

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



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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

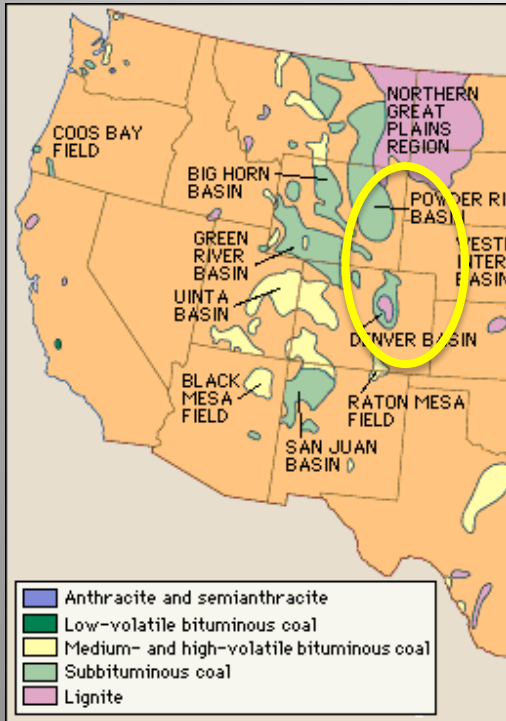
- Initially certified in 2005
- Recertification audits completed in 2017

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



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.

PERFORMANCE PARAMETER	GRAZING LAND	WILDLIFE HABITAT
WOODY PLANT DENSITY	1,112/HA 450/AC	5,740/HA 2,322/AC
PERENNIAL COVER	50%	46%
PEAK STANDING CROP	775 KG/HA 690 LBS/AC	NA

