

Establishment of Native and Introduced Grasses

Forage and Range Research Laboratory

- What is the problem?
- What has been done?
- What can we do to fix the problem?

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Geneticist

USDA/ARS

Logan, UT



PLANTS FOR THE WEST



What is the problem?

**Cheatgrass and Medusahead
can take over a landscape and
result in increased wildfires,
loss of soil structure, perennial
plant cover etc.**



**Great Basin (2000) ~ 31.5
million acres infested with
cheatgrass**



Research Challenges



- Low precipitation ~ 7 to 11 inches a year – mostly in the form of snow

- Shallow soils often saline



- Presence of invasive annual weeds (cheatgrass, medusahead, halogeton)

Plant characteristics needed:

1. Establishment
2. Persistence
3. Ability to compete against invasive annual weeds (cheatgrass, medusdahead, halogeton)
4. Defoliation tolerance

Weed Infestation – Following Disturbance





Breeding for Drought Resistance

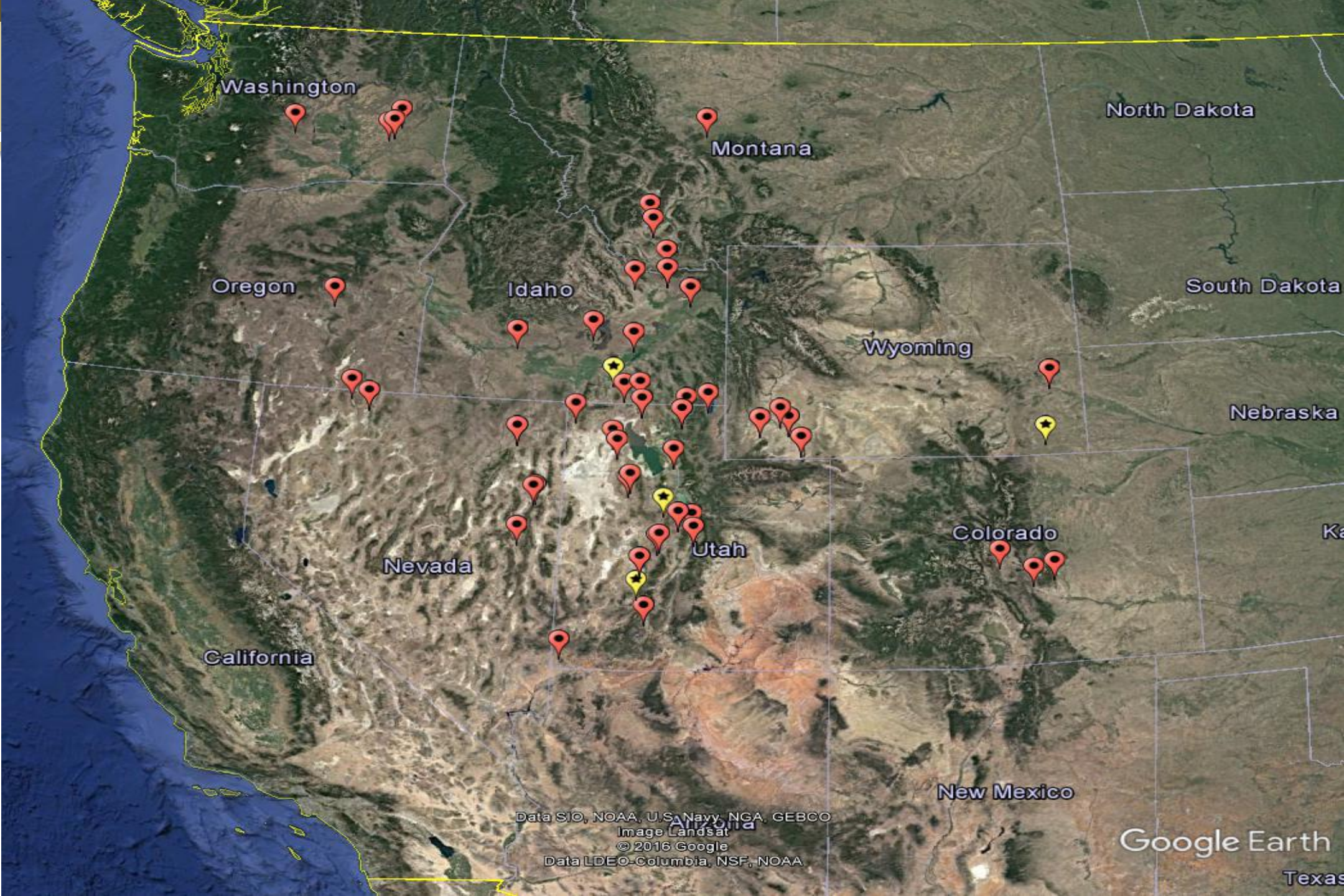
Rapid seedling establishment in early spring when water is available with persistence



Selection for individual lines that germinate and emerge from a deep seeding depth (3 inches).

Ability to out-compete weedy species





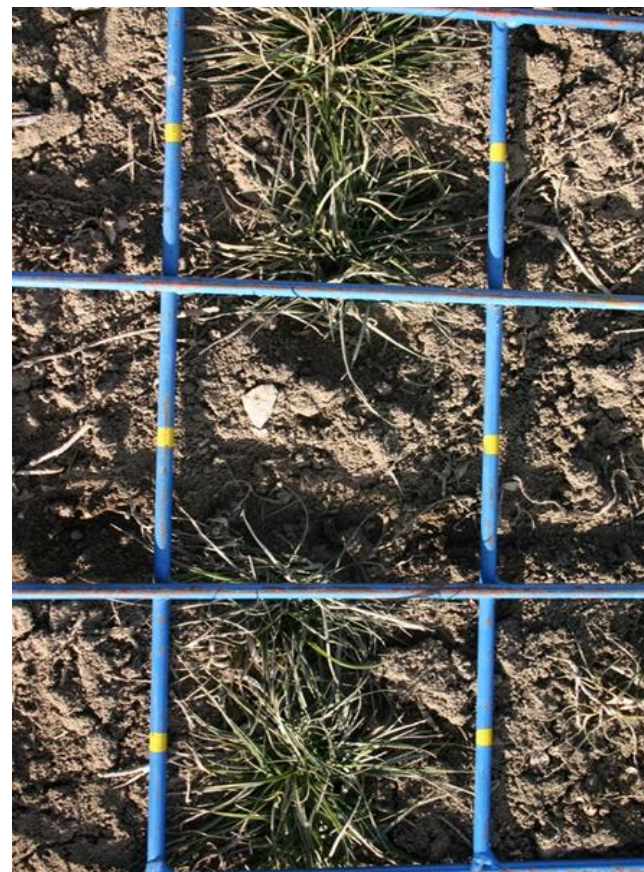
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
© 2016 Google
Data LDEO-Columbia, NSF, NOAA

Google Earth
Texas



Seedling Frequency

X		X		X		X
		X				X
		X				
		X		X		
X						X
X						X
X		X				X
X		X		X		X
X		X				X
X				X		
X				X		
X		X		X		
X		X		X		X
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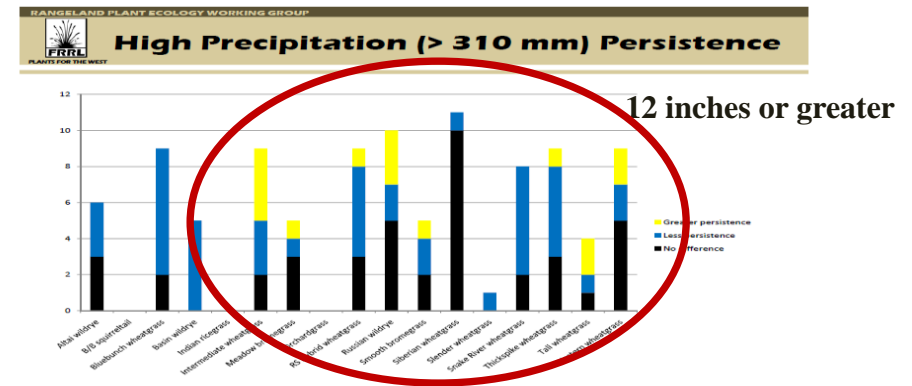




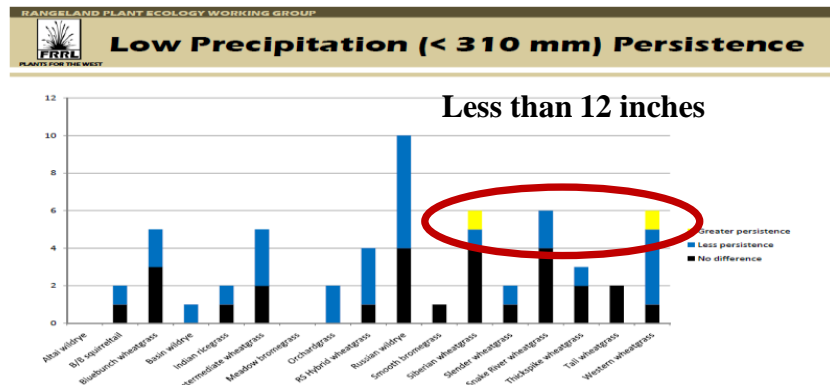
What did we learn?

- Annual precipitation is most critical.

- Amount of available water (when)
- Soil Type (Loam, Clay, Sand)
- Summer Temperatures
- Winter Temperatures
- Snow Depth



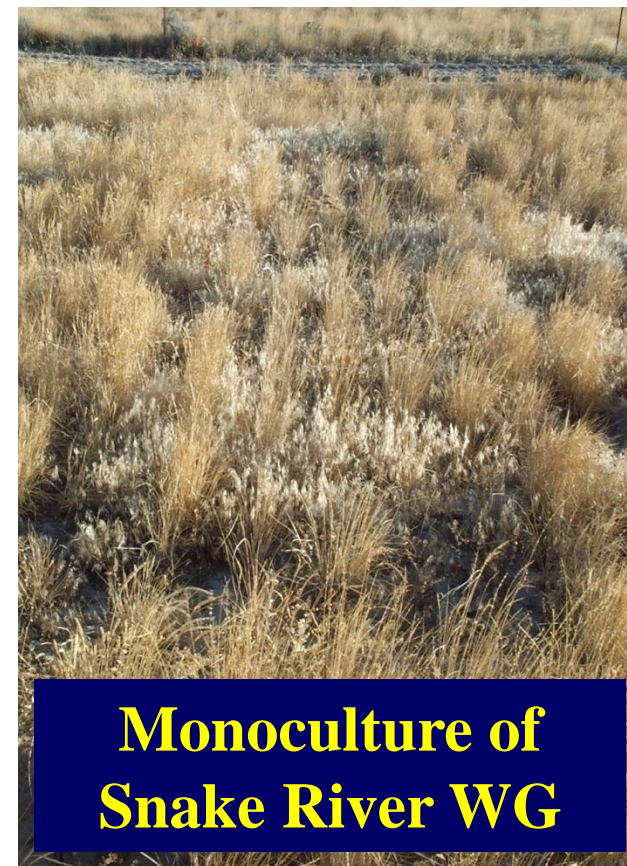
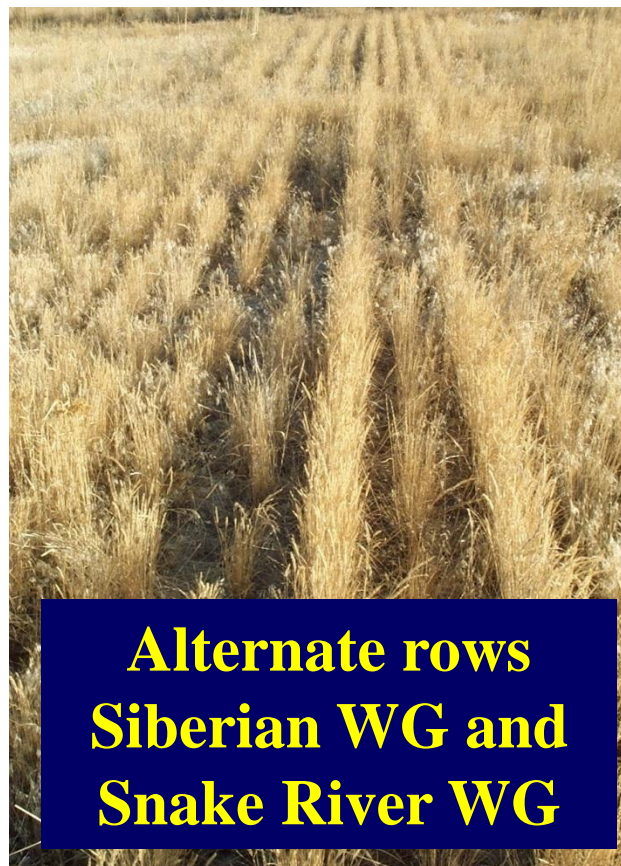
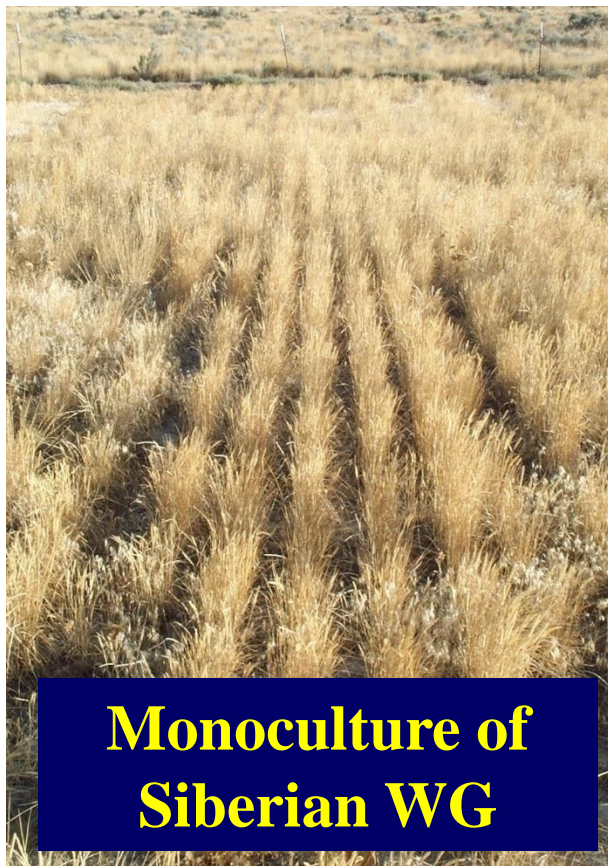
Est. 1989 - 21 Years Later





Siberian Wheatgrass cont.

Siberian wheatgrass is one of a few grasses that can compete with difficult to control weedy annuals such as cheatgrass and halogeton in arid environments.





Percent cheatgrass in establishment-study plots at Yakima Training Center in 2000

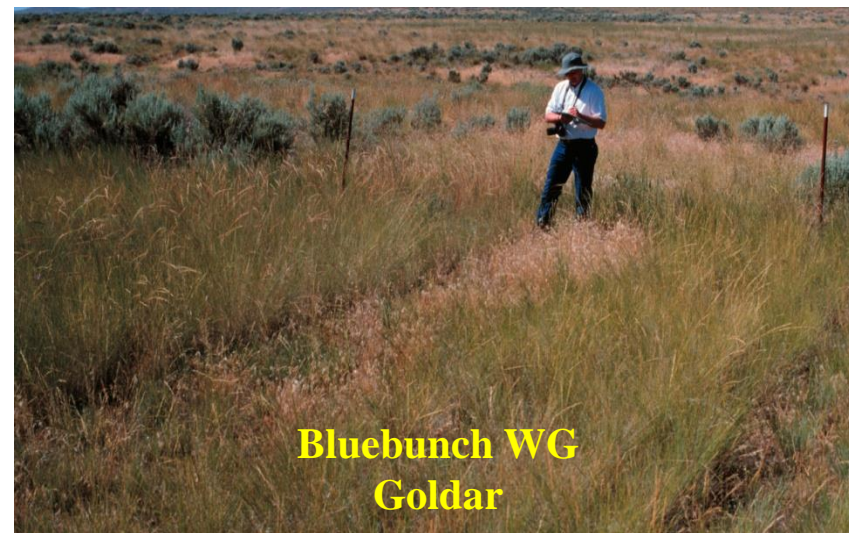
(two years after establishment)

Grasses	Row Spacing		Mean
	25 cm	35 cm	
Bluebunch wheatgrass	53	65	59
Snake River wheatgrass	35	78	57
Vavilov Siberian wheatgrass	7	30	19
Bluebunch/Snake River Mix	57	70	64
Bluebunch/Snake River Alternating Rows	30	52	41
Bluebunch/Vavilov Mix	17	47	32
Bluebunch/Vavilov Alternating Rows	30	52	41
Snake River/Vavilov Mix	25	48	36
Snake River/Vavilov Alternating Rows	25	48	36
Bluebunch/Snake River/Vavilov Mix	16	50	33
Mean	32	56	44
LSD (0.05)	23	19	15



What is our challenge?

Can we improve native grasses, legumes, and forbs to be more competitive with invasive annuals such as cheatgrass and medusahead?

