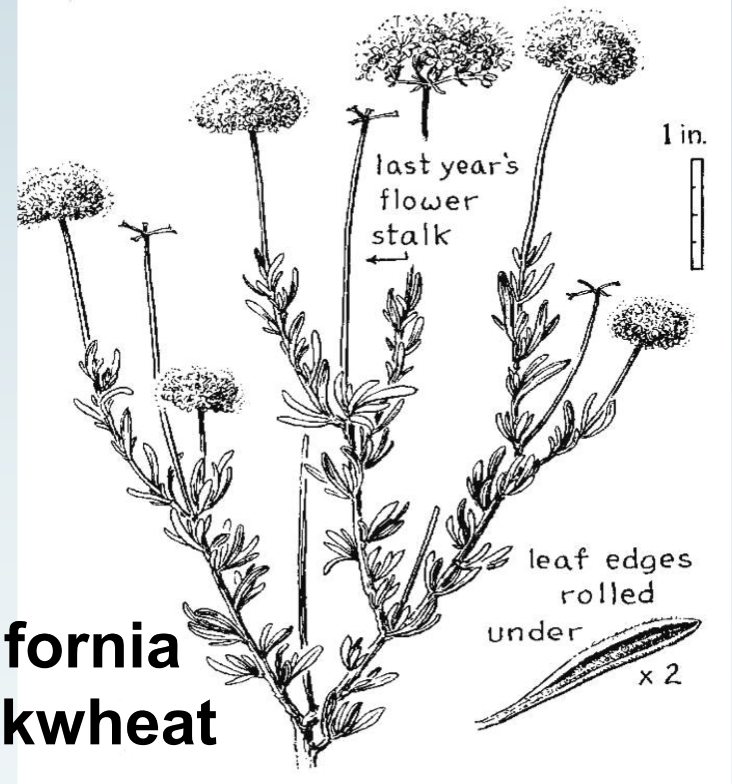
Identifying Native Species for Use in Successful Revegetation Projects in the Desert Southwest

Scott R. Abella
Associate Research Professor
University of Nevada Las Vegas
scott.abella@unlv.edu
http://faculty.unlv.edu/abellas2/



California buckwheat

School of Environmental and Public Affairs

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03/30/2011

Many disturbance types

Goal and Outline

To illustrate methods used in applied scientific studies to identify native species for use in revegetation, and to provide insight on species that may be successful

- Literature review
- Species selection experiments
- Testing diverse seed mix
  for burn reveg

Literature Review: Questions

(1) **Which species have been most commonly and effectively planted or seeded?**

(2) **Which treatments have increased plant establishment?**

(3) **What are the relative performances of planting and seeding?**

Methods

• Systematic review: included all published studies located using defined search criteria

• Article databases: Google Scholar, Agricola, Biological Sciences, Science Direct, and the journals Restoration Ecology, Ecological Restoration, and Native Plants Journal