- Desire a field full of a variety of woody plants and perennial grasses





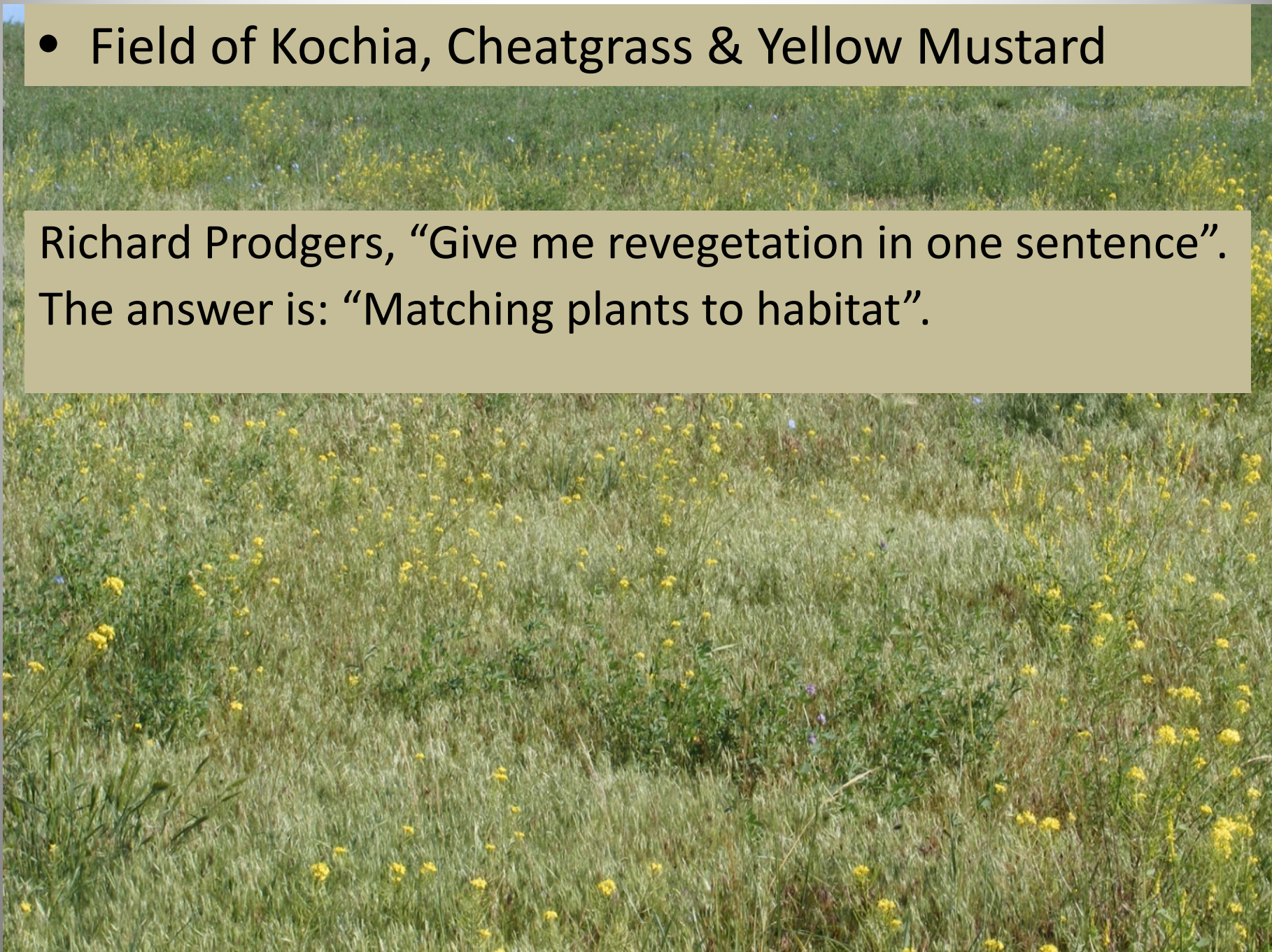
PAR 4C SEEDED 11/99
PHOTO 2012

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

- Field of Kochia, Cheatgrass & Yellow Mustard

Richard Prodgers, “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

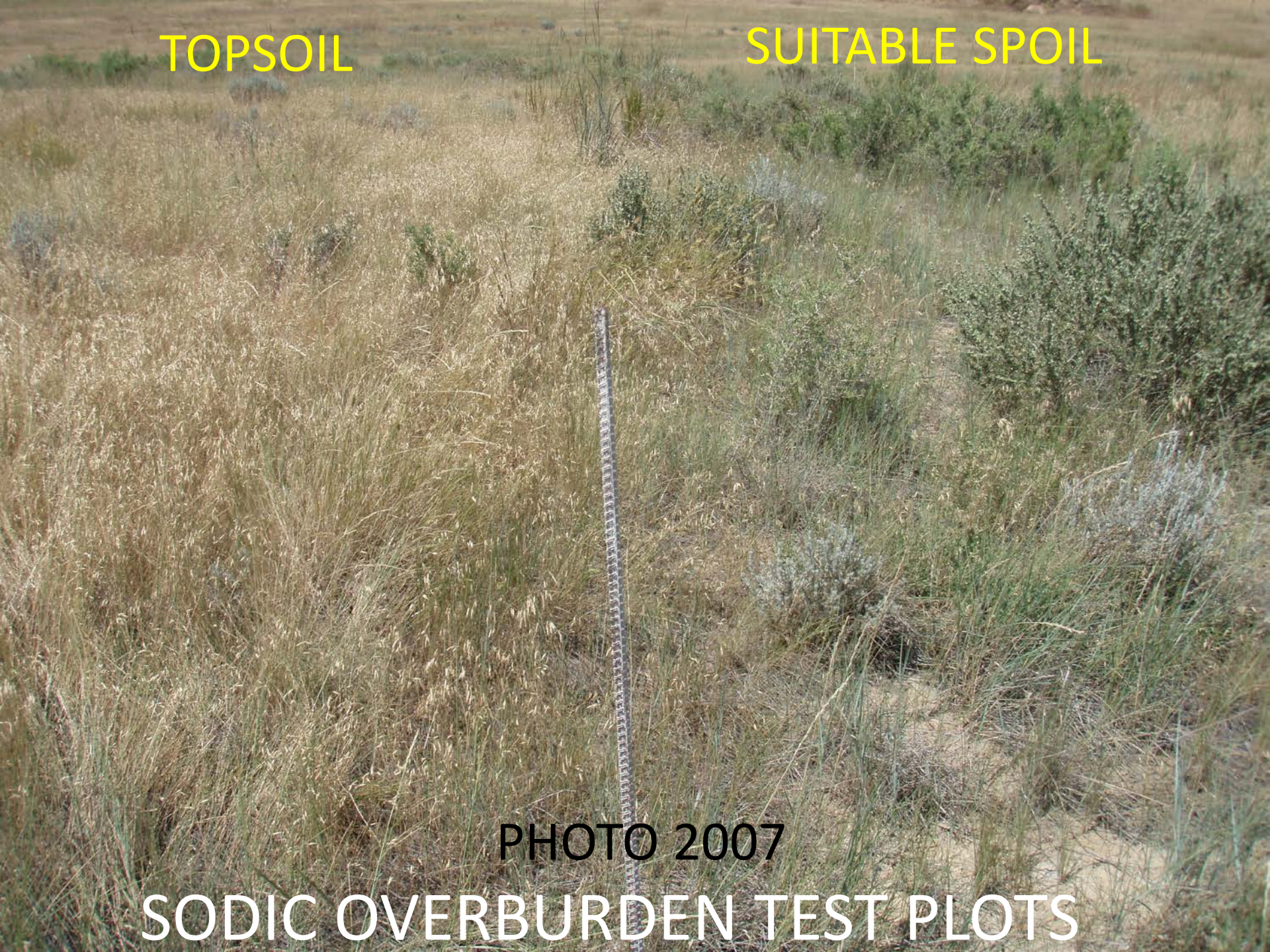
- Use Best substrate “*Vegetation is the soil map*”
 - Topsoil from stockpile, **not direct haul**
 - Suitable Spoil
 - Suitable Spoil with 6” of B Topsoil ontop (**ideal**)
 - Scoria (not too coarse)

TOPSOIL

SUITABLE SPOIL

PHOTO 2007

SODIC OVERBURDEN TEST PLOTS

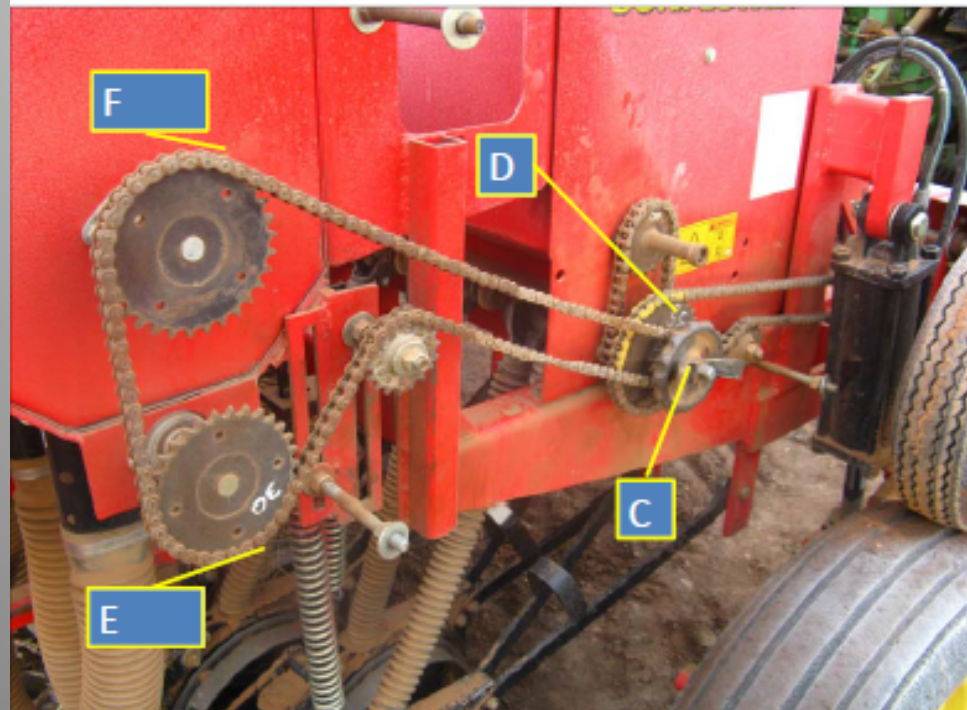


- Seeding “*Proper implementation*”
 - Calibrate seeder and check seed cups while seeding
 - check seed depth
 - check seed quality
 - seed before majority of spring moisture...pray for nice steady rain with no wind...