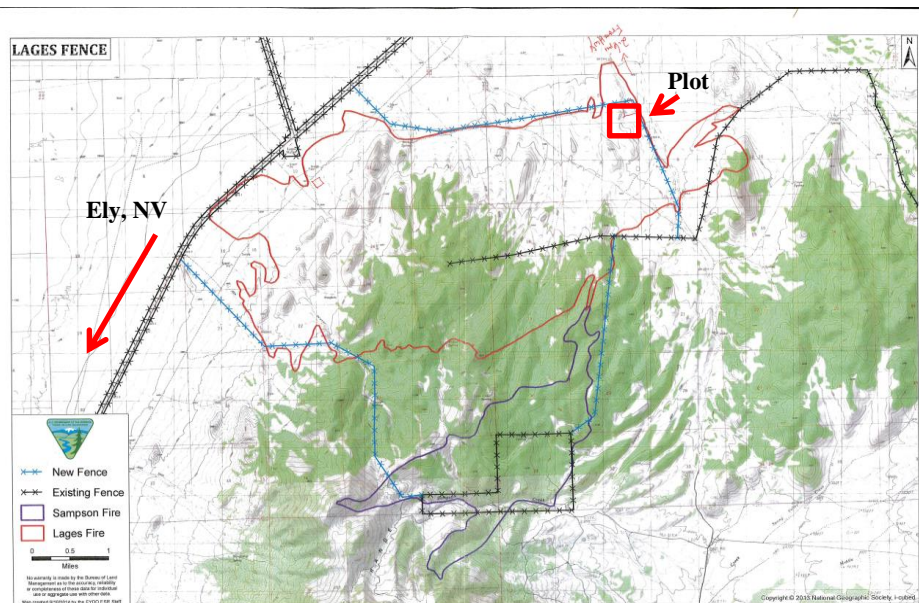




Ely_Fire Seeding Study

Background Information

- Fire burned through area summer of 2015
- Planted November of 2015 – no land prep





Ely_Fire Seeding Study

Small Plot Study – 664 plots – 5ft x 20 ft – 8 replications

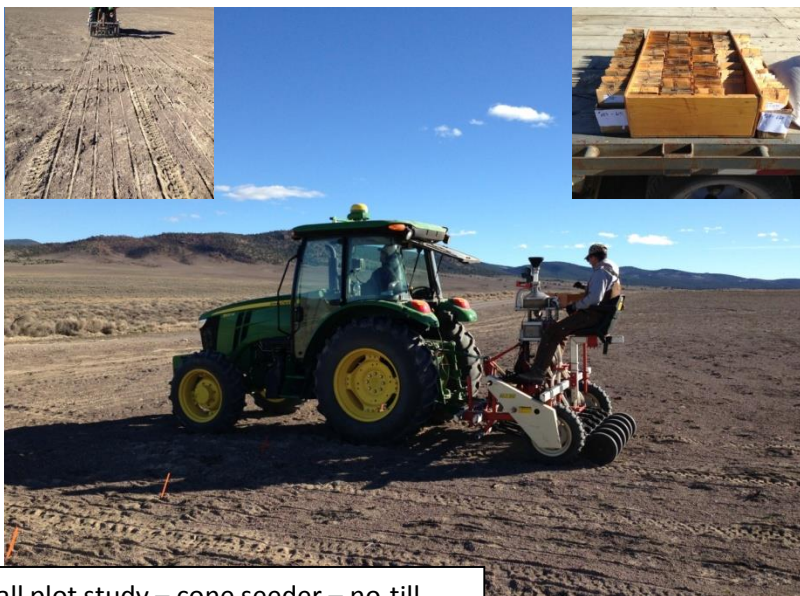
Compare currently used native grasses, legumes, and forbs used for rangeland reseeding with improved native plant materials from the FRR and others (NRCS, BLM etc.) for establishment and competition against invasive annual.

Grasses

- Thickspike wheatgrass (4)
- Bluebunch wheatgrass (10)
- Western wheatgrass (2)
- Slender wheatgrass (3)
- Snake River wheatgrass (5)
- Basin wildrye (8)
- Bottlebrush squirreltail (7)
- Indian ricegrass (3)
- Muttongrass (1)
- Fine fescues (4)
- Sand dropseed (1)
- Bluegrasses (7)
- Russian wildrye (1)
- Crested wheatgrass (3)
- Siberian wheatgrass (3)
- Intermediate wheatgrass (2)
- Tall wheatgrass (2)
- Meadow brome (2)

Legumes

- Small burnett (3)
- Flax (2)
- Cicer milkvetch (2)
- Basalt milkvetch (2)
- Bee plant (1)
- Alfalfa (4)
- Western prairie clover (2)
- Searls' prairie clover (2)
- Globemallow (3)
- Showy goldeneye (1)
- Yarrow (1)
- Black sage (1)
- Wyoming big sage (1)



Small plot study – cone seeder – no-till





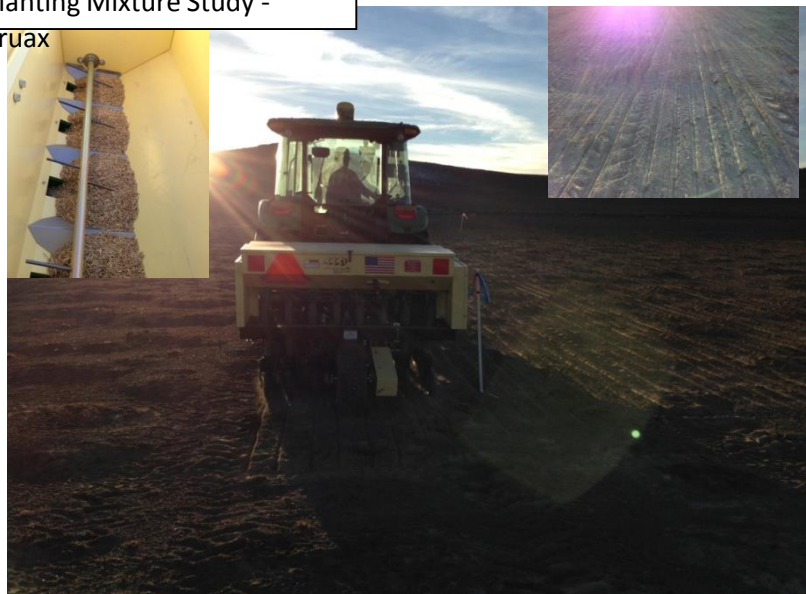
Ely_Fire Seeding Study

Large Plot Study – 40 plots – 20ft x 80 ft – 4 replications

Using the standard Ely BLM native mix, what is the effect on native plant establishment and competition against invasive annual by adding different amounts of Siberian wheatgrass to the mix ? (0, 10, 20, 30, ... 100%)

Planting Mixture Study -

Truax

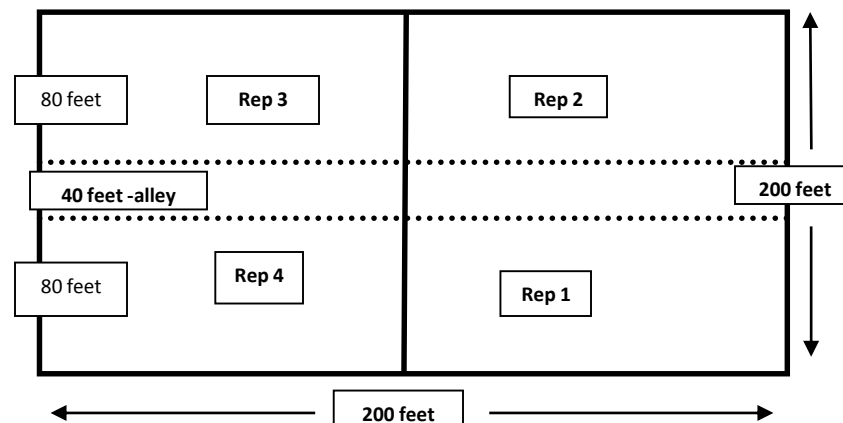


Native seed mix:

- Sandberg bluegrass - VNS
- Needleandthreadgrass - VNS
- Sand dropseed - VNS
- Globemallow - VNS
- Lewis flax - VNS
- Yarrow - VNS
- Wyoming big sage -VNS
- Indian ricegrass – White River
- Bluebunch wheatgrass – Anatone
- Thickspike wheatgrass – Bannock II
- Western wheatgrass – Recovery
- Slender wheatgrass – FirstStrike
- Snake River wheatgrass - Discovery

Treatments:

1. 100% Native Mix (BLM) – 10 lbs acre
2. 90% Mix + 90% (~1lb acre) Siberian WG
3. 80% Mix + 20% (~2lbs acre) Siberian WG
4. 70% Mix + 30% (~3lbs acre) Siberian WG
5. 60% Mix + 40% (~4lbs acre) Siberian WG
6. 50% Mix + 50% (~5lbs acre) Siberian WG
7. 30% Mix + 70% (~7lbs acre) Siberian WG
8. 10% Mix + 90% (~9lbs acre) Siberian WG
9. 100% (~10lbs acre) Siberian WG
10. Control – nothing planted





Ely_Fire Seeding Study

Small Plot Study – Establishment - 2015

Grasses

Species	% Plant frequency 2015	% Plant frequency 2016
Russian wildrye	81	58
Needle and Threadgrass	58	4
Thickspike wheatgrass	55	31
Intermediate wheatgrass	50	47
Tall wheatgrass	50	34
Siberian wheatgrass	46	49
Bluebunch wheatgrass	45	38
Meadow brome	43	23
Western wheatgrass	42	15
Slender wheatgrass	34	18
Crested wheatgrass	33	39
Snake River wheatgrass	32	34
Basin wildrye	30	24
Bottlebrush Squiraltail	27	22
Indian ricegrass	10	2
Muttongrass	2	0
Fine fescues	1	5
Sand-dropseed	1	0
Bluegrasses	1	11

Legumes

Species	% Plant frequency 2015	% Plant frequency 2016
Small burnett	73	31
Flax	60	67
Cicer milkvetch	60	47
Bee plant	56	6
Alfalfa	53	42
Western prairie clover	46	15
Searls' prairie clover	39	31
Sunflower	38	0
Astragalus fillipes	18	11
Globemallow	16	11
Showy goldeneye	16	1
Yarrow	1	4
Black sage	0	0
Wyoming bigsage	0	0



Bozoisky II – Russian WR



Delar Small burnett



Ely_Fire Seeding Study

Small Plot Study – Establishment - 2015

Thickspike wheatgrass	% Plant frequency 2015	% Plant frequency 2016
Bannock II	78*	55*
Bannock	58	24
Critana	42	24
Schwendimar	41	21

Western wheatgrass	% Plant frequency 2015	% Plant frequency 2016
Recovery	50*	17
Arriba	34	18

Slender wheatgrass	% Plant frequency 2015	% Plant frequency 2016
FirstStrike	55*	19
Pryor	49	32
San Luis	0	4





Ely_Fire Seeding Study

Small Plot Study – Establishment – 2015 - Surprises

Meadow bromegrass	% Plant frequency 2015	% Plant frequency 2016
Cache	44	18
Arsenal	42	28*

Intermediate wheatgrass	% Plant frequency 2015	% Plant frequency 2016
AI	59*	64*
Oahe	41	31

Crested wheatgrass	% Plant frequency 2015	% Plant frequency 2016
Hycrest II	38	46*
HxB28	34	36
Hycrest	28	37





Ely_Fire Seeding Study

Small Plot Study – Establishment – 2015

Flax	% Plant frequency 2015	% Plant frequency 2016
Lewis	67	60
Blue	54	73



Alfalfa	% Plant frequency 2015	% Plant frequency 2016
Don	64	64*
BB2014	52	34
K&H2014	49	36
Vernal	47	35



Globemallow	% Plant frequency 2015	% Plant frequency 2016
VNS	29*	15*
Gooseberry	18	19*
Scarlett	2	3





Ely_Fire Seeding Study

Small Plot Study – Establishment – 2015 - Surprises

Western prairie clover	% Plant frequency 2015	% Plant frequency 2016
DO_Acid	71*	50*
DO-no acid	26	15

Basalt milkvetch	% Plant frequency 2015	% Plant frequency 2016
AF_acid	27*	18
AF_no acid	10	4





Ely_Fire Seeding Study

Large Plot Study – Establishment

Mixtures	Grass	Globemallow	Flax	Yarrow
100_Native_Mix	31	2.8	18	1.8
90_Native_Mix	27	2	19	0.8
80_Native_Mix	39	1.8	17	1.2
70_Native_Mix	27	1.5	16	3.3
60_Native_Mix	32	2	17	0.8
50_Native_Mix	35	1.3	19	0.5
30_Native_Mix	35	0.5	17	1.0
10_Native_Mix	30	0	7	2.0
100_Siberian_WG	30	0	9	0.8
Control	2	0	3	1.3





Four Location Study





Study Locations

Location	Year Planted	County	ST	El. (m)	Precip. (mm)	Soil Type	Ecoregion Level IV
Beaver	2006	Beaver	UT	1981	365	Murdock Silt Loam, 1 -3% slopes	Woodland- and Shrub-Covered Low Mountains
Cheyenne	2009	Laramie	WY	1901	397	Altvan loam, 0 to 6 percent slopes	Moderate Relief Rangeland
Malta	2004	Cassia	ID	1481	292	Declo Silt Loam, 1-3% Slope	Saltbush-Dominated Valleys
Tintic	2009	Juab	UT	1789	415	Doyce Silt Loam, 2-4% Slope	Sagebrush Basins and Slopes

Elevation, google earth, <https://earth.google.com/>

Precipitation, Prism Climate Group, <http://prism.oregonstate.edu>

Soil type, USDA-NRCS, websoilsurvey.nrcs.usda.gov/app/

Ecoregions U. S. EPA, http://archive.epa.gov/wed/ecoregions/web/html/level_iii_iv-2.html



Research Objectives

- Examine species ability to establish under a range of climatic conditions and locations
- Look at trends in plant persistence over time
- Compare biomass production as an indicator of stand vigor
- Verify performance of cultivars or germplasms within species





Plant Materials

Indian Ricegrass

Crested Wheatgrass

Siberian Wheatgrass

Meadow Brome

Smooth Brome

Bottlebrush Squirreltail

Thickspike Wheatgrass

Slender Wheatgrass

Snake River Wheatgrass

Basin Wildrye

Western Wheatgrass

Russian Wildrye

Bluebunch Wheatgrass

Intermediate Wheatgrass

Achnatherum hymenoides

Agropyron cristatum

Agropyron fragile

Bromus riparius

Bromus inermis

Elymus elymoides

Elymus lanceolatus

Elymus trachycaulus

Elymus wawawaiensis

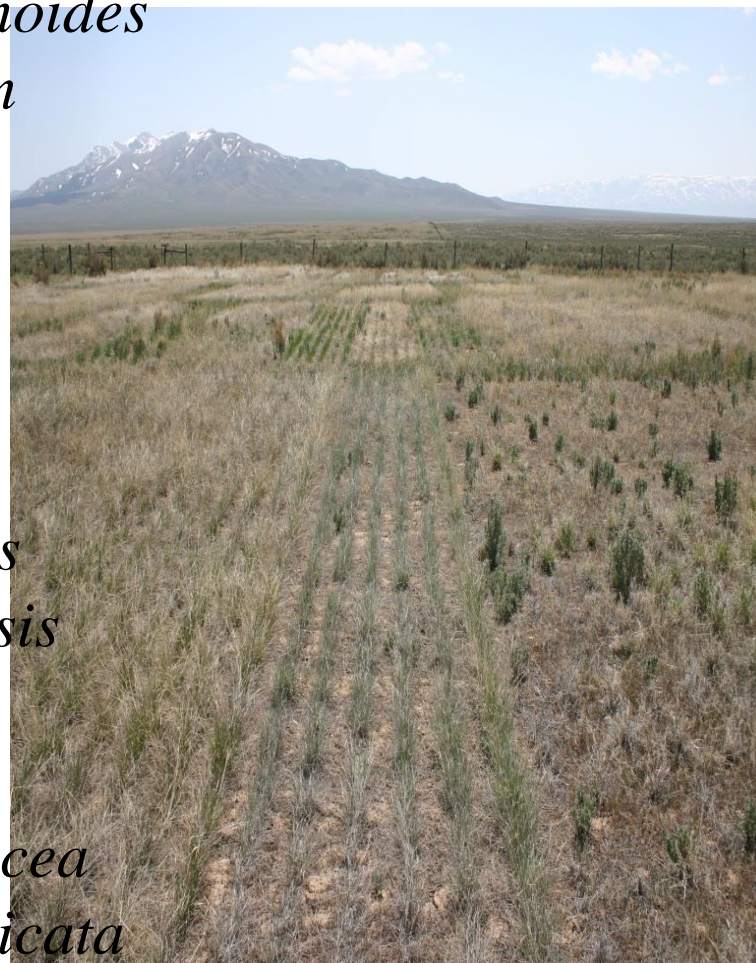
Leymus cinereus

Pascopyrum smithii

Psathyrostachys juncea

Psuedoroegneria spicata

Thinopyrum intermedium





Plots were tilled and prepared prior to planting

All locations were planted with a Hege 1000 cone seeder 6 rows at 10" spacing

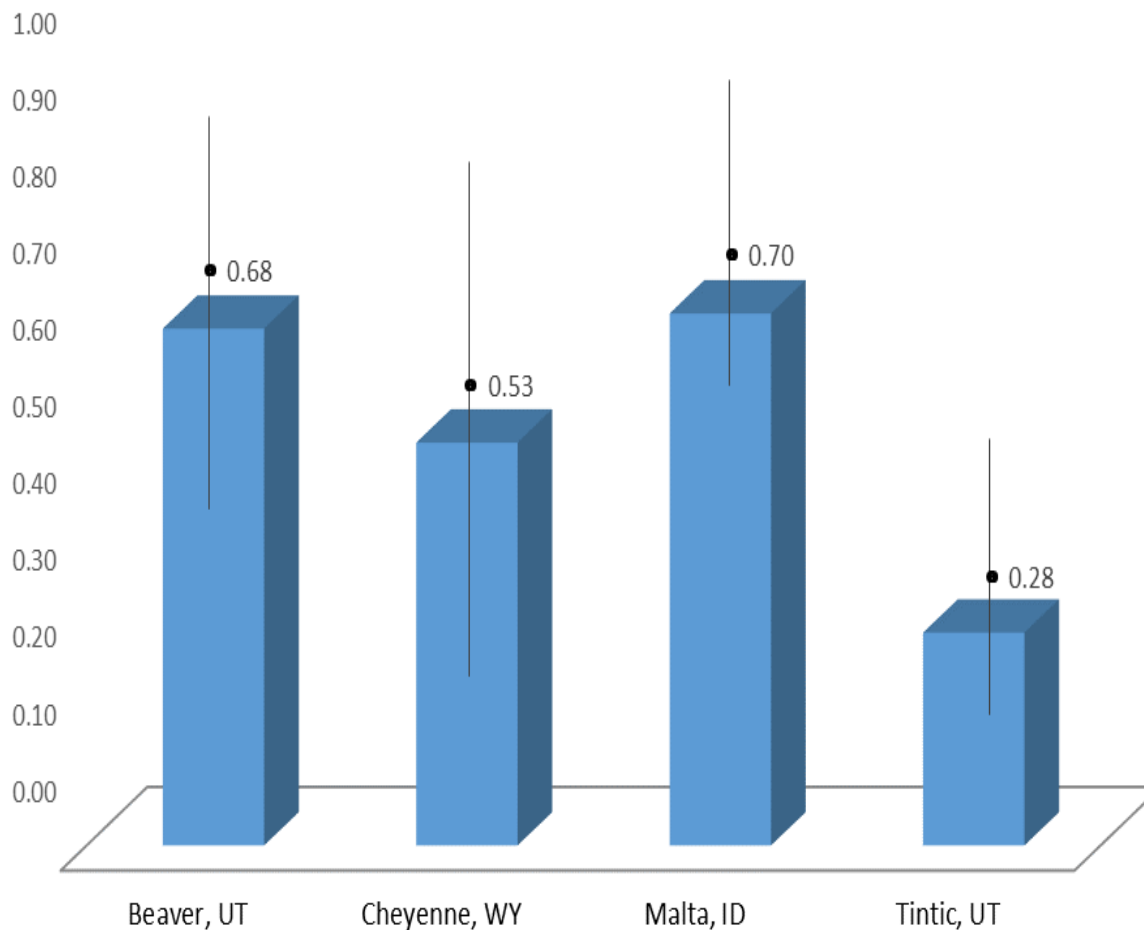
Locations were planted as a fall dormant planting