• Search words: e.g., Mojave Desert, revegetation, rehabilitation, seeding

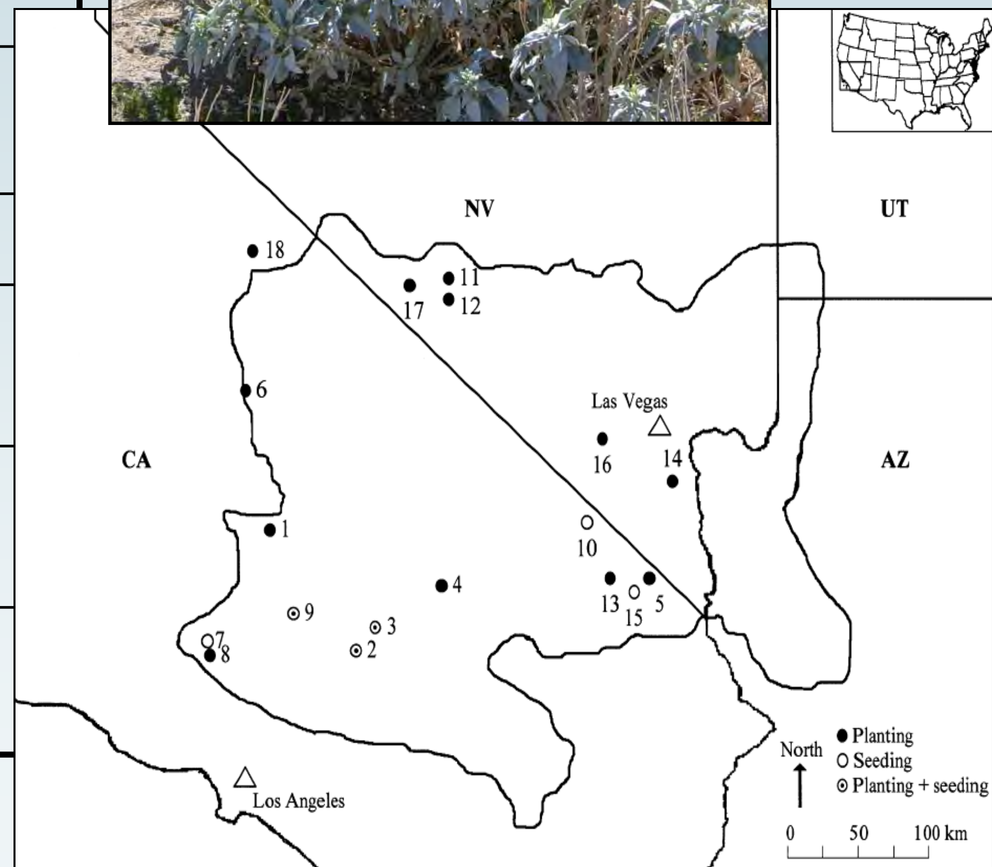
• Examined all references therein

• Criteria for inclusion (e.g., monitor 1 yr)

Results: Summary of Studies

	Planting	Seeding
No. studies	13	8
Environments, e.g.	Corridors, mine spoil	Old road, ag land
Precipitation (%)	27-148	33-157
No. spp/study	1-21	3-12
Care, e.g.	Irrigation, cages	Less common
Tmts tested, e.g.	Shelters, cages	Less common
Years monitored	1-5	1-5

Brittle-bush



Planting – species comparisons

- **40 total species, 36 of them shrubs**
- **16 species planted in ≥ 2 studies**
- **≥ 50% survival in 1 or more tmts:**
  - **White bursage 5/9 studies**
  - **Creosote 5/7 studies**
  - **Fourwing saltbush 4/5, alkali saltbush 2/3**
  - **Nevada jointfir (*Ephedra*), cheesebush (*Hymenoclea*), Mojave yucca 2/2**

Seeding – Species Comparisons

- 26 total species
  - White bursage est. in 3/3 studies (e.g. 0.1/m^2)
  - Saltbush spp. 3/3 (e.g., 0.6-4.2/m^2)
  - Creosote fails in 2/3 studies
  - In study of 12 spp: Palmer's penstemon 7 plants/m^2, desert marigold 3 plants/m^2

Saltbush

Marigold

Planting and Seeding Comparisons

- **Few studies directly compared methods**
- **In comparing separate studies:**
  - **Bursage and saltbush spp. perform relatively well in both planting and seeding**
  - **Creosote performs well in planting but poorly in seeding**

Creosote bush

Thoughts

- Species specificity
- Species that establish infrequently in nature (e.g., late successional creosote), establish better by planting than by seeding without supplemental tmt
- Species that need little tmt for establishing are a key for reveg
- Multifactor studies essential
- Reveg can meet management objectives in certain contexts

Fire in the Mojave Desert

- **Nearly 3% of the entire desert burned in 2005 alone**
- **Kills animals, alters habitat**
- **Long recovery times: 40 yrs for cover, > 100 comp.**