Drill: Sunflower 10' Wide Drill; 17 Hoses

56.2 tire revolutions to cover 1/10 the of an acre

Mix	Type	"A" Driven (by meter)	"B" Main Drive (with small tire)	"D" Heavy Box Feeder	Exact Inches of Opening on Heavy Box	Chain Between "A" and "C"	"C" Square Sprocket	Chain Between "C" and "E & F"	"E" Light Box (bottom)	"F" Light Box (top)
13B (calibrated Fall '16 with Granite Seed)	Alternative Rows	21	10	35	6/16" (right side of white mark)	Yellow	20	Green	30	40
13f Old @ 3 PLS '16	Alternative Rows	13	10	35	Between 8 and 9/16"	Grey	20	Green with Small Section	30	40
13f NEW @ 4 PLS '17	Alternative Rows	13	10	35	9/16" Plus 5/16"idge	Grey	25	Green with Small Section	30	40
13D (calibrated Spring '17 with Granite Seed)	Alternative Rows	21	10	35	1/2" (right side of white mark)	Yellow	20	Green	30	40
14	Every Row	21	10	35	1/2" (right side of white mark)	Yellow	light box empty or with some 13c, then use 15 at "C" and doesn't really matter for E and F.			
15 (calibrated Spring '17 with Granite Seed)	Alternative Rows	13	10	35	1/2" (right side of white mark)	Grey	25	Green	30	40
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.									