All entries planted at 1 pure live seed cm^{-1} (32 PLS/ ft^2)

Plots are randomized complete block design with 4 replications



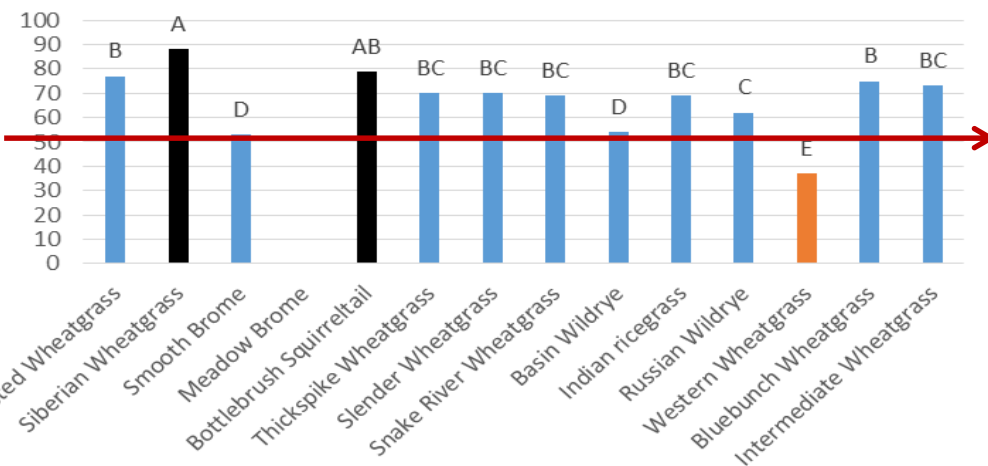
Establishment by Location All Entries



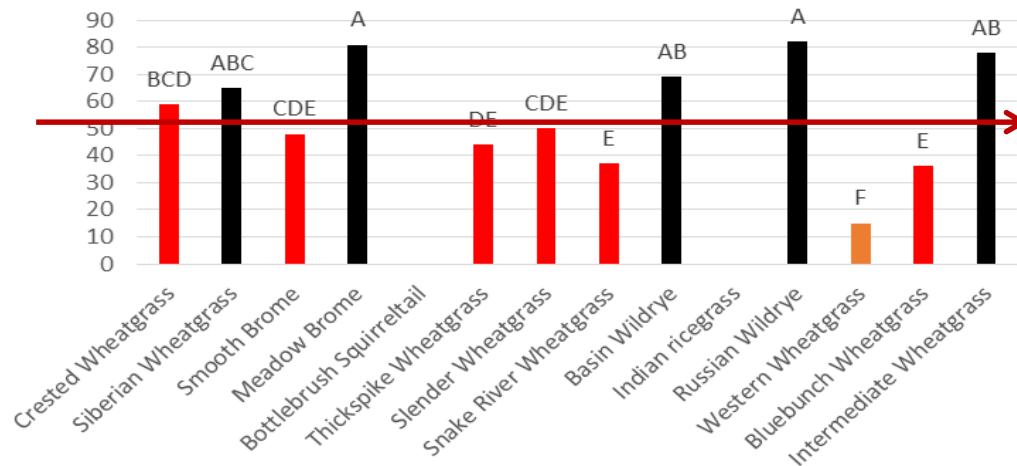


Seedling Frequency Year One

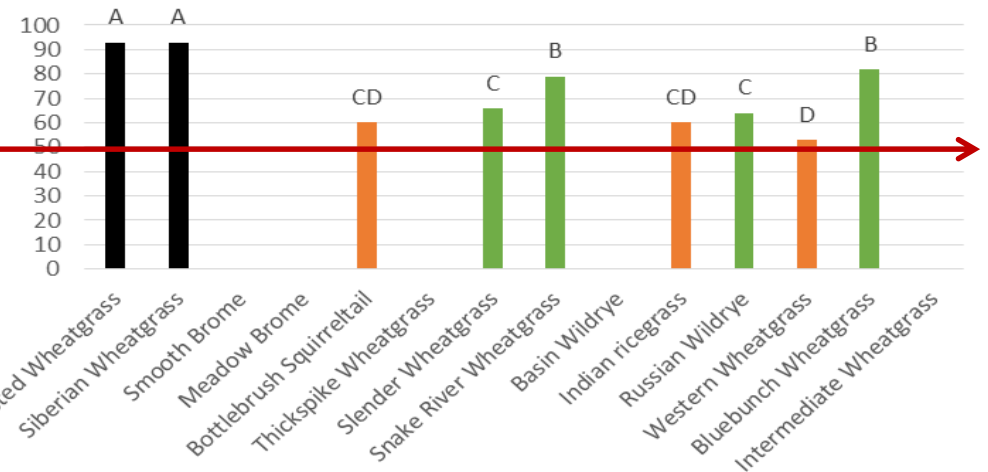
Beaver Seedling Frequency



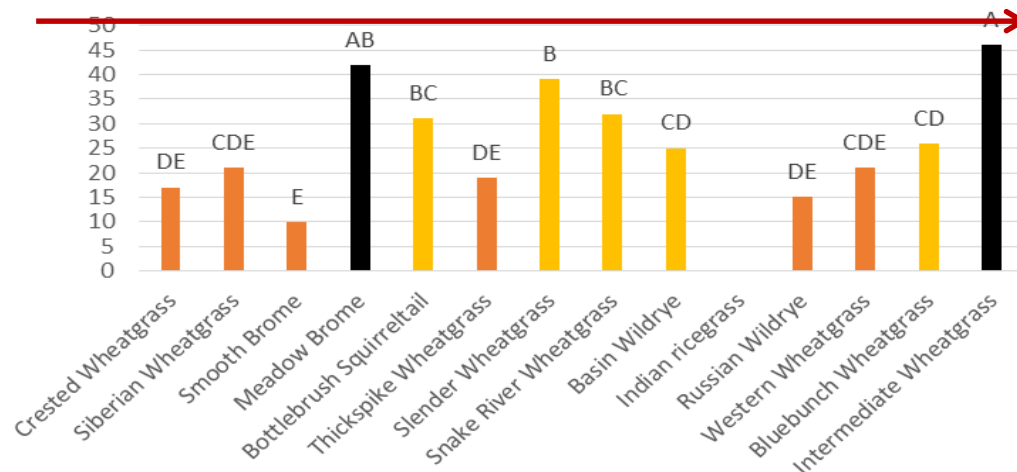
Cheyenne Seedling Frequency



Malta Seedling Frequency

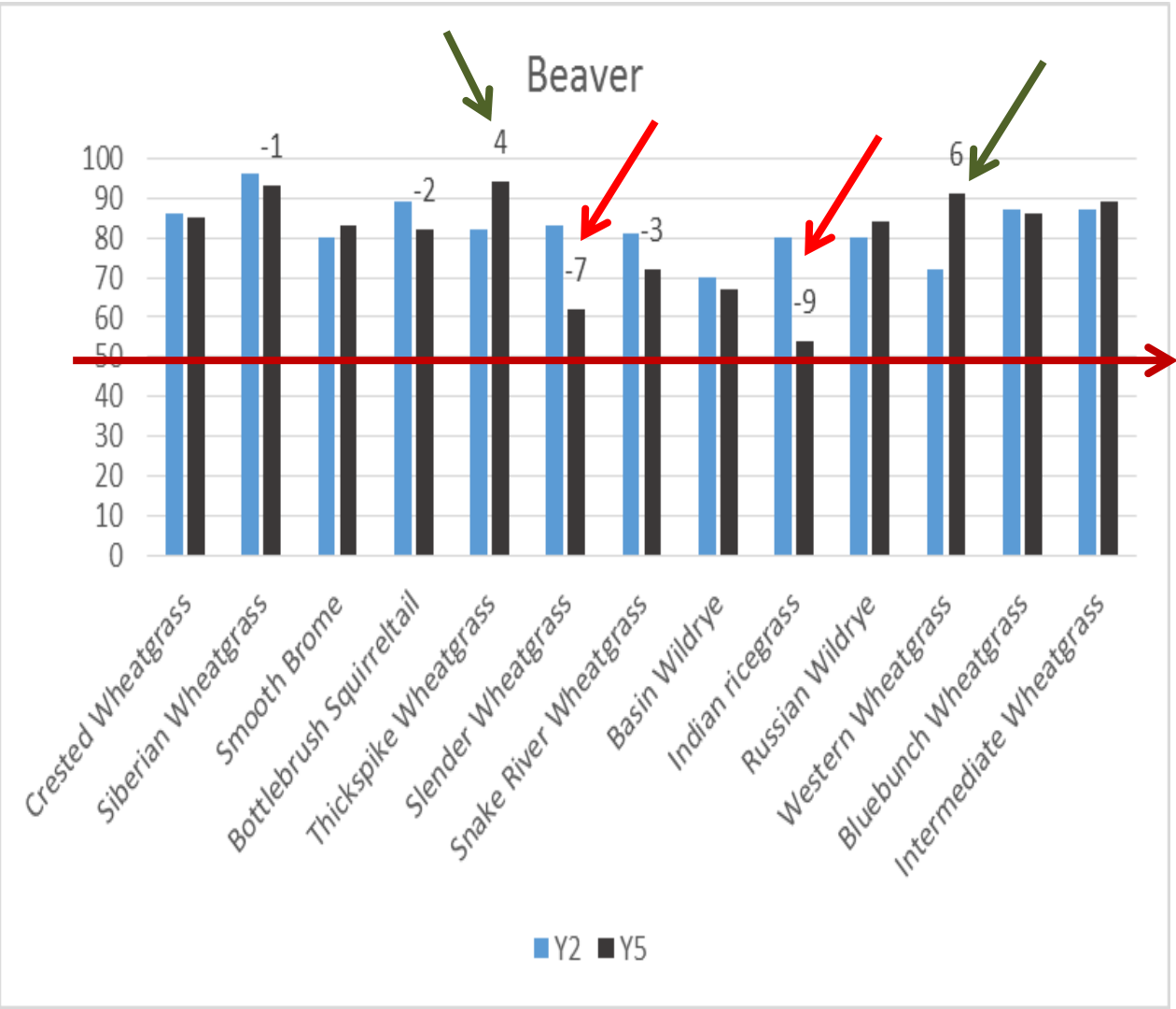


Tintic Seedling Frequency





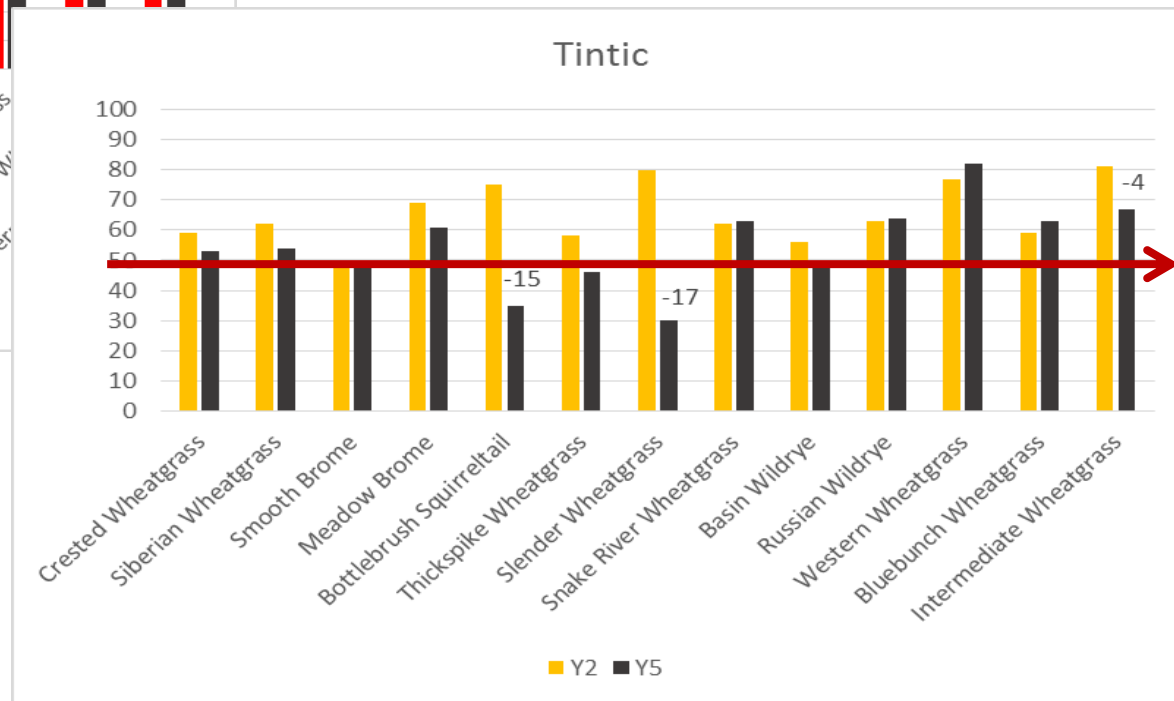
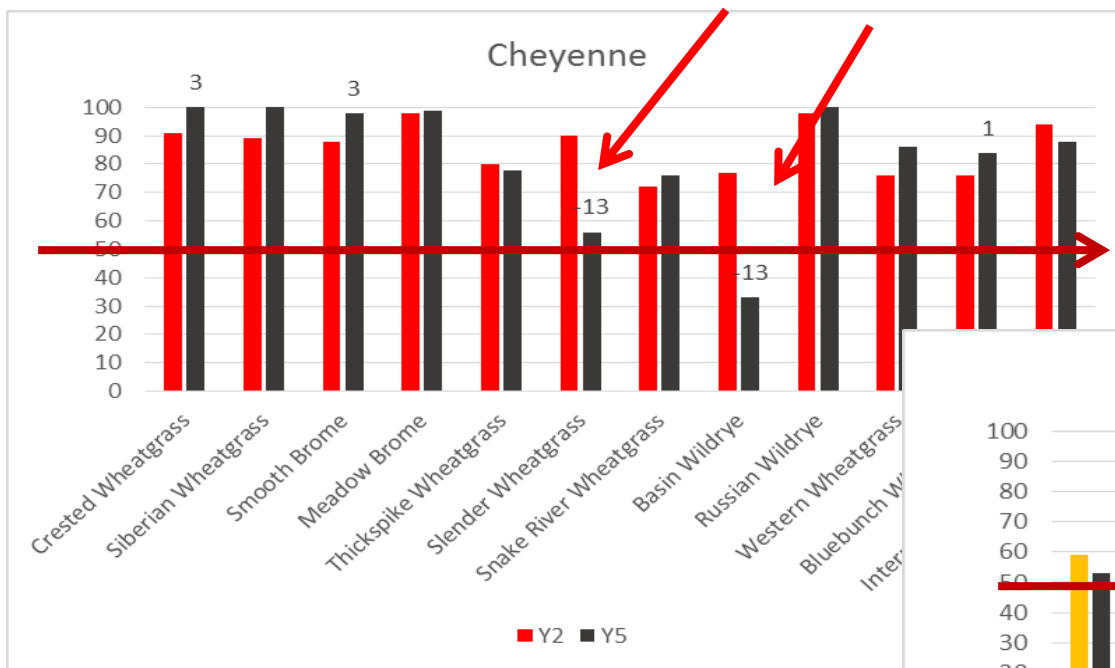
Year Two to Year Five Trends in Persistence