Revegetating Desert Wildfires

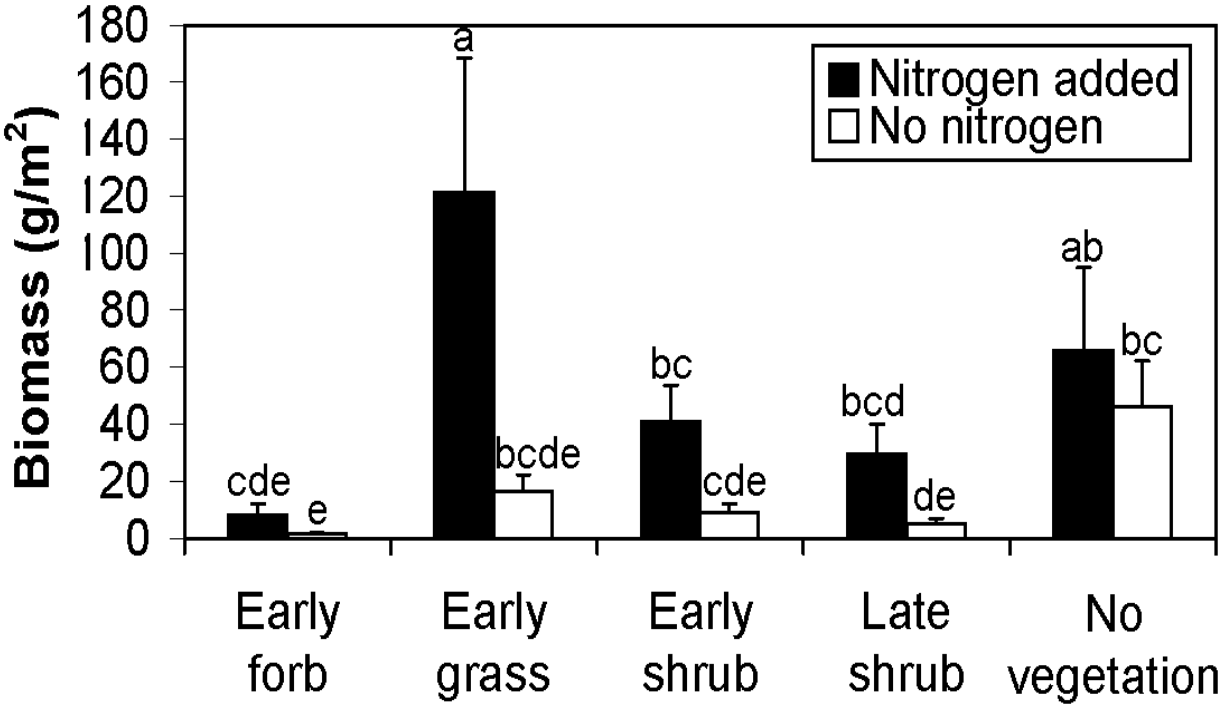
- Importance of species selection
- Revegetation species must:
  - (1) compete
  - (2) establish
  - (3) food, function

Study goal:
to identify candidate species through integrative field invasibility experiments, field studies, greenhouse experiments, and revegetation studies

Invasibility Experiment: Methods

- Invasion-reducing communities
- Five community types: early forb, early shrub, grass, late shrub, none
- Each of 12 species also grown individually
- *Bromus* or *Schismus* added, nitrogen added or not

Invasibility Community Experiment: Results



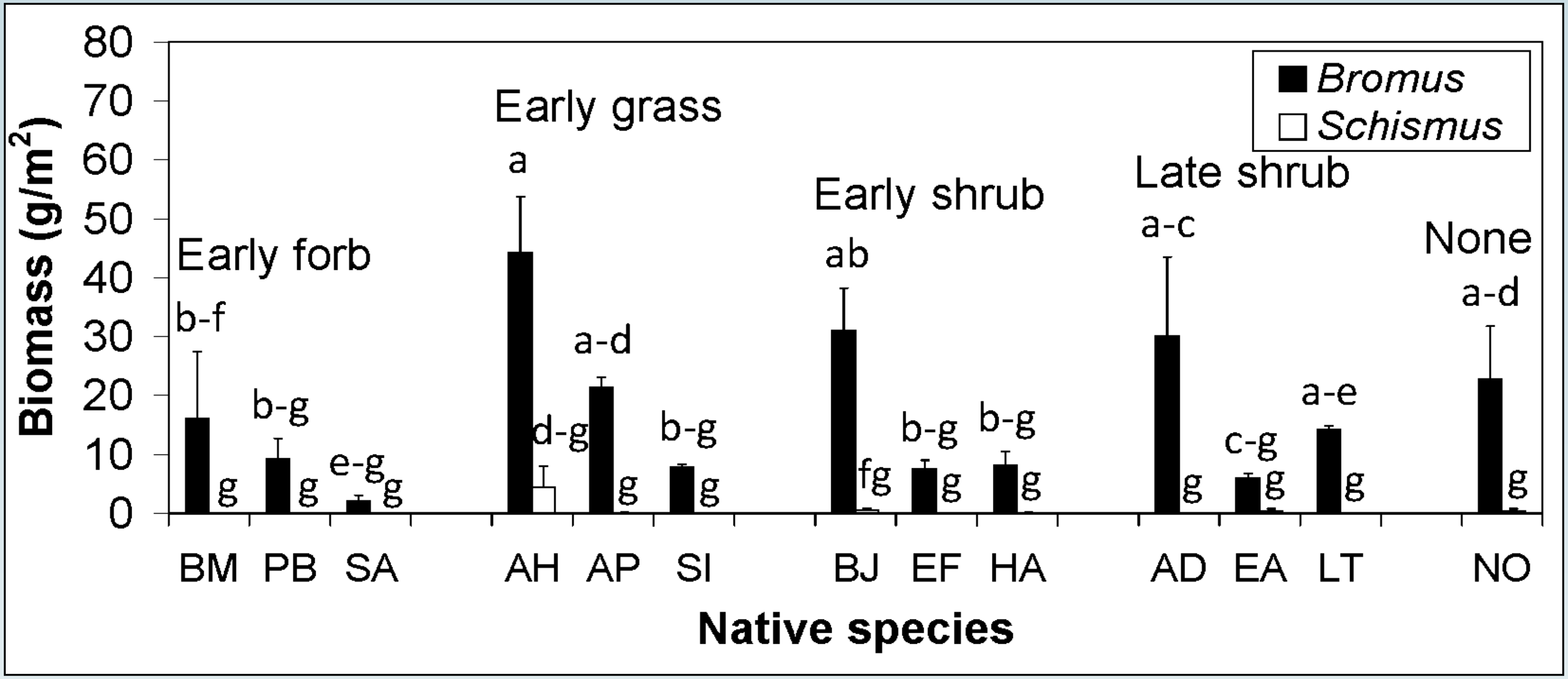
Early forb:
Baileya multiradiata
Penstemon bicolor
Sphaeralcea ambigua