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



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



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!**

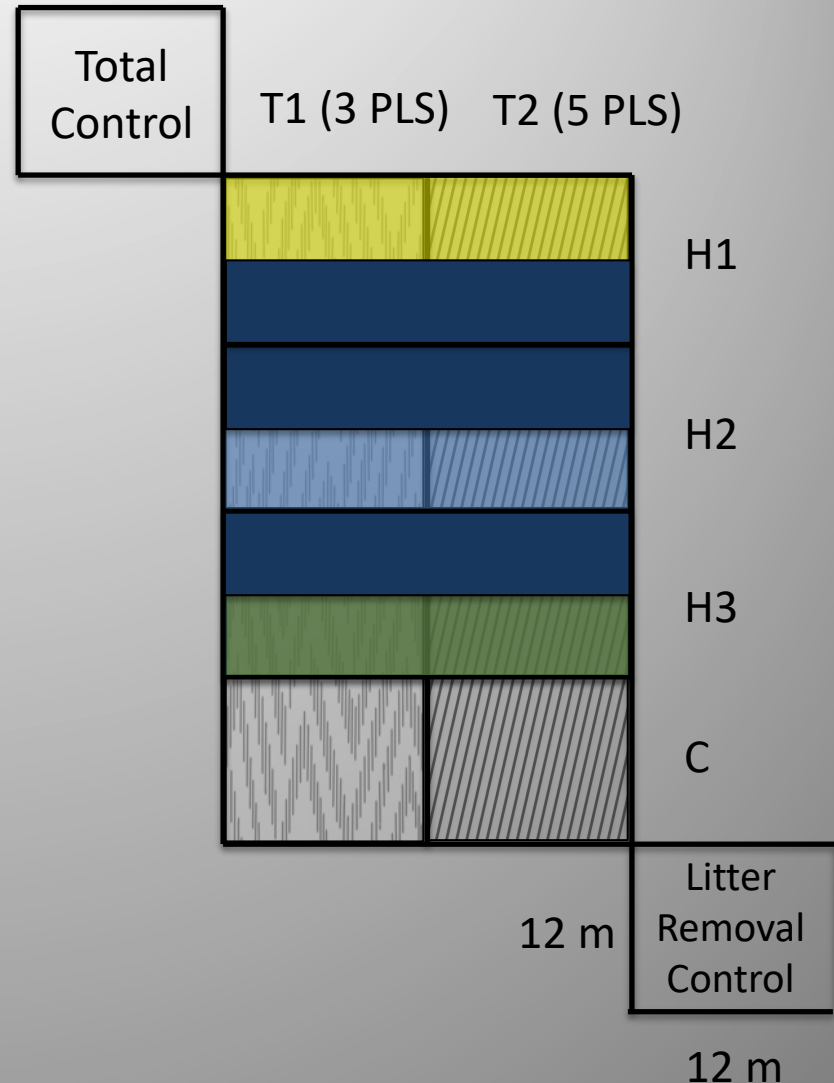


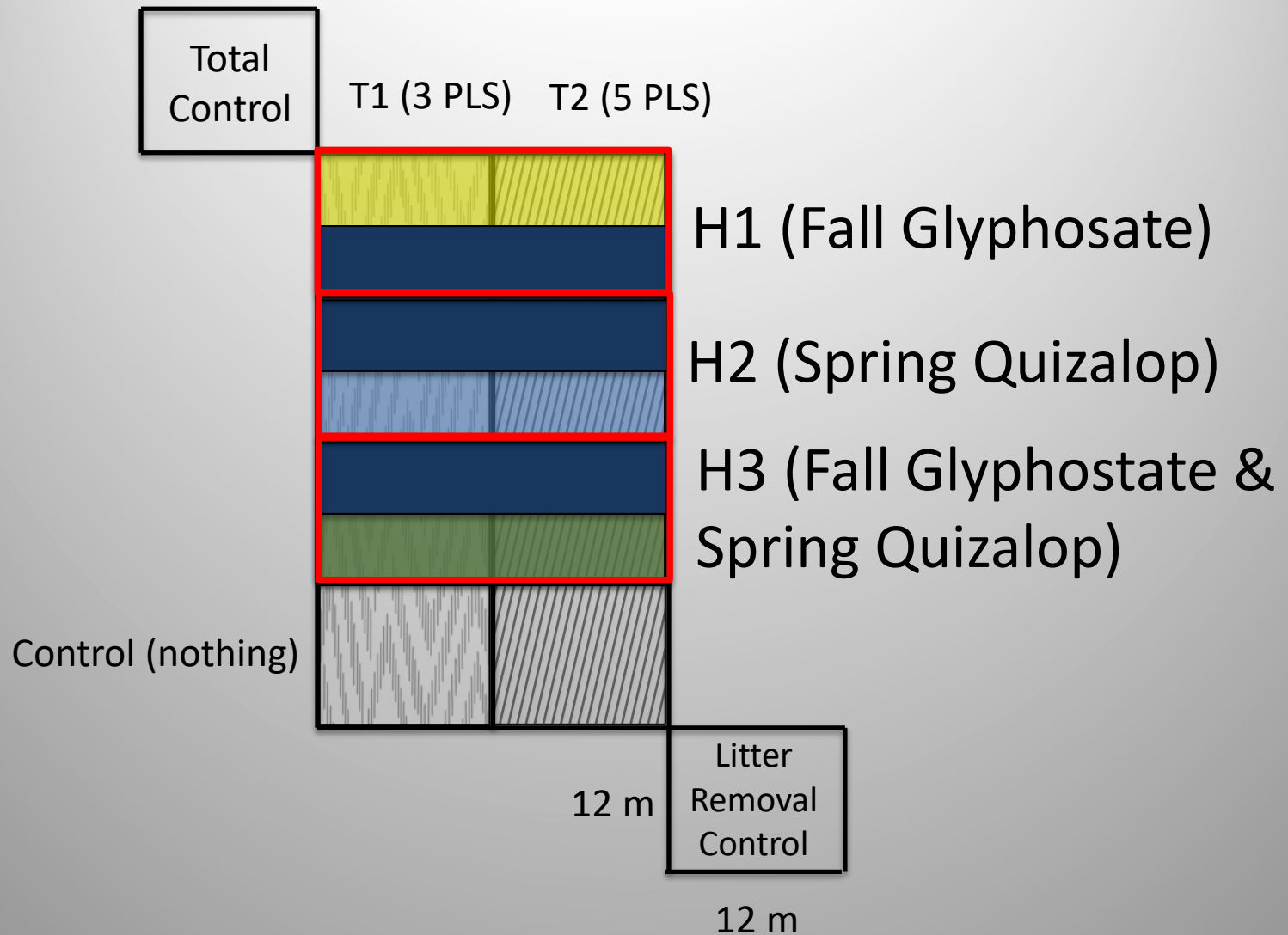
Test Plot Treatments

- 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





Project Schedule

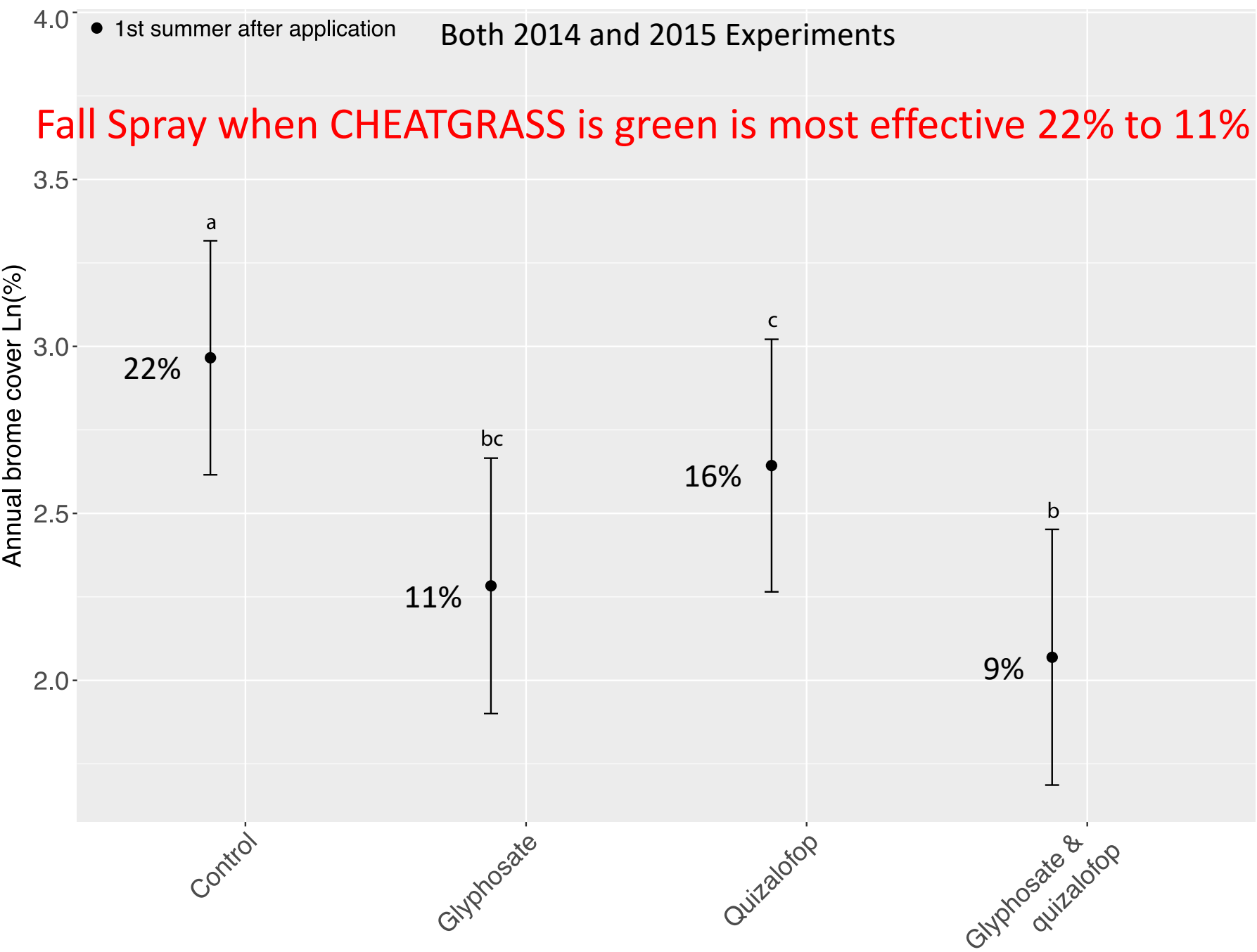
- 2014 Test Plots
 - Oct. 2014 Sampled
 - Oct. 2014 glyphosate (like Roundup) H1 and H3
 - April 2015 quizalofop (grass only) H2 and H3
 - May 2015 remove litter with flexible chain harrow
 - May 2015 calibrate seeder and seeded T1 (3 PLS) and T2 (5 PLS)
 - July 2015 Sampled
 - April 2016 quizalofop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