Numbers indicate significant linear trends

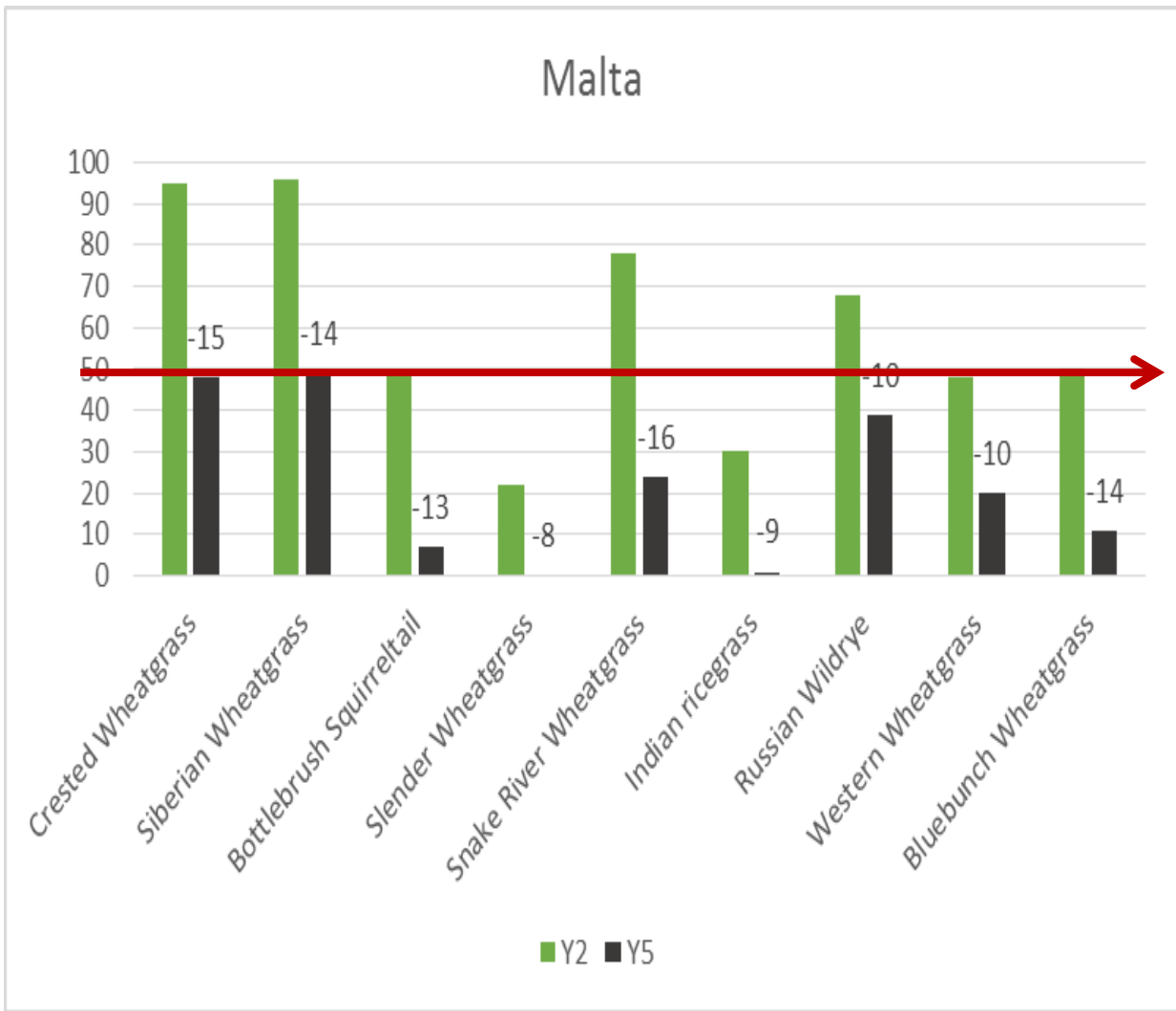


Year Two to Year Five Trends in Persistence



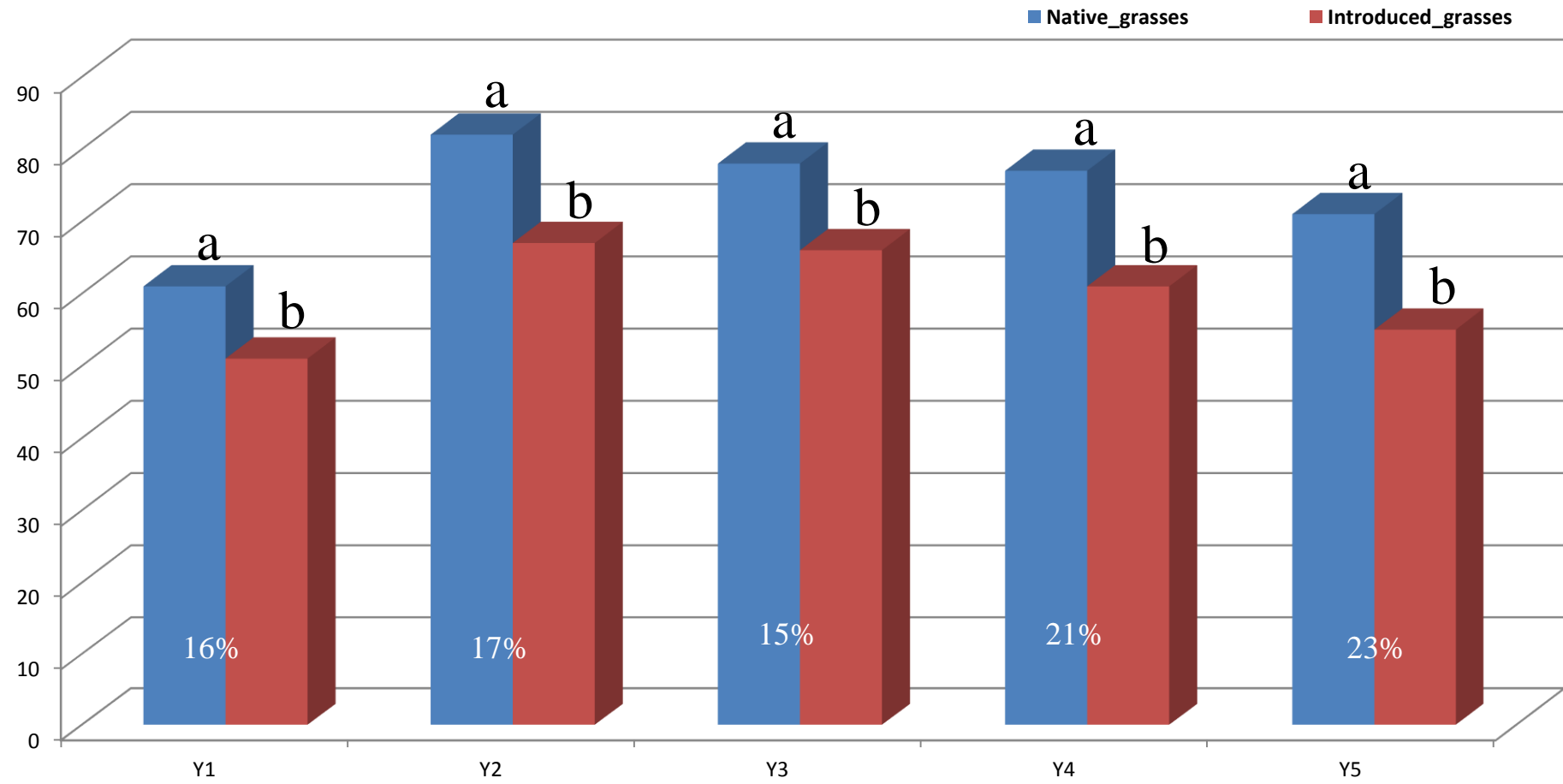


Year Two to Year Five Trends in Persistence





Introduced vs Native Grasses





Bluebunch Wheatgrass P7

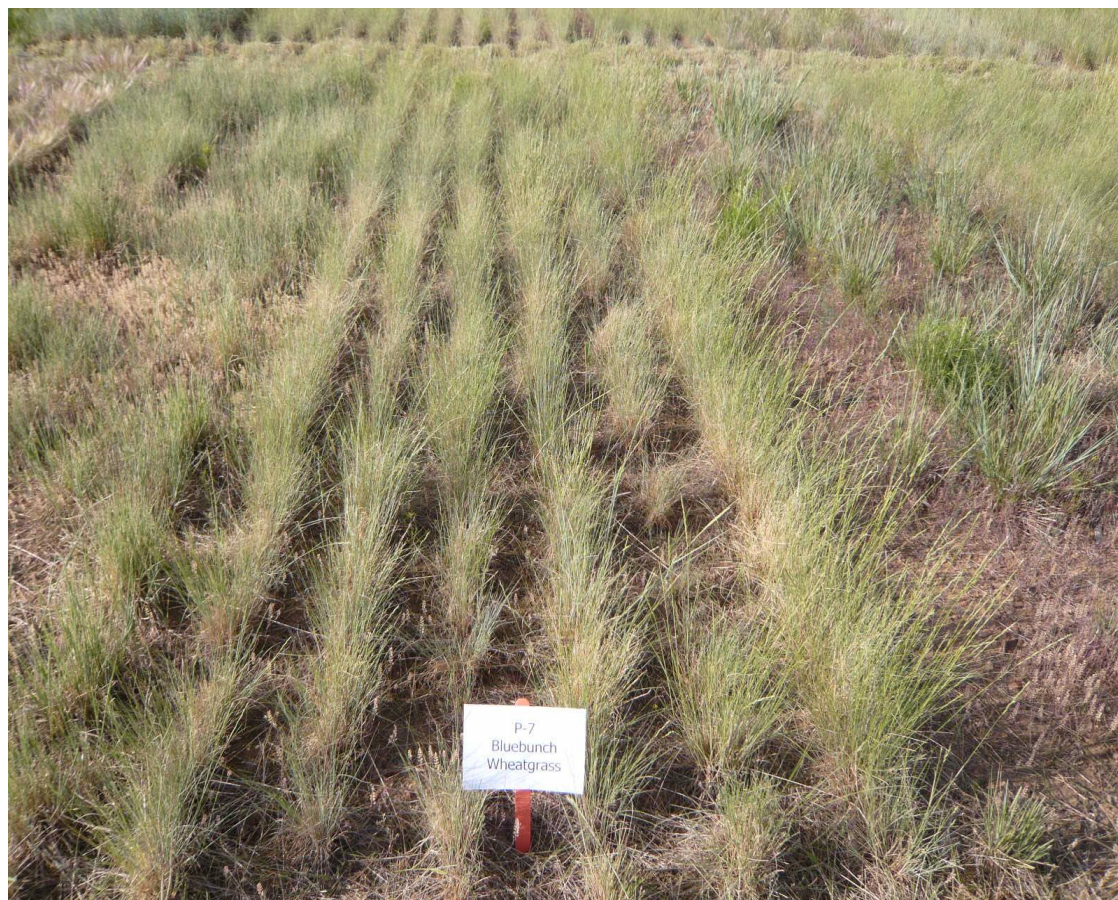
Multi Origin Germplasm

25 - lines

UT, ID, WA, OR,
NV, MT, and British
Columbia

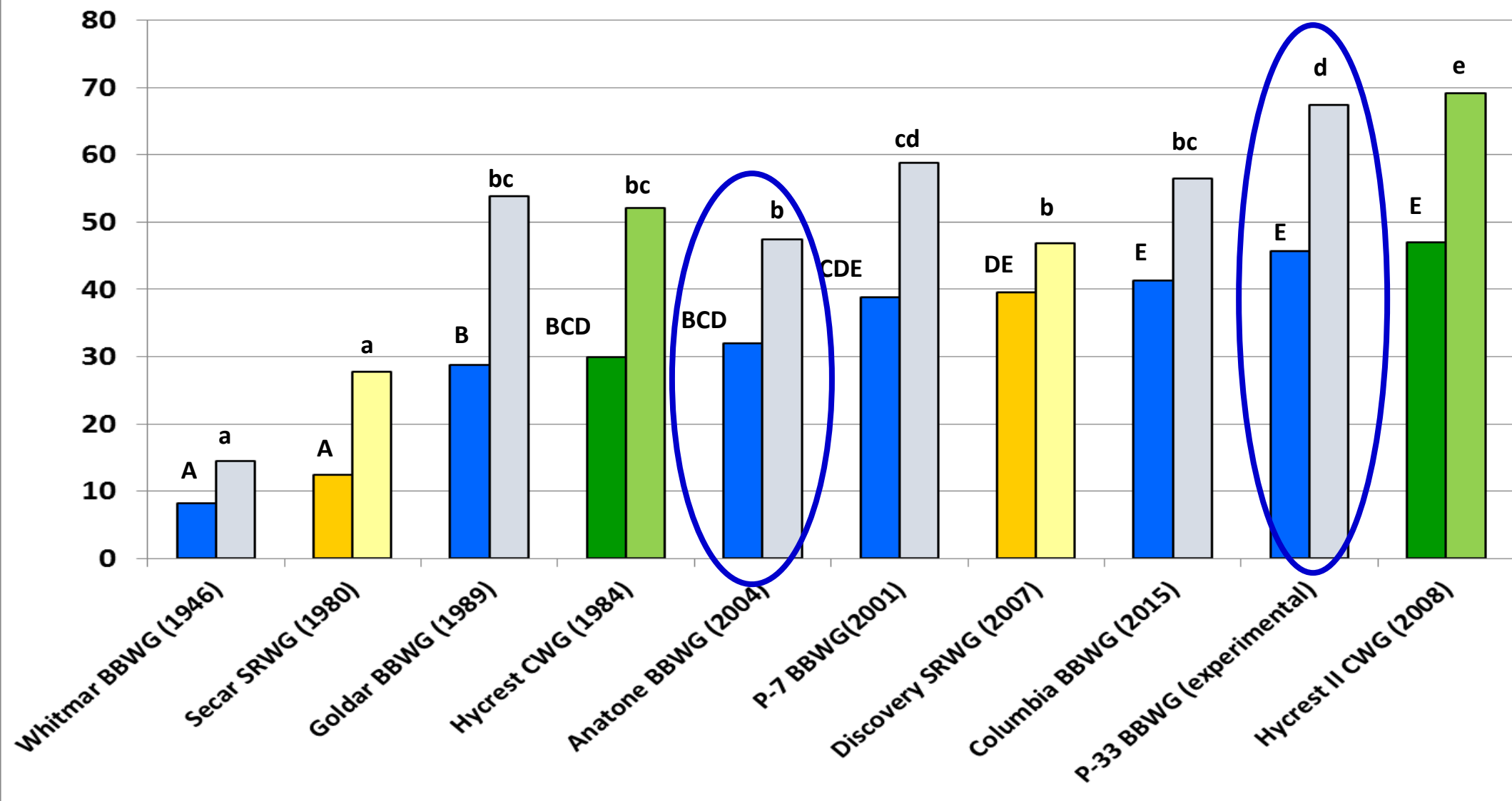
Wider genetic base – adapted to
a wider range of
environments

Foundation Seed Available



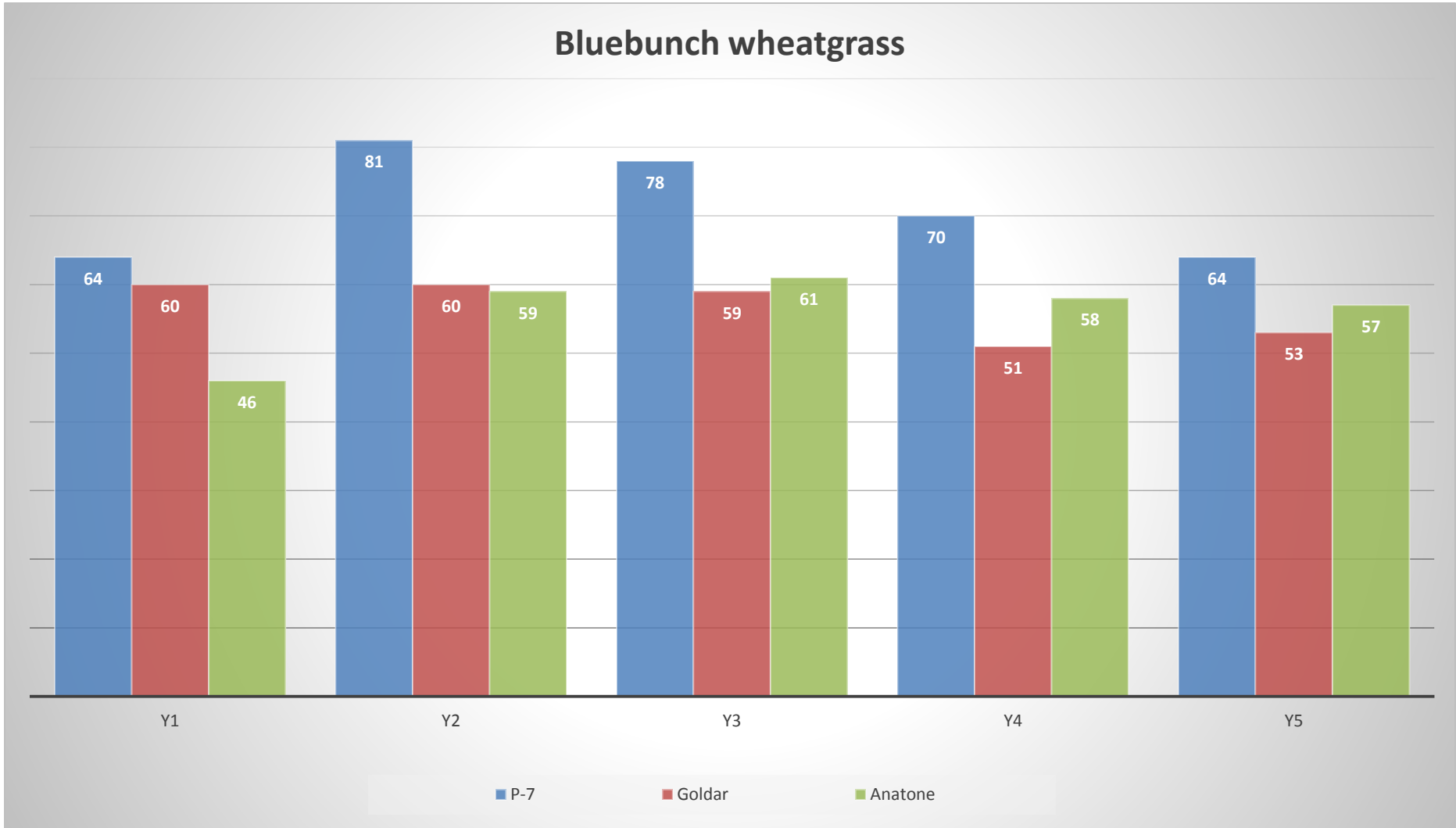


Seedling frequency on May 30, 2013 and April 3, 2014 in a dormant seeding planted November 6, 2012 at Nephi, Utah





Bluebunch Wheatgrass – Four Loc.