Early grass:
Achnatherum hymenoides
Aristida purpurea
Sporobolus airoides

Early shrub:
Bebbia juncea
Encelia farinosa
Hymenoclea salsola

Late shrub:
*Ambrosia dumosa***
Eriogonum fasciculatum
Larrea tridentata

Invasibility Species Experiment: Results

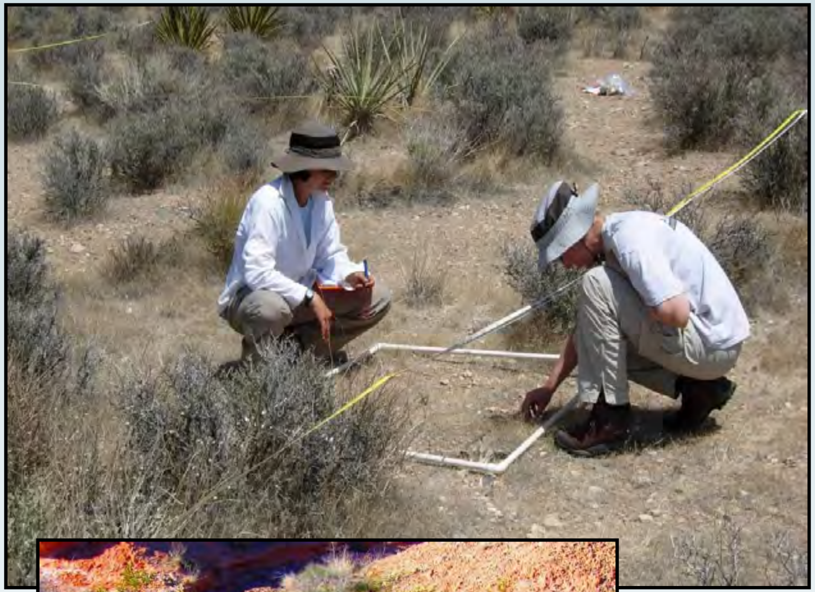


Sphaeralcea ambigua **(SA – desert globemallow): 11-fold reduction**

Globemallow

Correlation Study: Methods & Results

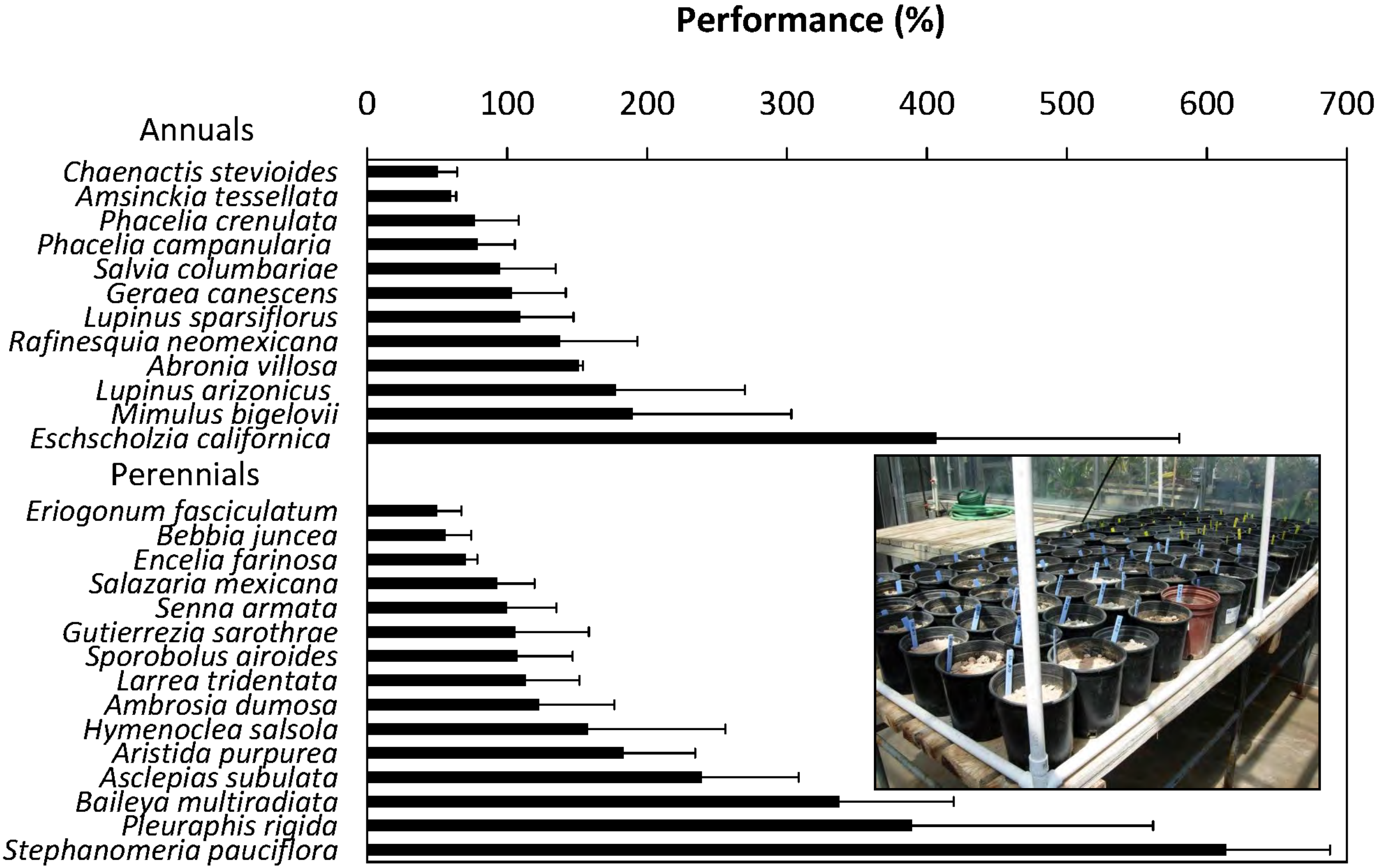
- 7 sites, *in situ* patterns
- Categorize *Bromus* cover below perennials



Microsite	Median	95% CI[a]	n[b]
Interspace	1 a	1-2	56
Thamnosma montana	2 ab	2-5	22
Bebbia juncea	2 abc	0-9	7
Encelia virginensis	2 abc	1-19	7
Salazaria mexicana	2 abc	2-9	9
Encelia farinosa	3 bc	2-5	30
Coleogyne ramosissima	5 abc	2-5	40
Pleuraphis rigida	5 abcd	2-9	6
Menodora spinescens	5 bc	5-5	37
Psorothamnus fremontii	5 bc	2-9	29
Ambrosia dumosa	5 c	5-9	22
Eriogonum fasciculatum	5 bc	2-38	11
Gutierrezia sarothrae	5 bc	2-9	11
Hymenoclea salsola	9 bcd	2-38	10
Larrea tridentata	9 bcd	2-38	13
Ephedra torreyana	9 c	5-19	28
Krameria erecta	19 d	19-19	37