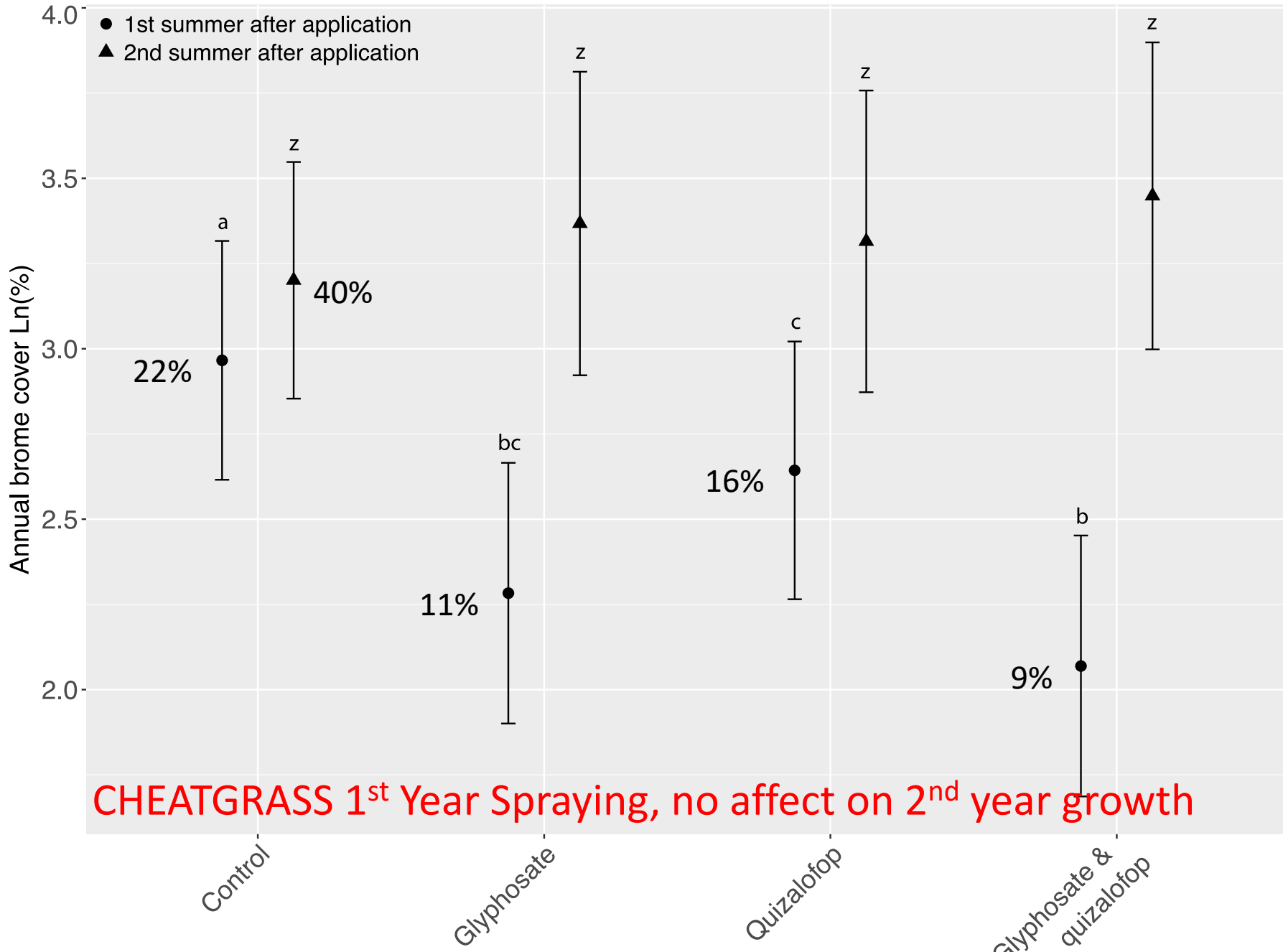






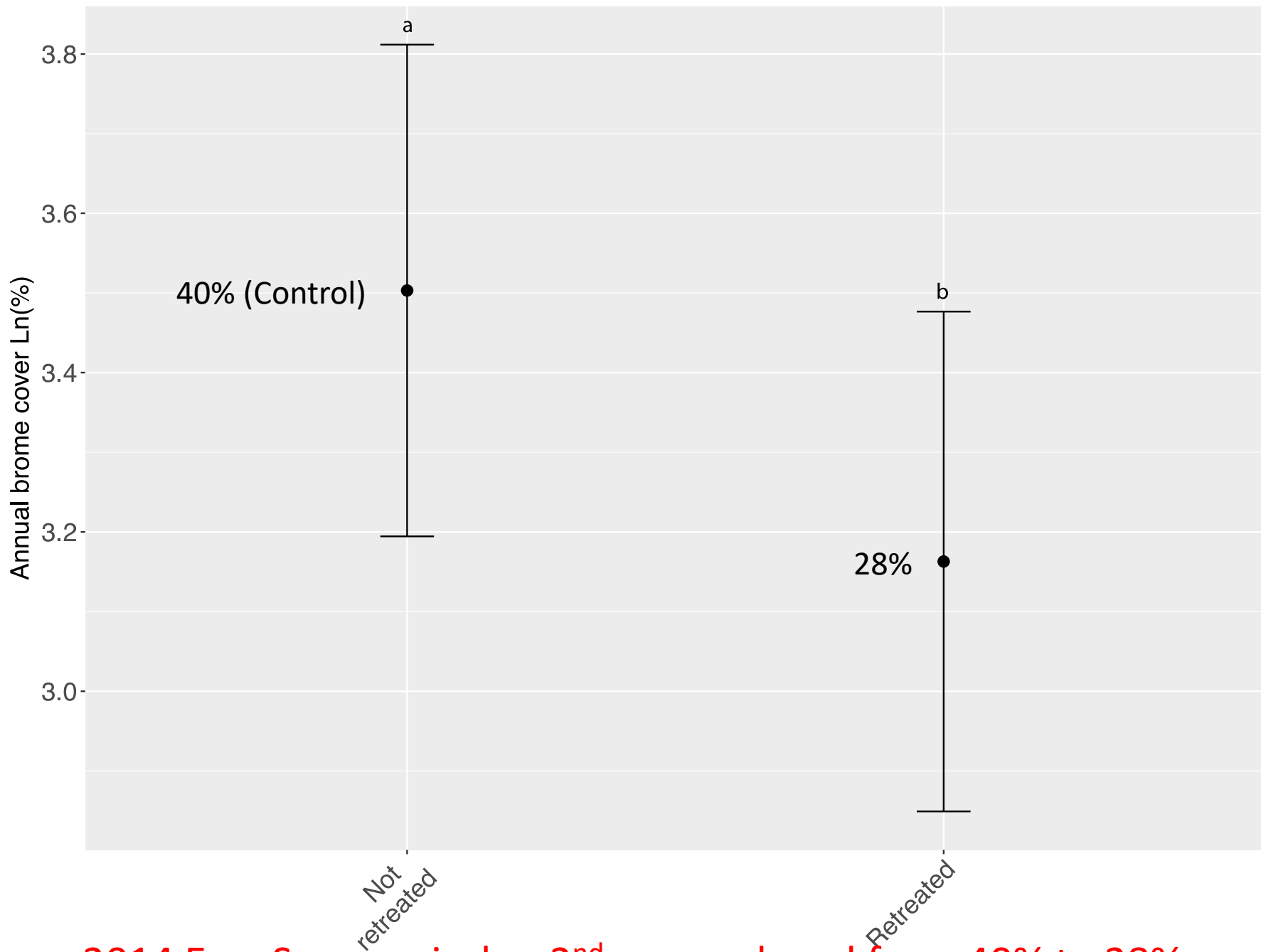
Test Plot Results





CHEATGRASS 1st Year Spraying, no affect on 2nd year growth

Spraying didn't kill seed bank previously fell on the ground.