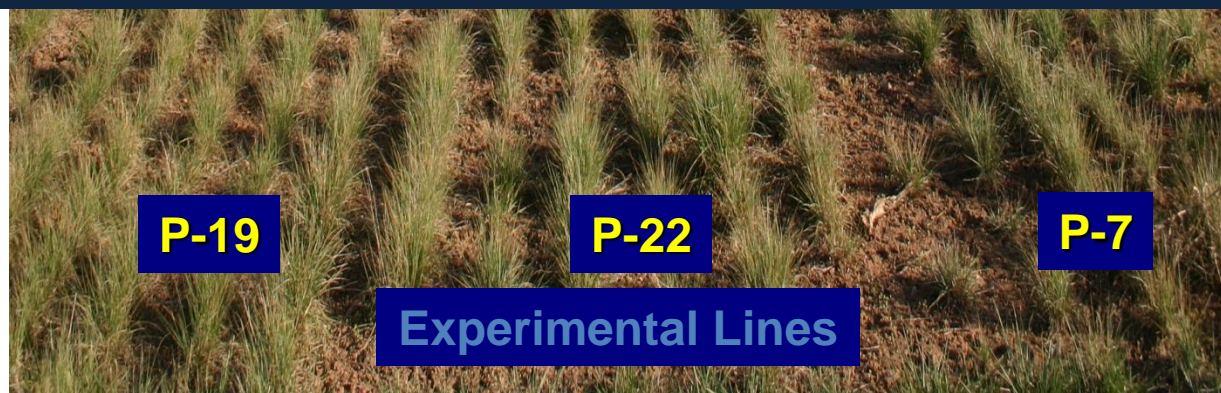




Bluebunch Wheatgrass

Bluebunch wheatgrass (Cheyenne, WY)

	Establishment	2 nd yr Persistence	DMY kg ha ⁻¹
cv. Anatone	31	62	357
cv. P-7	79	86	602



Developed for better establishment and persistence



Snake River wheatgrass

Assemble diverse seed collections

- Cultivars
- Breeding lines
- Raw collections that included wildland and National Plant Germplasm collections

3-cycles of recurrent selection for plant DMY and seed production, and increased seedling establishment.

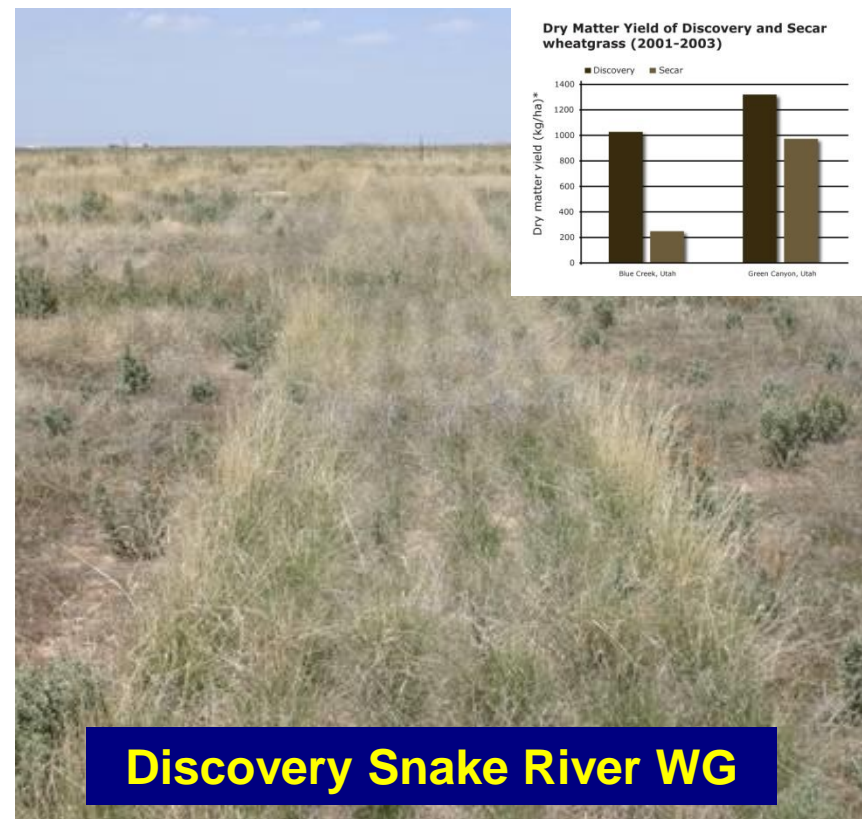
Did we change anything?



Discovery - Snake River Wheatgrass



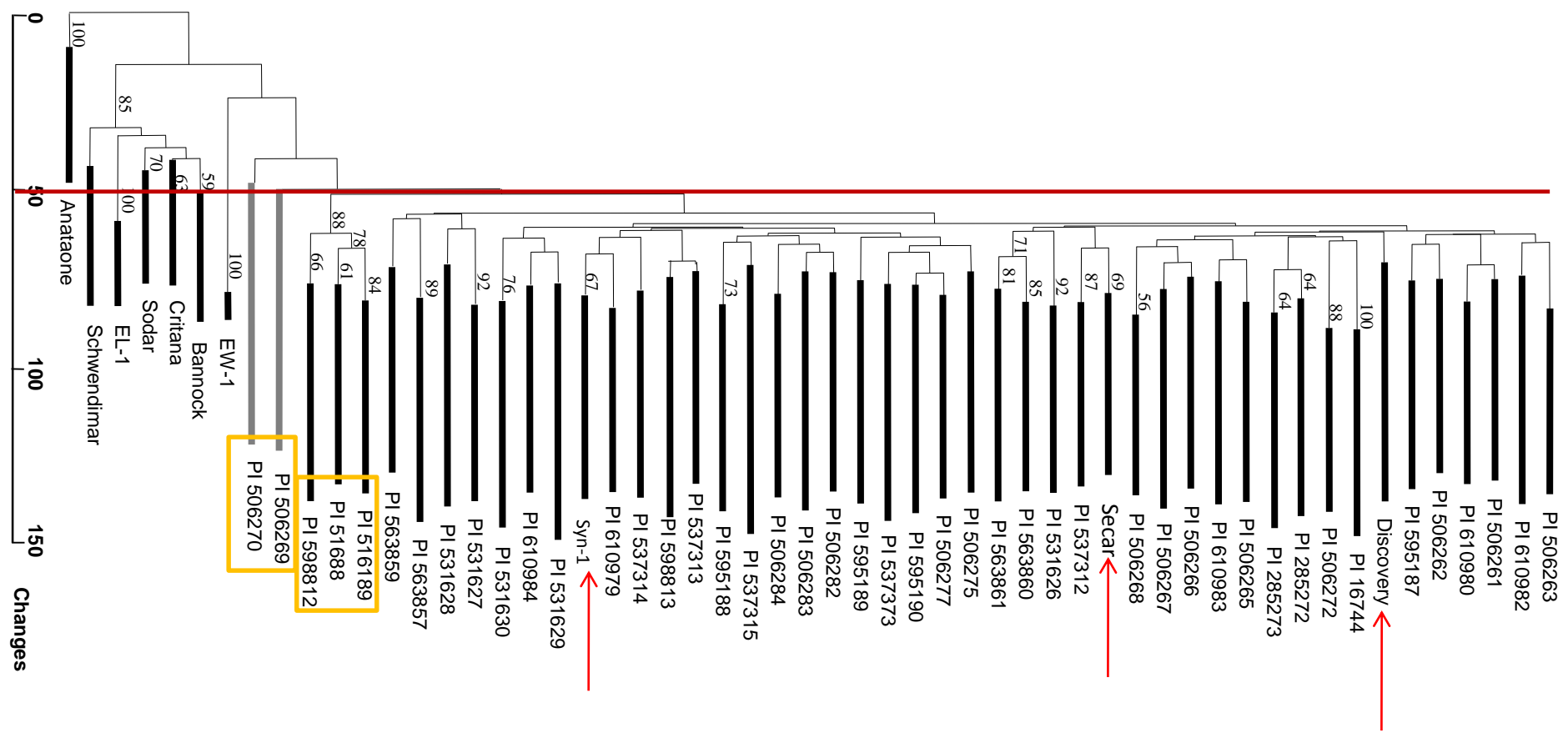
Snake River Wheatgrass fails under heavy grazing



Discovery Snake River Wheatgrass withstands heavy grazing

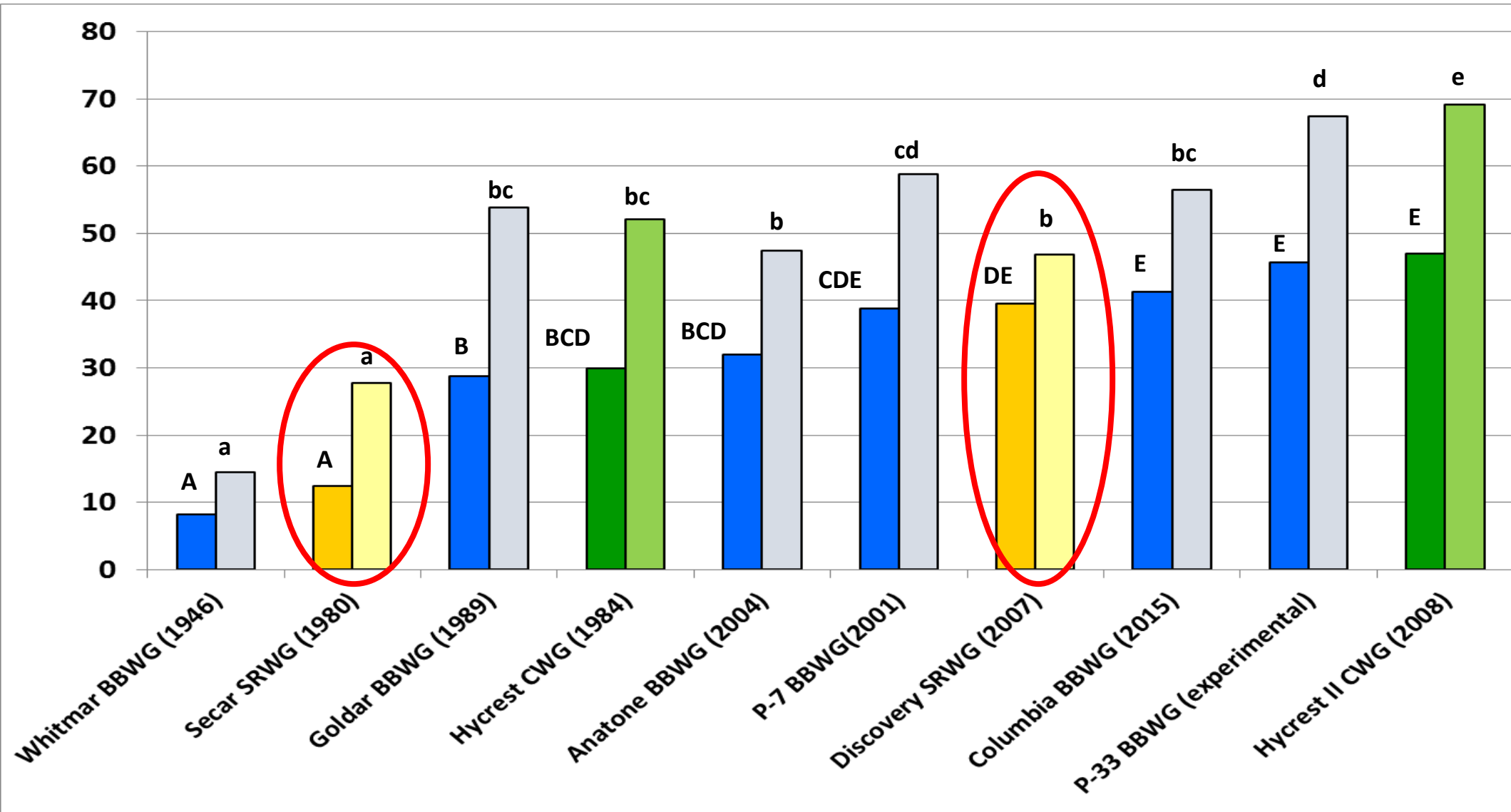


Snake River WG Genetic Relationships



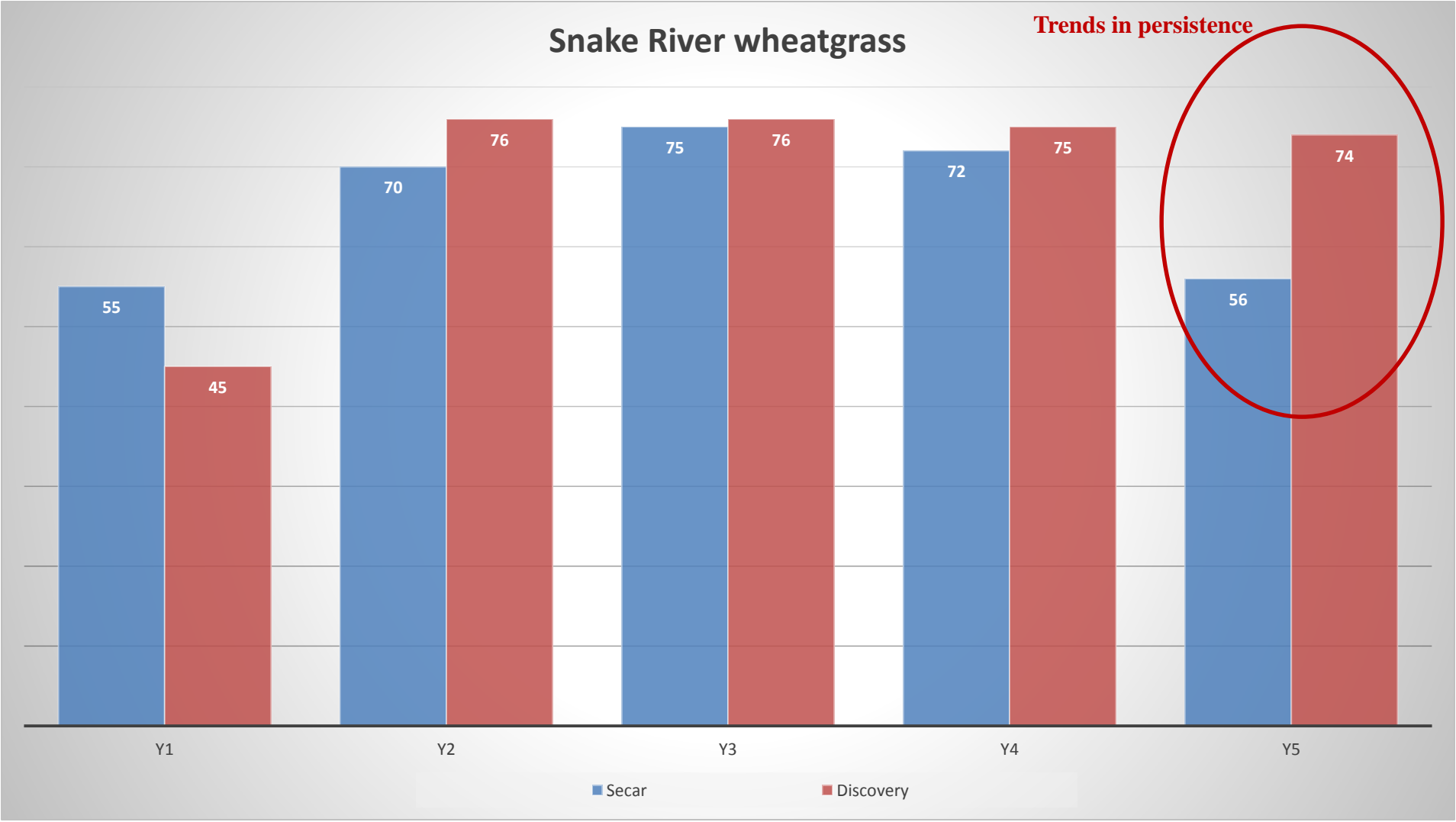


Seedling frequency on May 30, 2013 and April 3, 2014 in a dormant seeding planted November 6, 2012 at Nephi, Utah





Snake River wheatgrass – Four Loc.





