</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>13f Old @ 3 PLS '16</td>
<td>Alternative Rows</td>
<td>13</td>
<td>10</td>
<td>35</td>
<td>Between 8 and 9/16&quot;</td>
<td>Grey</td>
<td>Green with Small Section</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>13f NEW @ 4 PLS '17</td>
<td>Alternative Rows</td>
<td>13</td>
<td>10</td>
<td>35</td>
<td>9/16&quot; Plus Smidge</td>
<td>Grey</td>
<td>Green with Small Section</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>13d (calibrated Spring '17 with Granite Seed)</td>
<td>Alternative Rows</td>
<td>21</td>
<td>10</td>
<td>35</td>
<td>1/2&quot; (right side of white mark)</td>
<td>Yellow</td>
<td>Green</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>14</td>
<td>Every Row</td>
<td>21</td>
<td>10</td>
<td>35</td>
<td>1/2&quot; (right side of white mark)</td>
<td>Yellow light box empty or with some 13c, then use 15 at &quot;C&quot; and doesn't really matter for E and F.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>(calibrated Spring '17 with Granite Seed)</td>
<td>Alternative Rows</td>
<td>13</td>
<td>10</td>
<td>35</td>
<td>1/2&quot; (right side of white mark)</td>
<td>Grey</td>
<td>Green</td>
<td>30</td>
</tr>
</tbody>
</table>

**Notes:**
- Check Sprocket on lower shaft of light seed box, it tends to slip on the shaft. Allen Wrench to Tighten. Max opening on Drill box is 7/8". If it does not open all the way, loosen the lock nut on Drivers side. Minimum is about 1/2" before it starts grinding seed.

---

**Diagram Annotations:**
- **A:** LO/TO Tractor before removing guard. Use bright orange links to go from 10 to 20 for "B". Use RED chain for changing "A" from (21 or 19) to 26. "A" (21 or 19) uses YELLOW chain; using 13 for "A" may requires GREY.
- **B:**
- **C:**
- **D:**
- **E:**
- **F:**
Weedy Field Improvement Options
• Wait…… (10 year window).. Pass for Grazing Land?
• Graze it, cows, goats... fence is $
• Interseed directly into existing vegetation
  – Hundreds of Acres with limited success
  – Reset 6 year bond clock
• Disc it up again, then reseed
  – Limited success, rejuvenate soil fertility and start process over again (kochia, mustard, cheat grass..)
  – Reset 10 year bond clock
• Spray Herbicide, clear it off, then interseed
  – Success, only resets bond clock back 6 years
  – Restarts kochia/mustard cycle again, limits cheat grass
USDA Test Plot Objectives
• Manage invasive species (Bromus tectorum and Bromus japonicus) Cheat Grass with targeted herbicide applications
  – Glyphosate (broad spectrum) kills everything
  – Quizalofop (grass specific) won’t kill shrubs

• Establish native species, especially Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis)
Objective Challenge, WY Big Sage

- Little Endosperm compared to grass...within the seed that provides energy for the embryo, it provides the energy required for seed leaves to push up through the soil including any crust and reach the life-giving sun

- Grazing by Antelope!
Test Plot Treatments

• Herbicide Treatments
  – Fall glyphosate (like Roundup) 0.877 liters ha$^{-1}$
  – Spring quizalofop (grass only) 0.950 liters ha$^{-1}$
  – Fall glyphosate and spring quizalofop

• Seeding Treatments
  – Spring seeding 3.36 kg WY Big sagebrush (3 PLS) T1
  – Spring seeding 5.60 kg WY Big sagebrush (5 PLS) T2

• Control

• Herbicide Retreatment on half cells
  – Spring quizalofop one year after initial application
Test Plot Layout

• Replication
  – 2 years sampling
  – 2 different mines
  – 3 or 6 sites
  – 10 plots

• Sampling
  – 2 growing seasons
  – Annual brome cover
  – Cover of all other species
  – Sagebrush density
H1 (Fall Glyphosate)
H2 (Spring Quizalop)
H3 (Fall Glyphosate & Spring Quizalop)
Control (nothing)

12 m
Litter Removal
Control

Total Control
T1 (3 PLS) T2 (5 PLS)
Project Schedule

• 2014 Test Plots
  – Oct. 2014 Sampled
  – Oct. 2014 glyphosate (like Roundup) H1 and H3
  – April 2015 quizalofop (grass only) H2 and H3
  – May 2015 remove litter with flexible chain harrow
  – May 2015 calibrate seeder and seeded T1 (3 PLS) and T2 (5 PLS)
  – July 2015 Sampled
  – April 2016 quizalofop (grass only) H1, H2 and H3 split plots
  – July 2016 Sampled

• 2015 Test Plots
  – Oct. 2015 Sampled
  – Oct. 2015 glyphosate (like Roundup) H1 and H3
  – April 2016 quizalofop (grass only) H2 and H3
  – April 2016 remove litter with flexible chain harrow
  – April 2016 calibrate seeder and seeded T1 (3 PLS) and T2 (5 PLS)
  – July 2016 Sampled
Test Plot Results
Both 2014 and 2015 Experiments

Fall Spray when CHEATGRASS is green is most effective 22% to 11%
CHEATGRASS 1st Year Spraying, no affect on 2nd year growth

Spraying didn’t kill seed bank previously fell on the ground.
2014 Exp. Spray quizalop 2nd year reduced from 40% to 28%
Spraying restarted Kochia Cycle!, 8 to 24% ground cover

Non Native Forbs: Kochia, Russian Thistle

<table>
<thead>
<tr>
<th></th>
<th>Decker</th>
<th>Spring Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st summer after application</td>
<td>2nd summer after application</td>
</tr>
<tr>
<td>Control</td>
<td>y</td>
<td>a</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>yz</td>
<td>y</td>
</tr>
<tr>
<td>Quizalofop</td>
<td>b</td>
<td>z</td>
</tr>
<tr>
<td>Glyphosate &amp; quizalofop</td>
<td>c</td>
<td>8%</td>
</tr>
</tbody>
</table>

Spraying restarted Kochia Cycle!, 8 to 24% ground cover
Cheatgrass 2015, Sprayed 2016, Kochia 2017

Kochia 2015, not sprayed, now cheatgrass 2017
Fall Spray when cheatgrass is green is most Effective (annuals & sagebrush)

Long term testing may show quizalofop with Better results

Wildlife criteria = 0.57, Grazing land = 0.11 plants/m²
Spraying improved, too early to tell actual results

- ● 1st summer after seeding
- ▲ 2nd summer after seeding
Test Plot Conclusions

• Test Plot herbicide treatments reduced annual brome cover and substantially improved sagebrush establishment (goal accomplished)

• Glyphostate applied in Fall restarted Kochia cycle

• Herbicide retreatment (2014 Exp. Quizalofop 2\textsuperscript{nd} year) further controlled annual bromes but did not boost seeded species or sagebrush

• Sagebrush established at both mines in two seeding year environments: resulted in woody plant densities exceeding reclamation criteria

• Need ~ 10 years of monitoring data to see long term trends
Acknowledgements

- Emily Metier, USDA
- Dr. Matt Rinella, USDA ARS
- Dr. Lisa Rew, Montana State University
- Dr. Jane Mangold, Montana State University
- Dr. Erik Lehnhoff, New Mexico State University
- Kaylee Schmitz
- Spring Creek and Decker Coal Mines
- Montana Department of Environmental Quality
- Montana State University Department of Land Resources and Environmental Sciences
- USDA ARS Fort Keogh
- Big Horn Env. Rich Prodgers
- ASMR