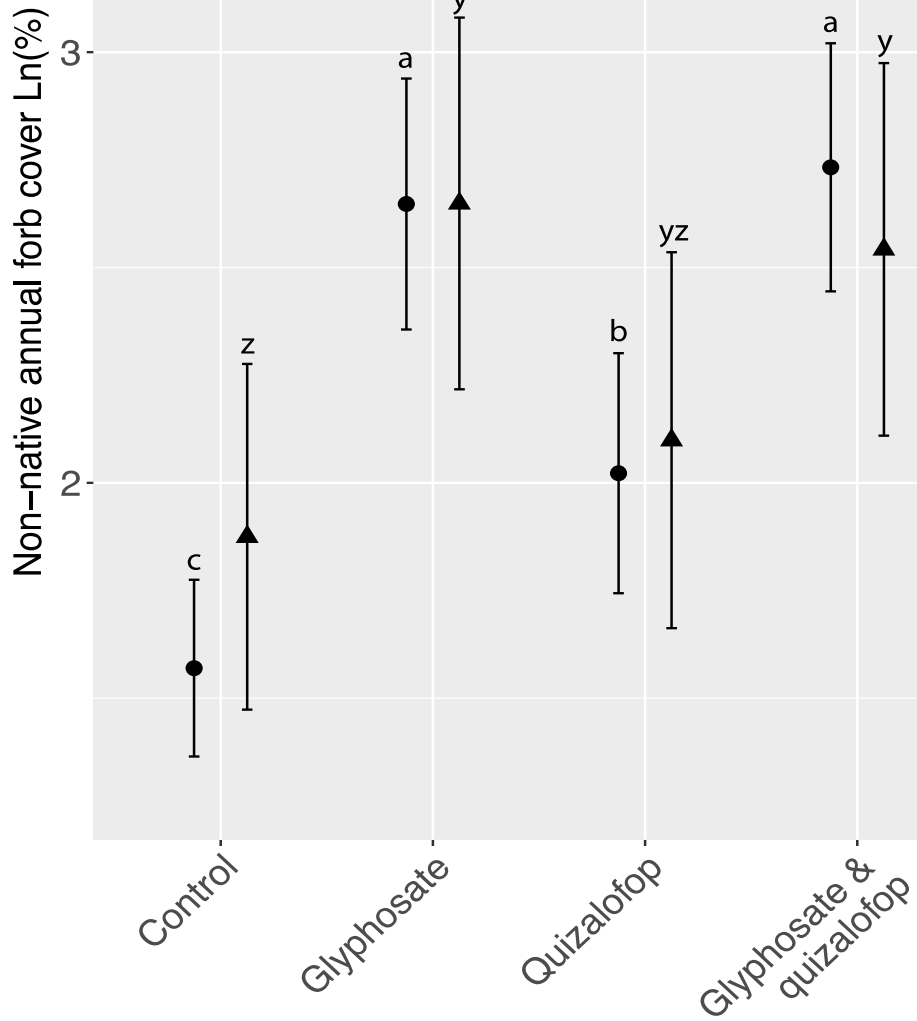
2014 Exp. Spray quizalop 2nd year reduced from 40% to 28%