Slender Wheatgrass (2006)



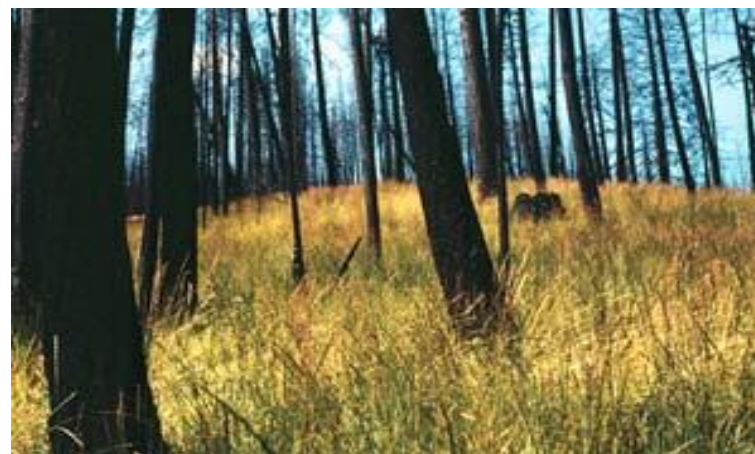
Slender Wheatgrass Cultivar (FIRSTSTRIKE)

Origin (Raw Collections)

Ruth 21, 26 - Collected - Fort Carson Training Center, Colorado.

Ruth 31- Collected - 10 mi. north of Rawlins, Wyoming, HWY 287.

Ruth 37 – Collected - Gillette, Wyoming, near Roadway Inn between Wyoming Highway numbers 14/16 & Railand.



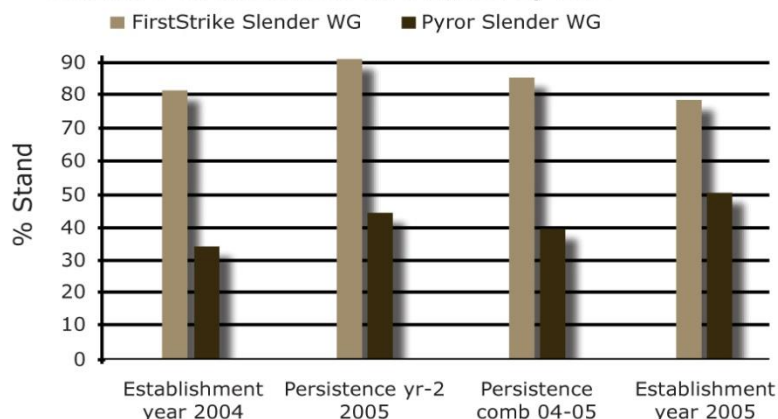
Under went one cycle of selection for overall plant vigor under extreme drought near Pueblo, CO



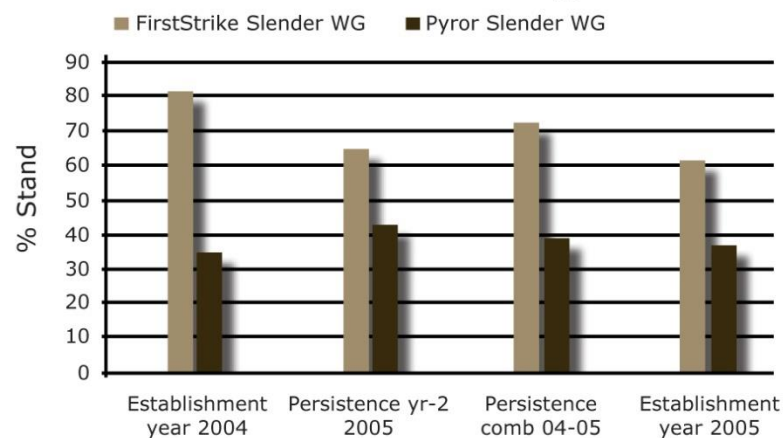
FirstStrike - slender Wheatgrass (2006)

Selected for rapid emergence and establishment

Stand Persistence at Filmore,



Stand Persistence at Guernsey, WY

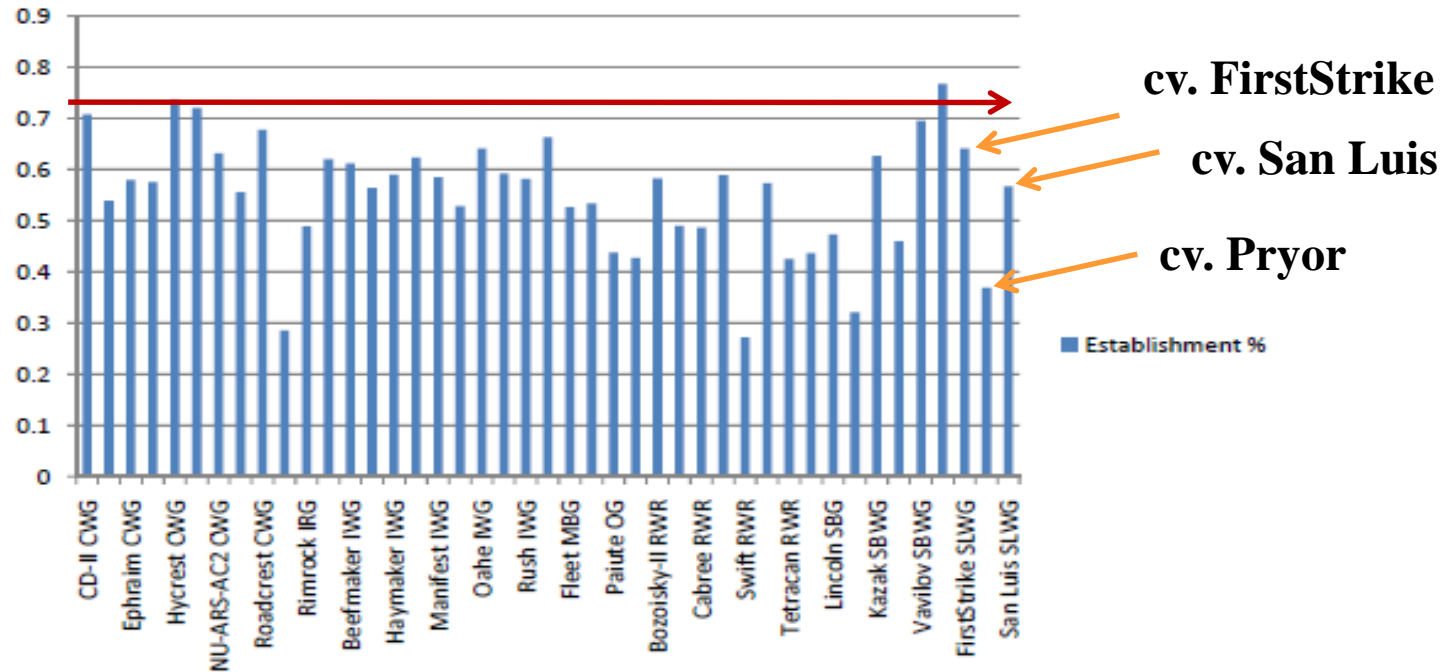


San Luis

FirstStrike



Slender Wheatgrass



'FirstStrike selected for rapid establishment on military installations following training

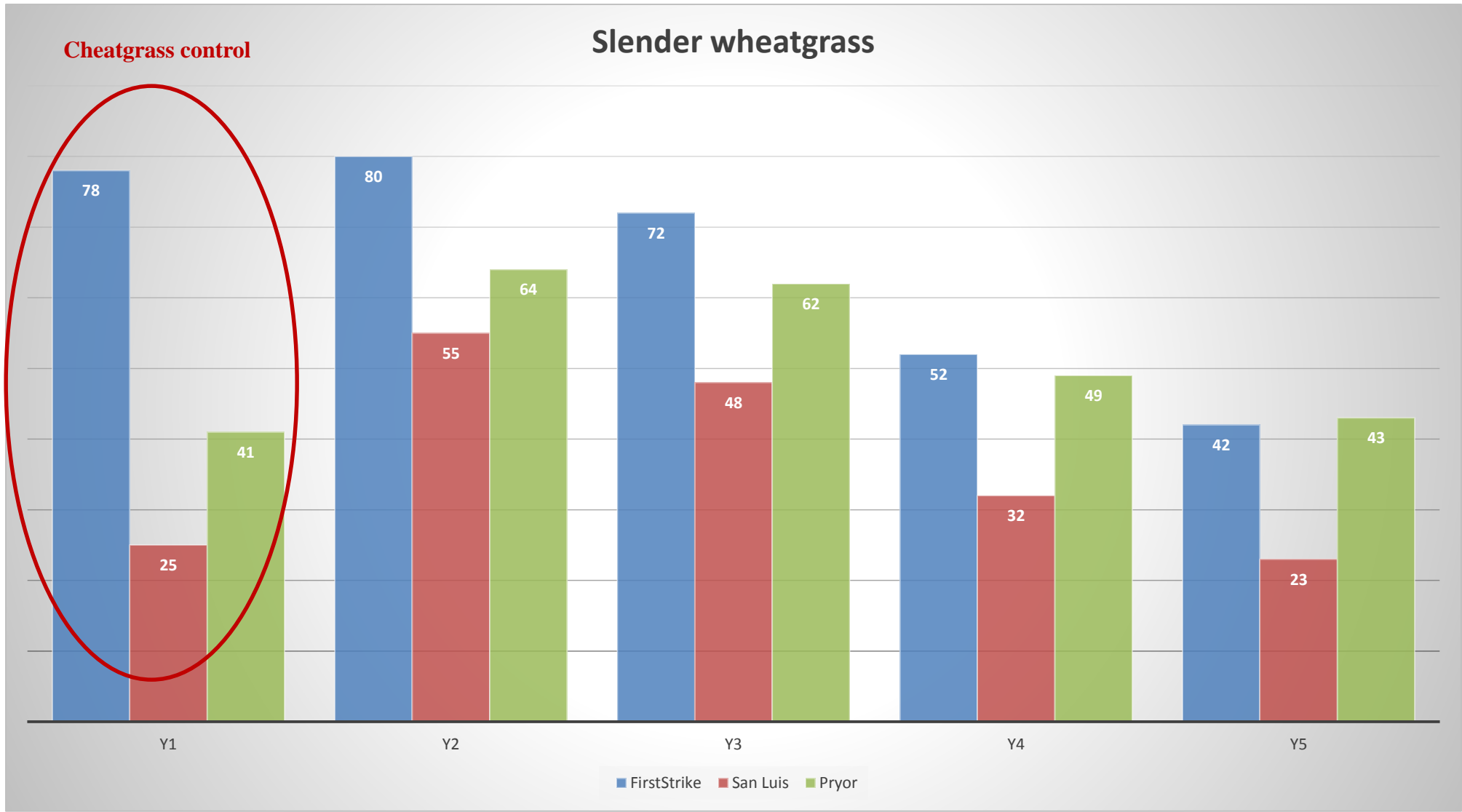


Seedling Frequency Percentage

Slender Wheatgrass	Beaver, UT	Cheyenne, WY	Malta, ID	Tintic, UT
Charleston Peak	43 b			
FirstStrike	84 a	89 a	86 a	53 a
Pryor	84 a	11 b	36 b	33 b
Revenue	87 a			
San Luis	50 b		76 a	29 b



Slender wheatgrass – Four Loc.





Western WG Germplasm Source

- All collections in the NPGS
- Collections from Southern CO
- All commercially available cultivars

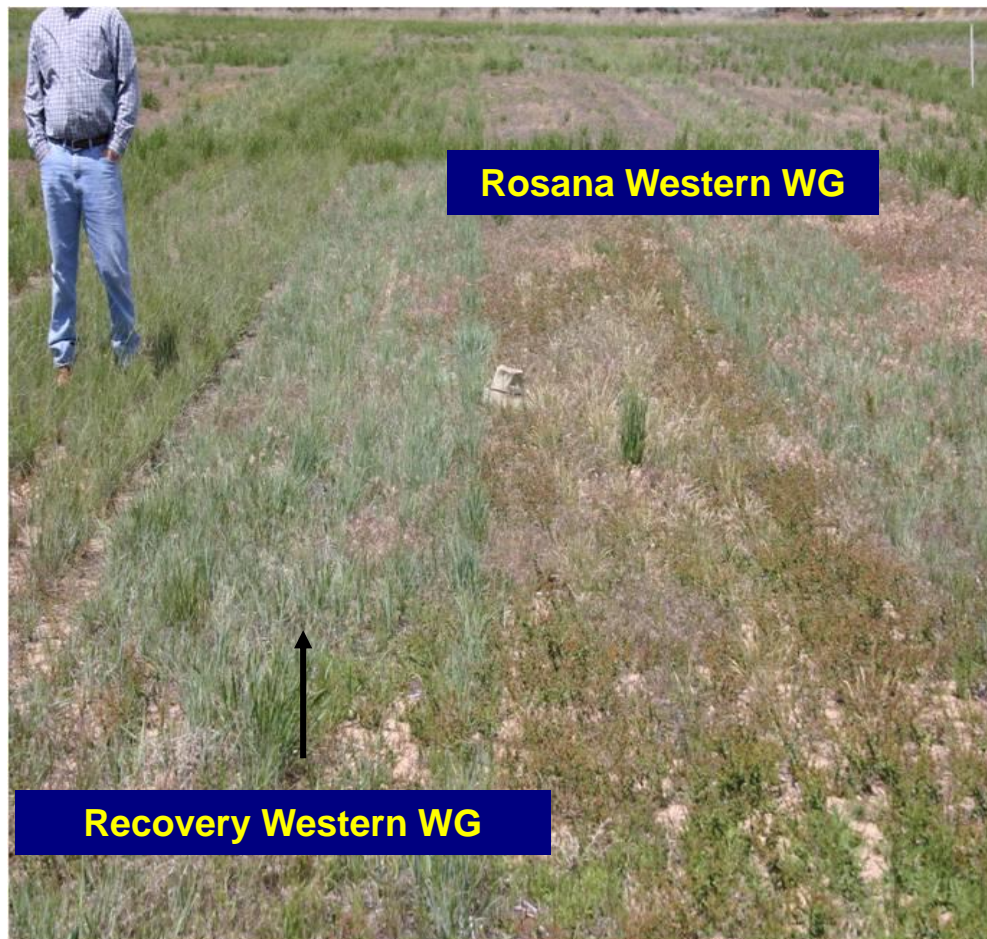


Evaluated for seed set, germination, and seedling vigor (2 cycles)

Improved population with enhanced germination and seedling vigor



Recovery Western Wheatgrass (2010)



Adaptations

- 14 inches (350 mm of precipitation)
- Rhizomatous
- Withstands heavy grazing
- Research for increased germination and seedling vigor for better stands