Decker

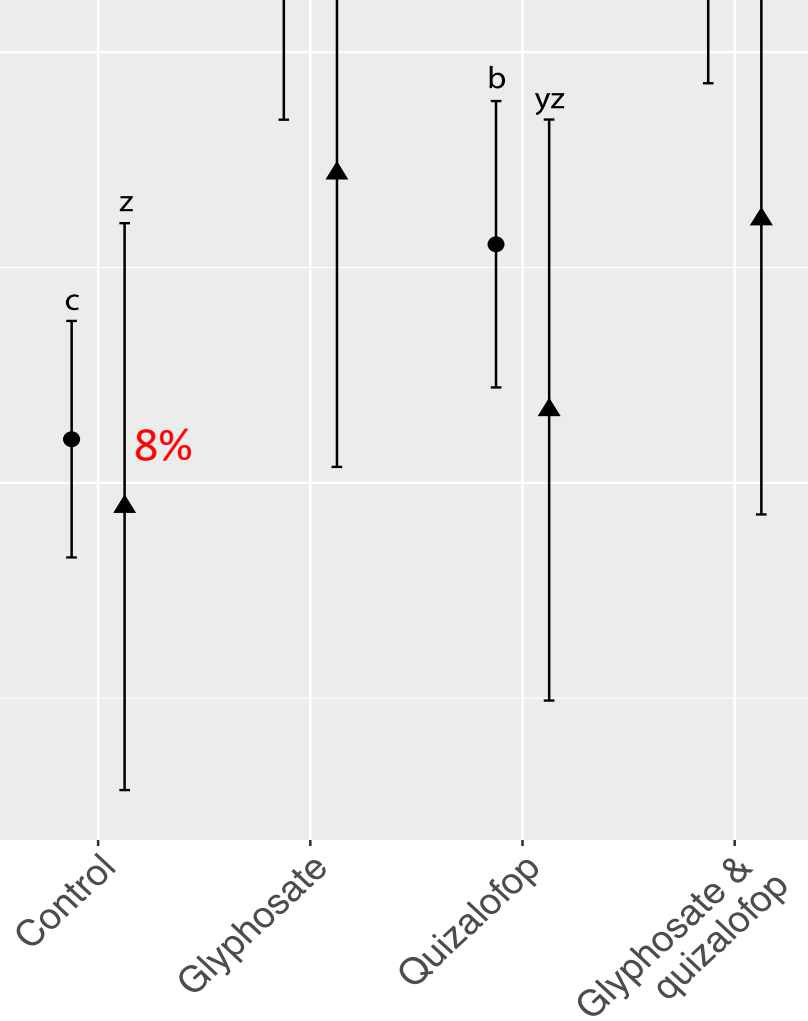
Spring Creek

- 1st summer after application
- ▲ 2nd summer after application

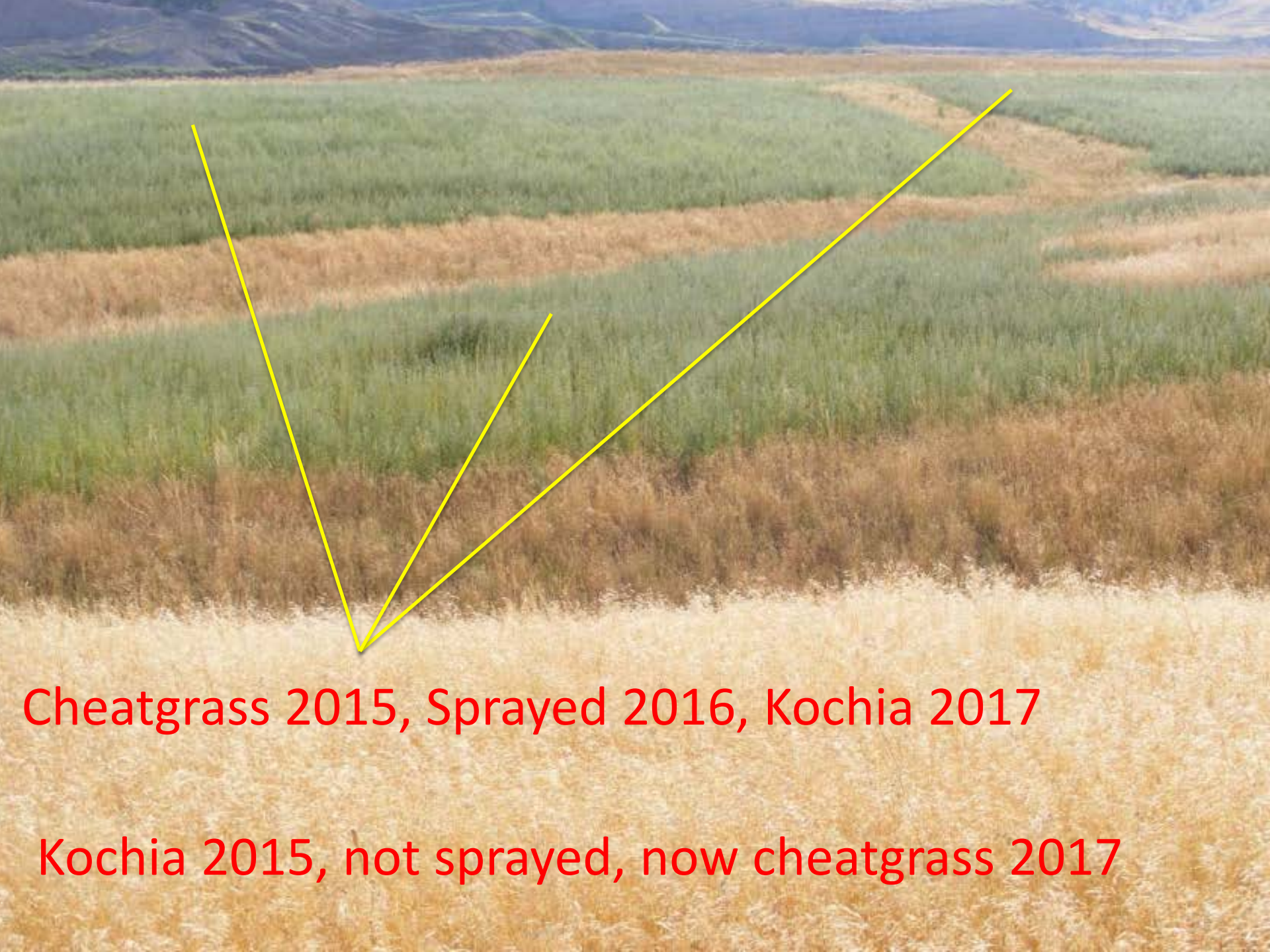
Non Native Forbs: Kochia, Russian Thistle 24%