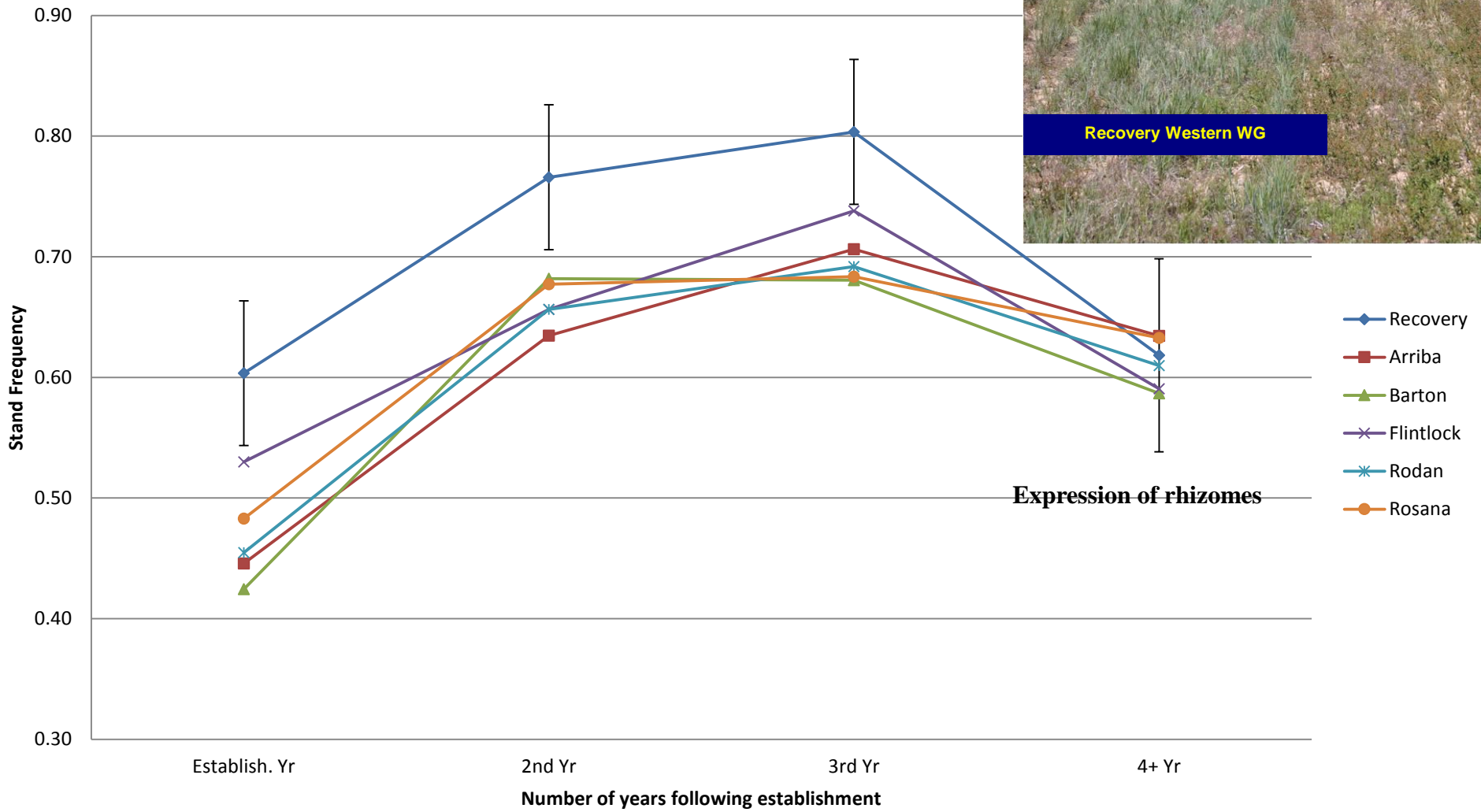


Recovery Western Wheatgrass



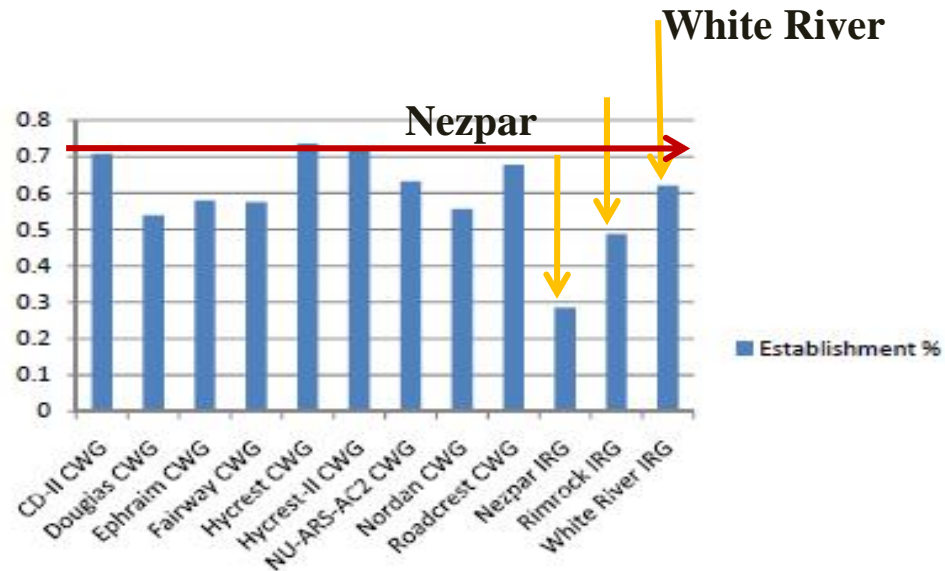
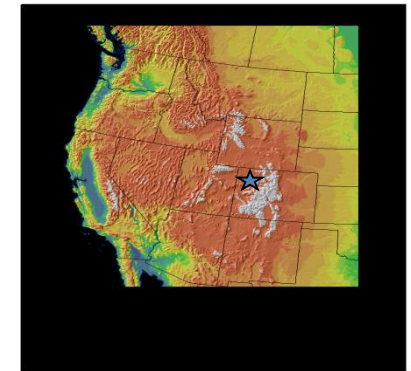
Rosana Western WG

Recovery Western WG

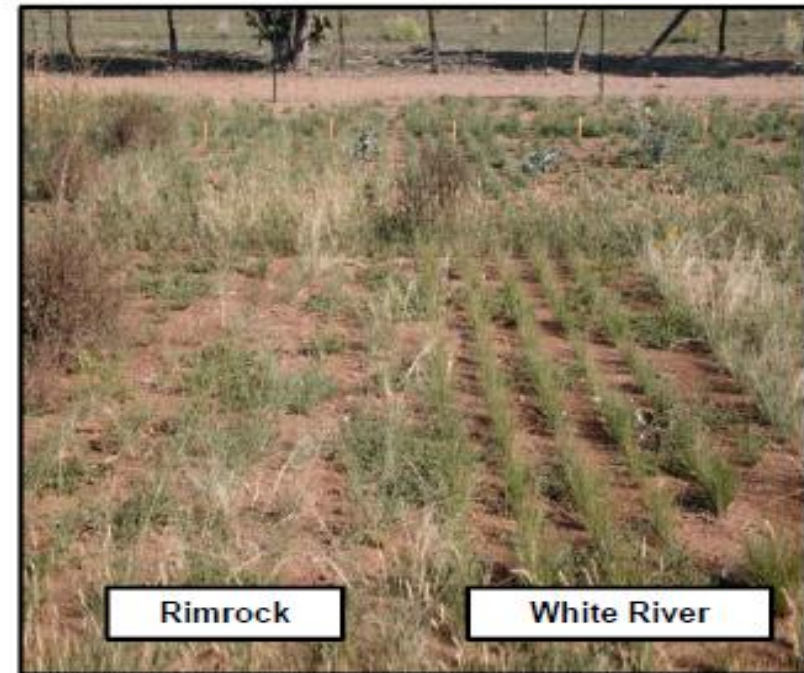




Indian Ricegrass



Screened for
decreased seed
dormancy

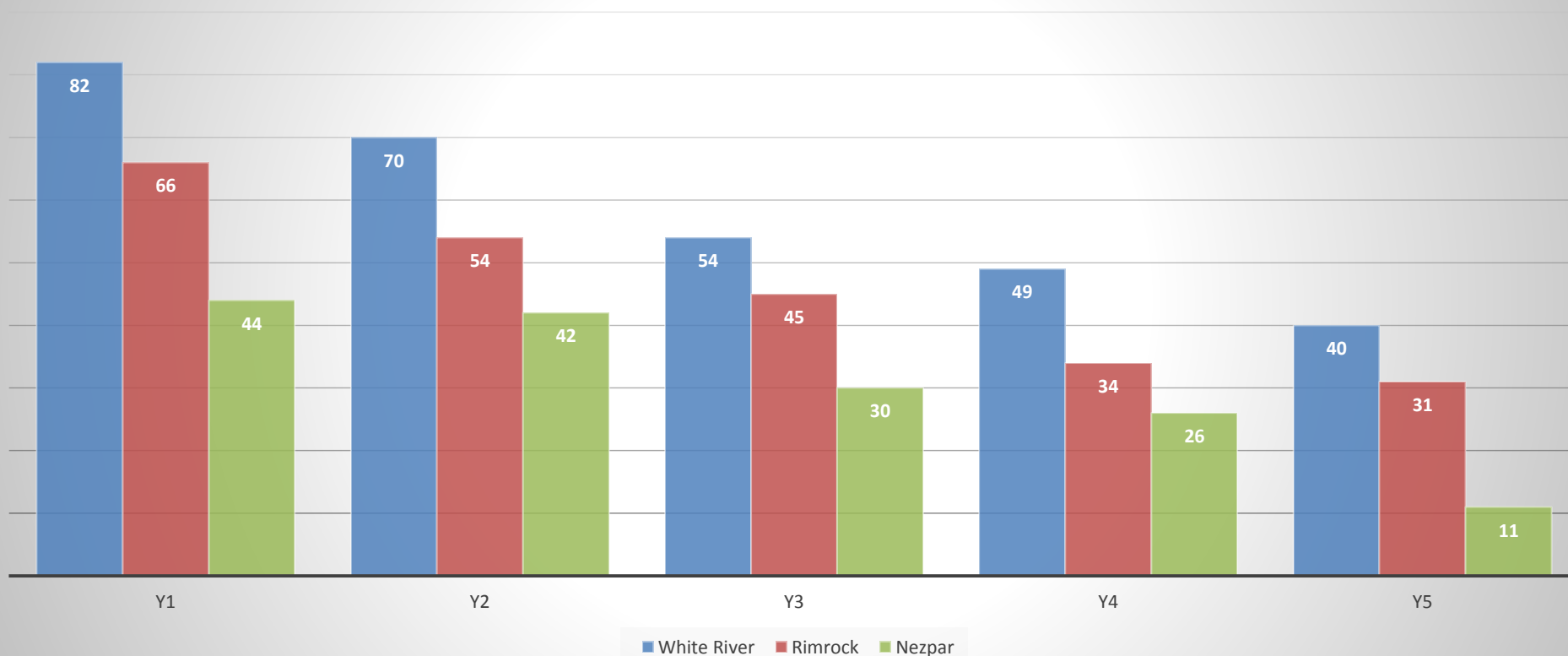




Indian ricegrass – Four Loc.



Indian ricegrass





White River Indian Ricegrass

Frequency Percentage

2009 2010 2011

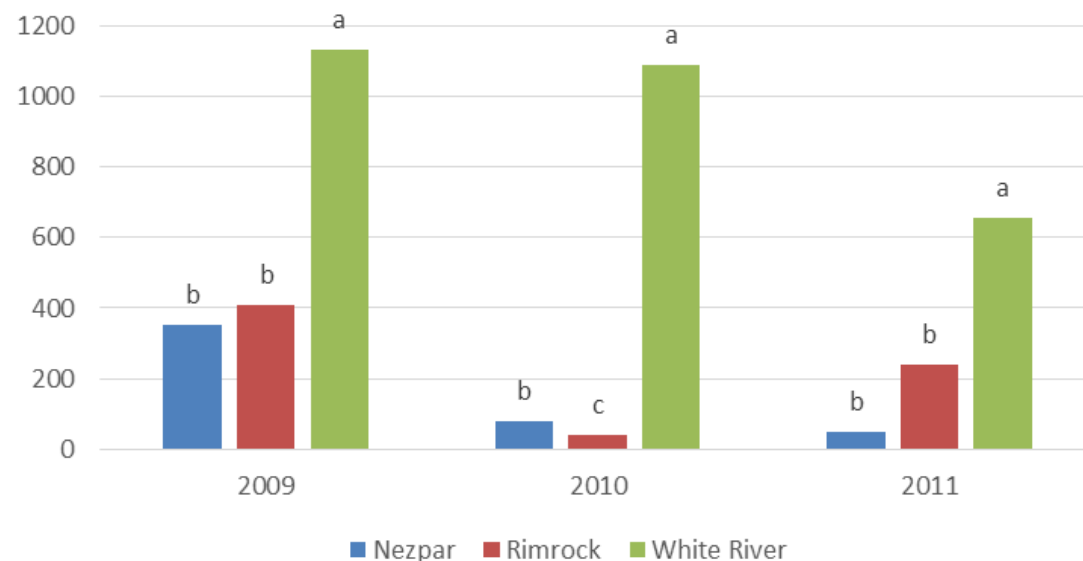
Indian
ricegrass

Nezpar 57^b 52^b 22^b

Rimrock 86^a 68^{ab} 62^a

White River 87^a 86^a 79^a

DMY (kg ha⁻¹) of Indian Ricegrass at Beaver, UT





Continental – Basin wildrye

Trailhead ($2n=4x=28$)

**Doubled Chromosome
Number**

Magnar ($2n=8x=56$)

Trailhead ($2n=8x=56$)

Continental basin wildrye ($2n=8x=56$)



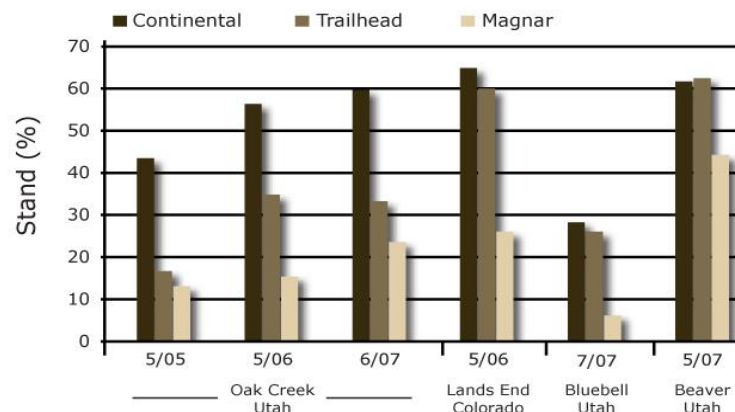


Basin wildrye – Continental

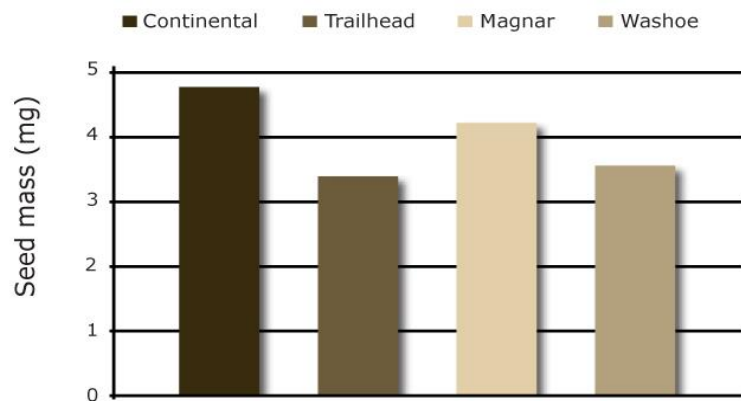


Stand Establishment and Seed Mass of Basin Wildrye

Stand Establishment

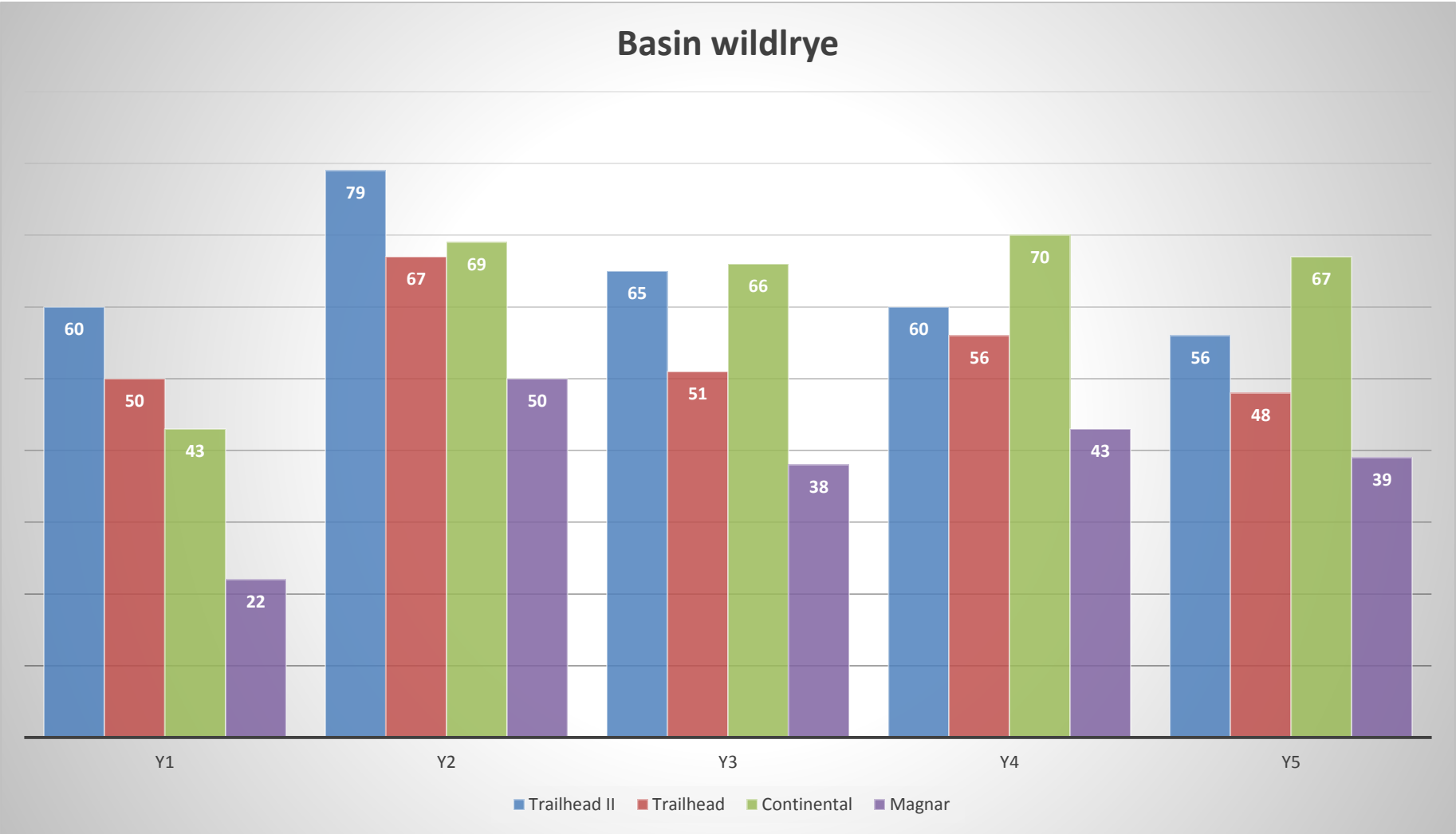


Seed Mass at Millville, UT (2009)





Basin wildrye – Four Loc.

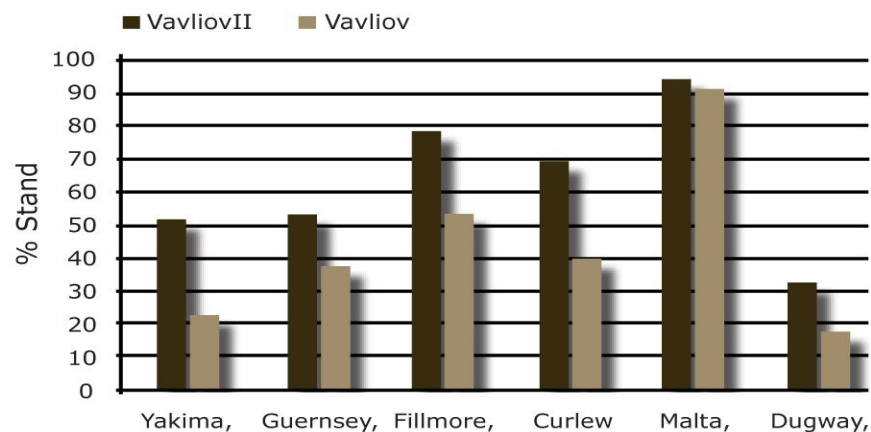




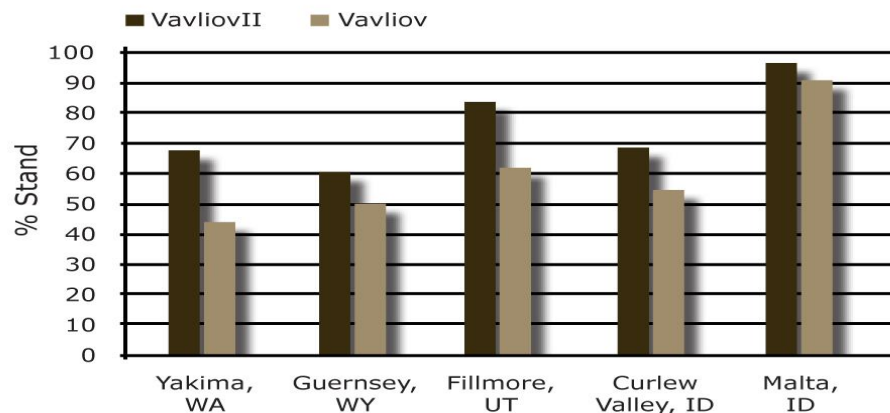
Siberian wheatgrass

‘Vavilov II’.... 2008 70% derived from the cultivar Vavilov (plants selected under extreme drought) and 30% from collections made in 1988 in Kazakhstan...Increased seedling germination, establishment and persistence over Vavilov.

Stand Establishment



Stand Persistence



Winter Forage Study –
Cheyenne, WY



Siberian Wheatgrass

Species/Entry	Frequency Percentage		
	2009	2010	2011
Siberian Wheatgrass	97 A	97 A	93 AB
Vavilov	95 b	95 b	85 a
Vavilov II	97 ab	100 a	95 a
Stabilizer	99 a	98 ab	98 a

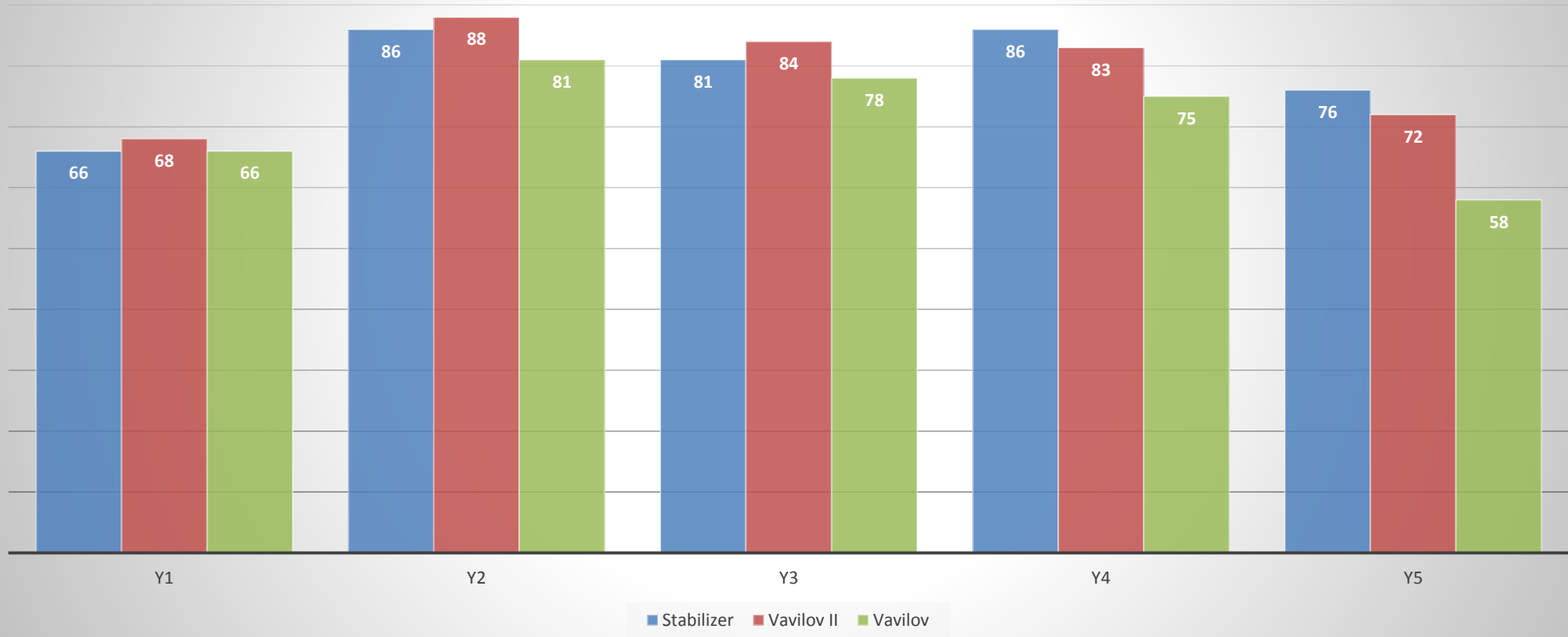
Species/Entry	DMY (kg ha ⁻¹)		
	2010	2011	2012
Siberian Wheatgrass			
Vavilov	812 a	604 ab	590 a
Vavilov II	719 a	727 a	453 ab
Stabilizer	341 b	333 b	310 b





Siberian wheatgrass – Four Loc.

Siberian wheatgrass





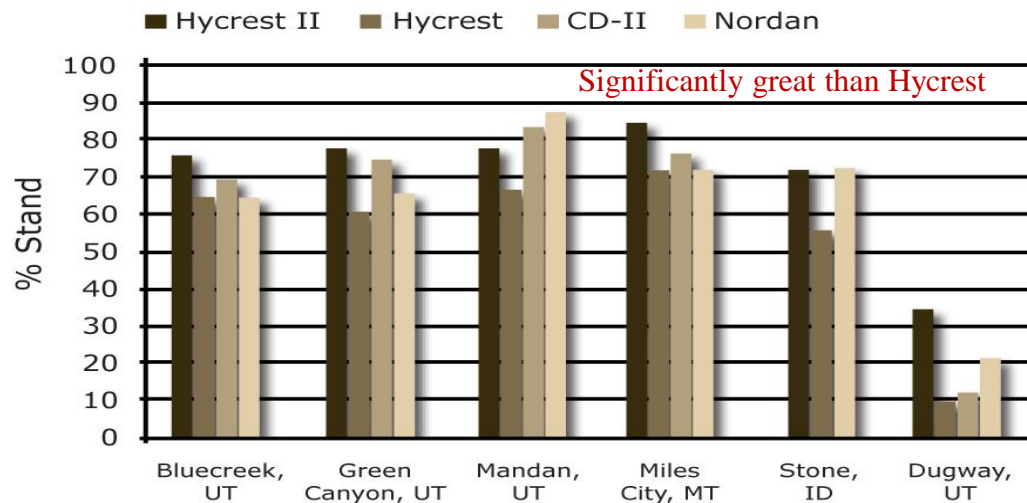
Crested wheatgrass

'Hycrest II'.... 2008 (*A. cristatum*-4x) ... USDA-ARS....One of the original parents to Hycrest....Increased seedling establishment.

2x $\xrightarrow{\text{colchicine}}$ 4x



Stand Establishment





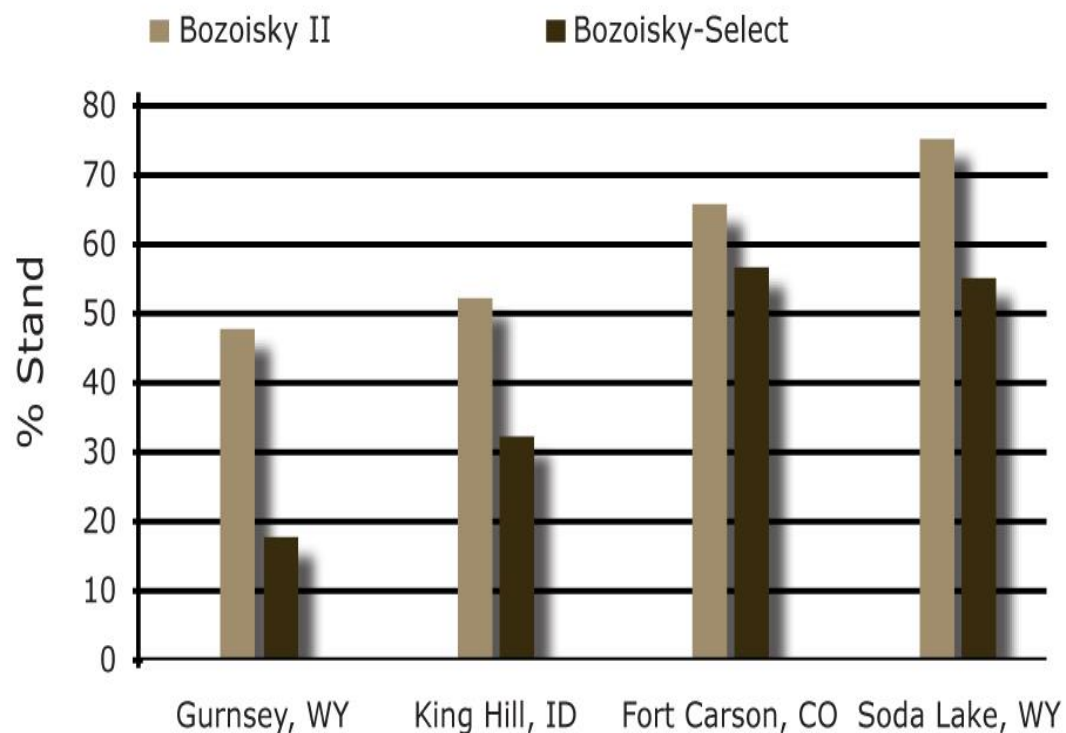
Crested wheatgrass – Four Loc.





Russian Wildrye

Superior Stand Establishment



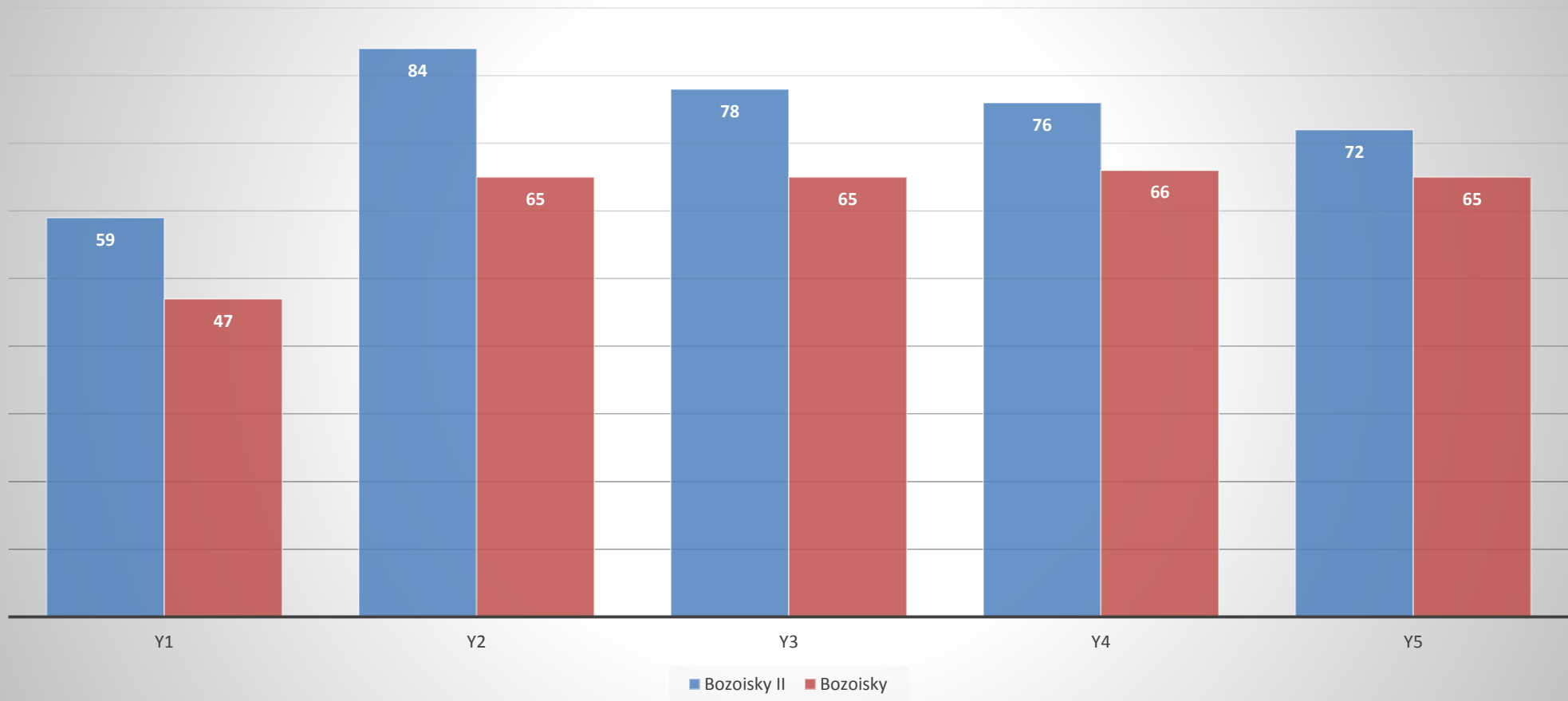
Bozoisky

Bozoisky II



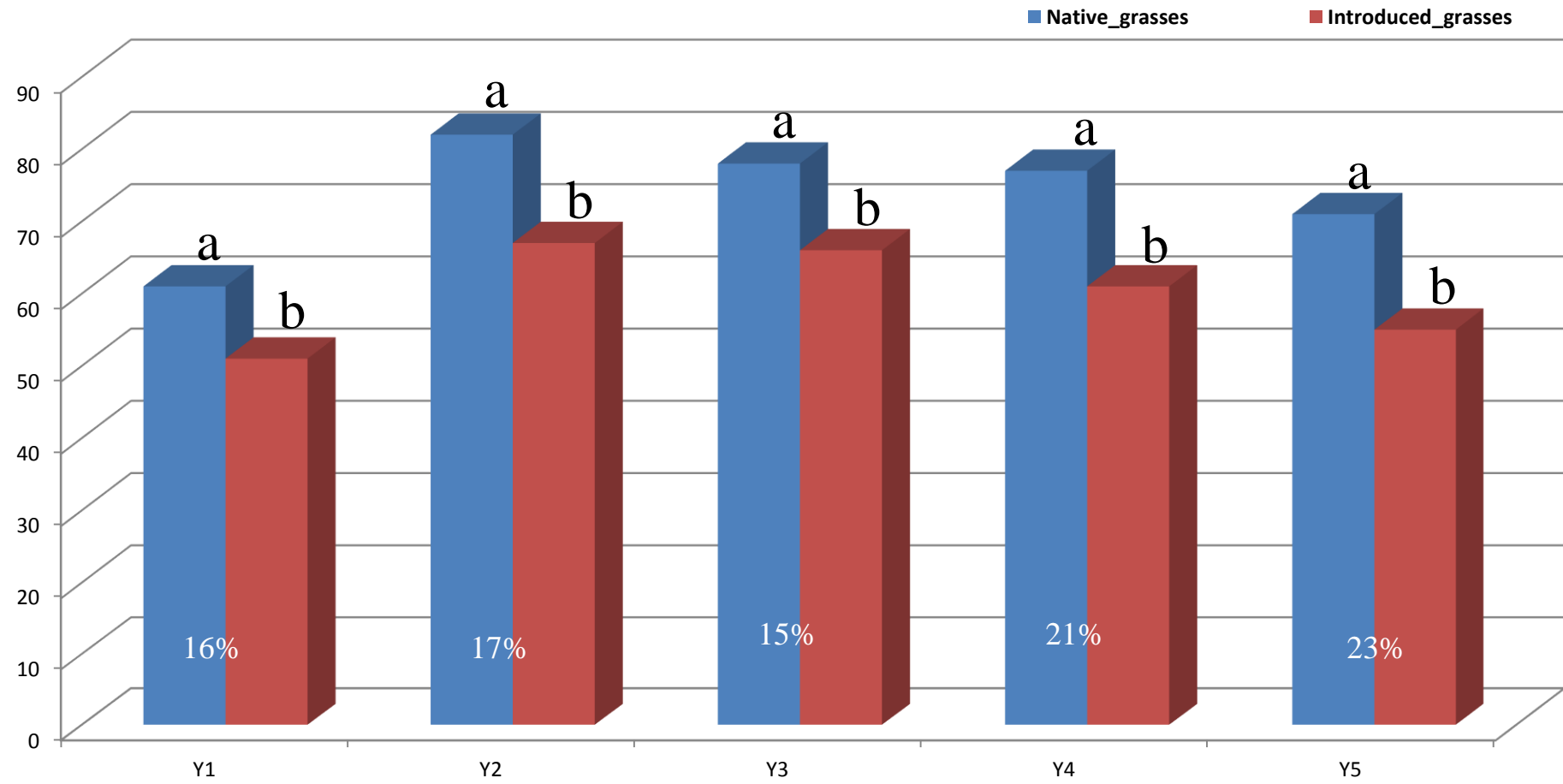
Russian wildrye – Four Loc.

Russian wildrye





Introduced vs Native Grasses





Take Home - Thoughts