24%

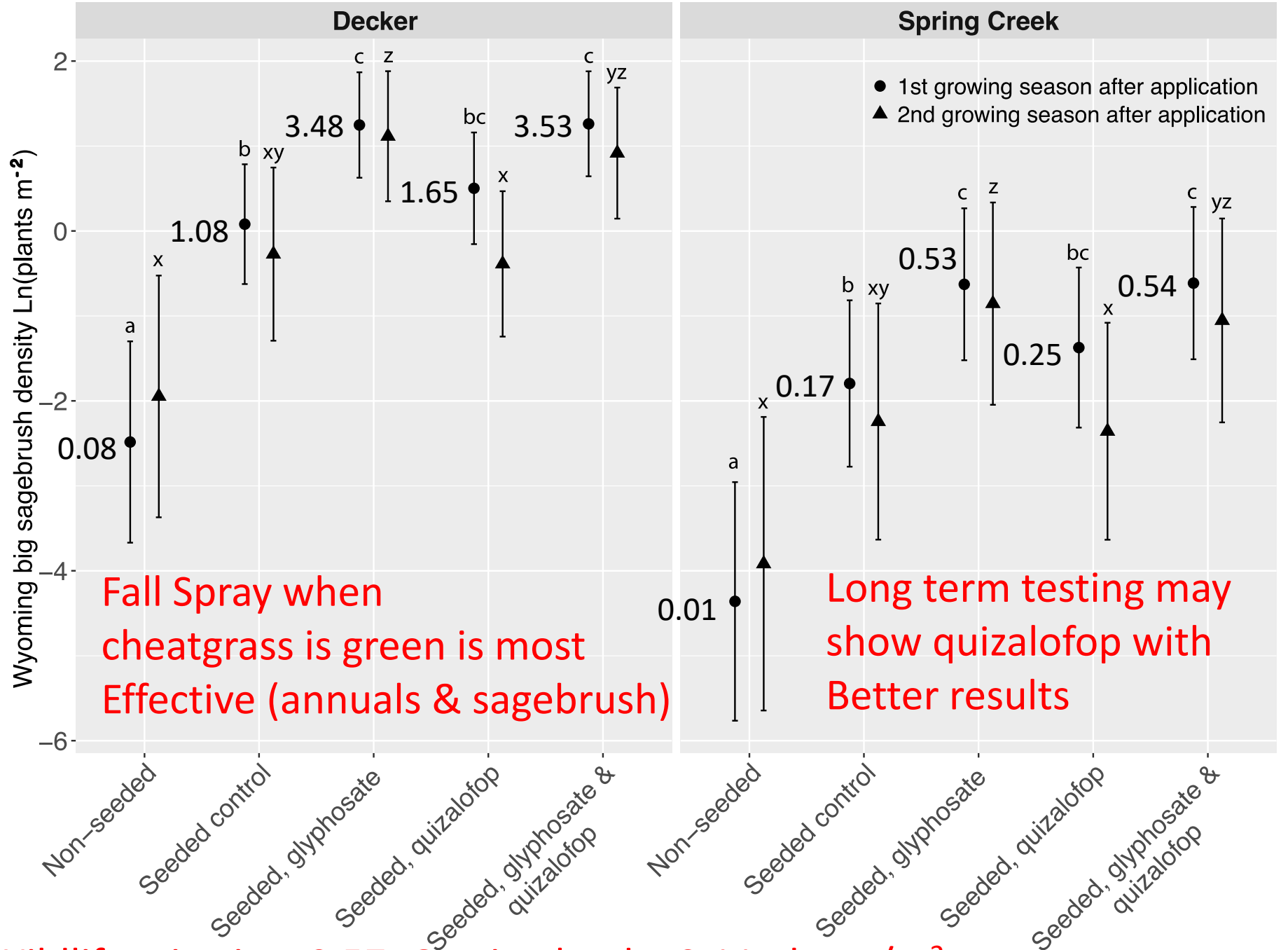


Spraying restarted Kochia Cycle!, 8 to 24% ground cover

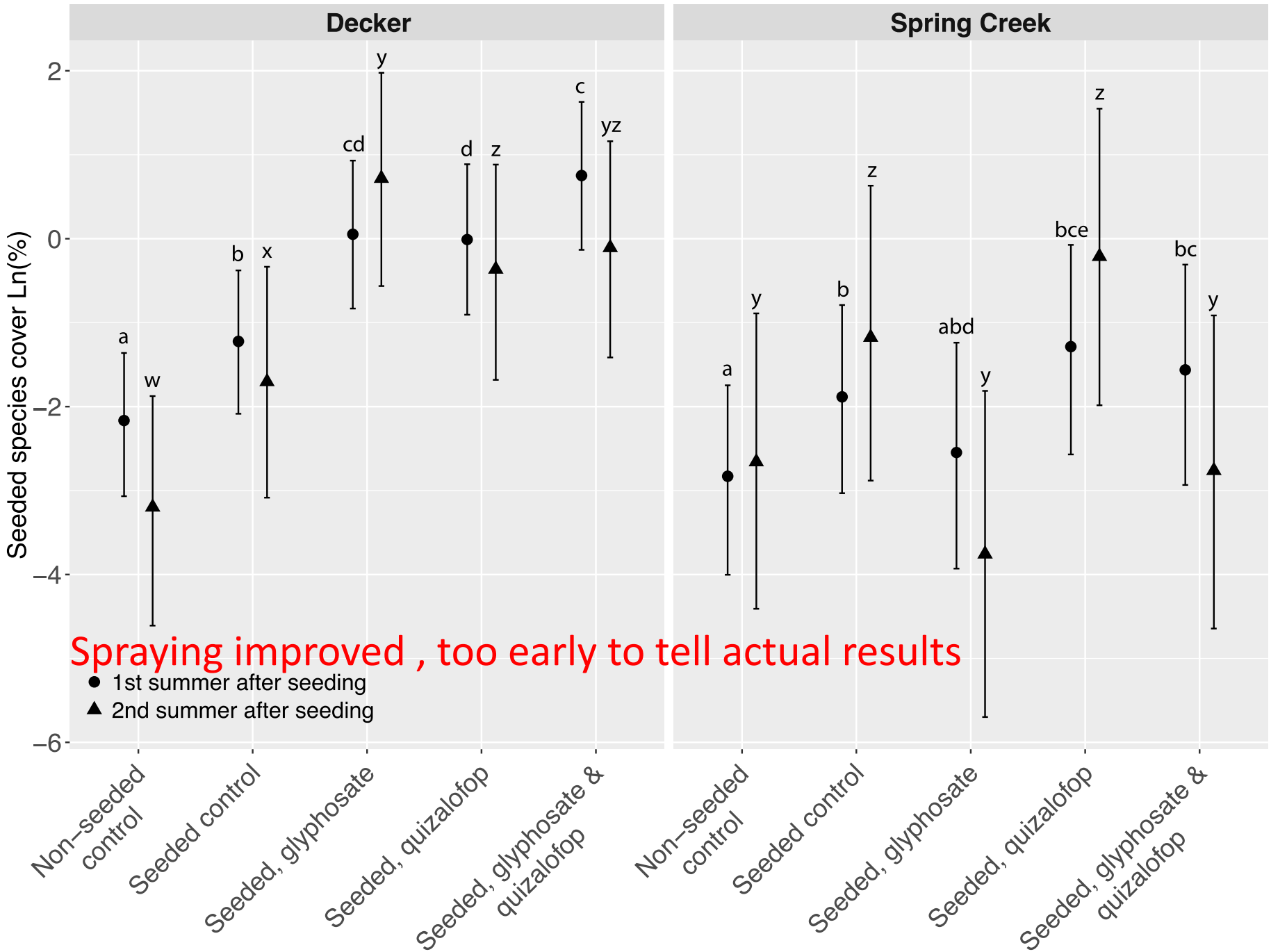


Cheatgrass 2015, Sprayed 2016, Kochia 2017

Kochia 2015, not sprayed, now cheatgrass 2017



Wildlife criteria = 0.57, Grazing land = 0.11 plants/m²





Test Plot Conclusions

- Test Plot herbicide treatments reduced annual brome cover and substantially improved sagebrush establishment (goal accomplished)
- Glyphosate applied in Fall restarted Kochia cycle
- Herbicide retreatment (2014 Exp. Quizalofop 2nd 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

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- Big Horn Env. Rich Producers
- ASMR