- ***Bromus*** **cover varied 19-fold among interspaces and native perennial plant microsites**

Greenhouse Experiment: Results

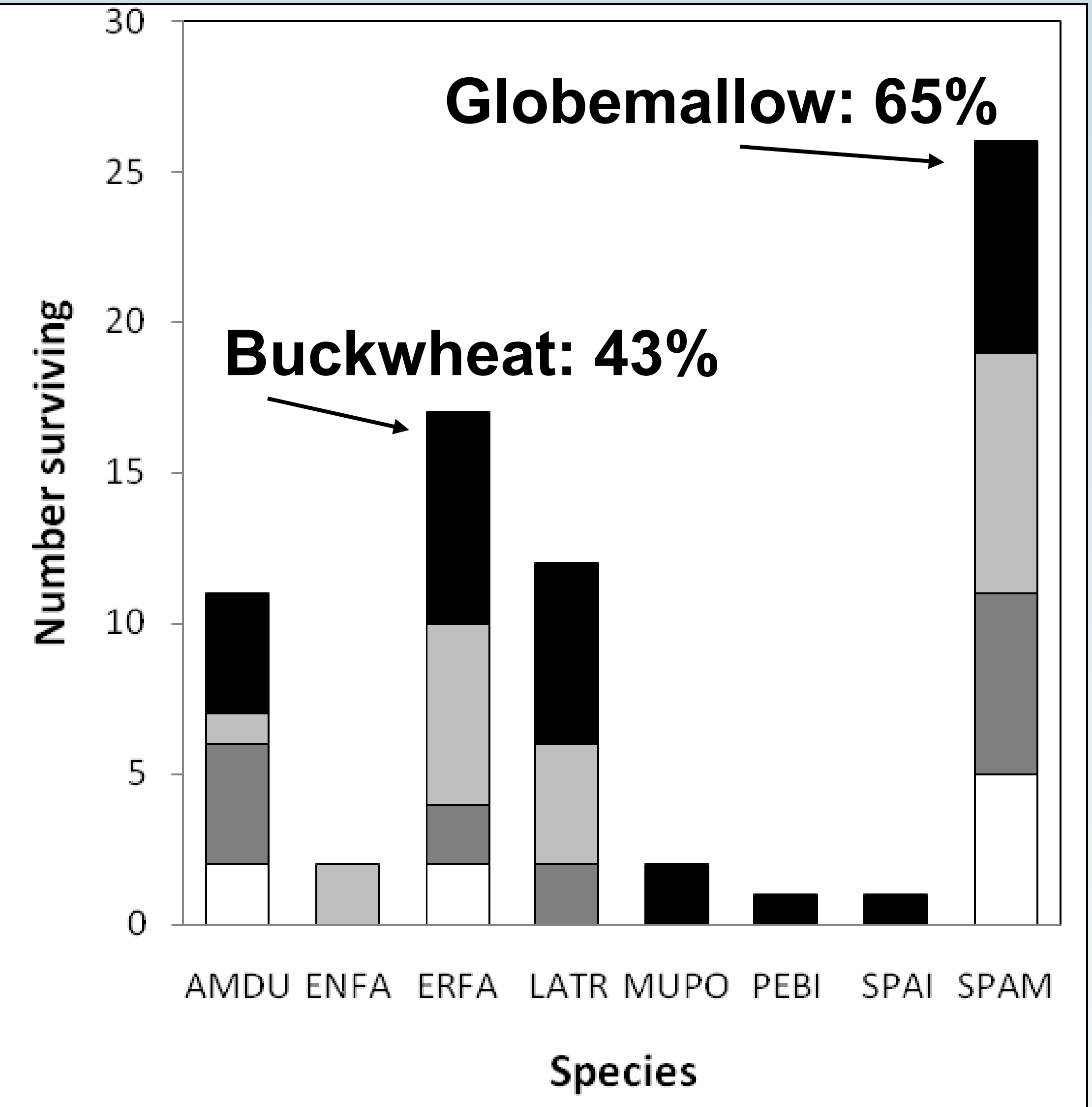


Revegetation Experiment: Methods

- 40, 1-yr old outplants of each of 8 species
- Shelter and water treatments
- Survival for 2 years (3 this spring)
- Seeded 10 species each at 500 seeds/m^2

Revegetation Experiment: Results

- Planting effective, seeding not

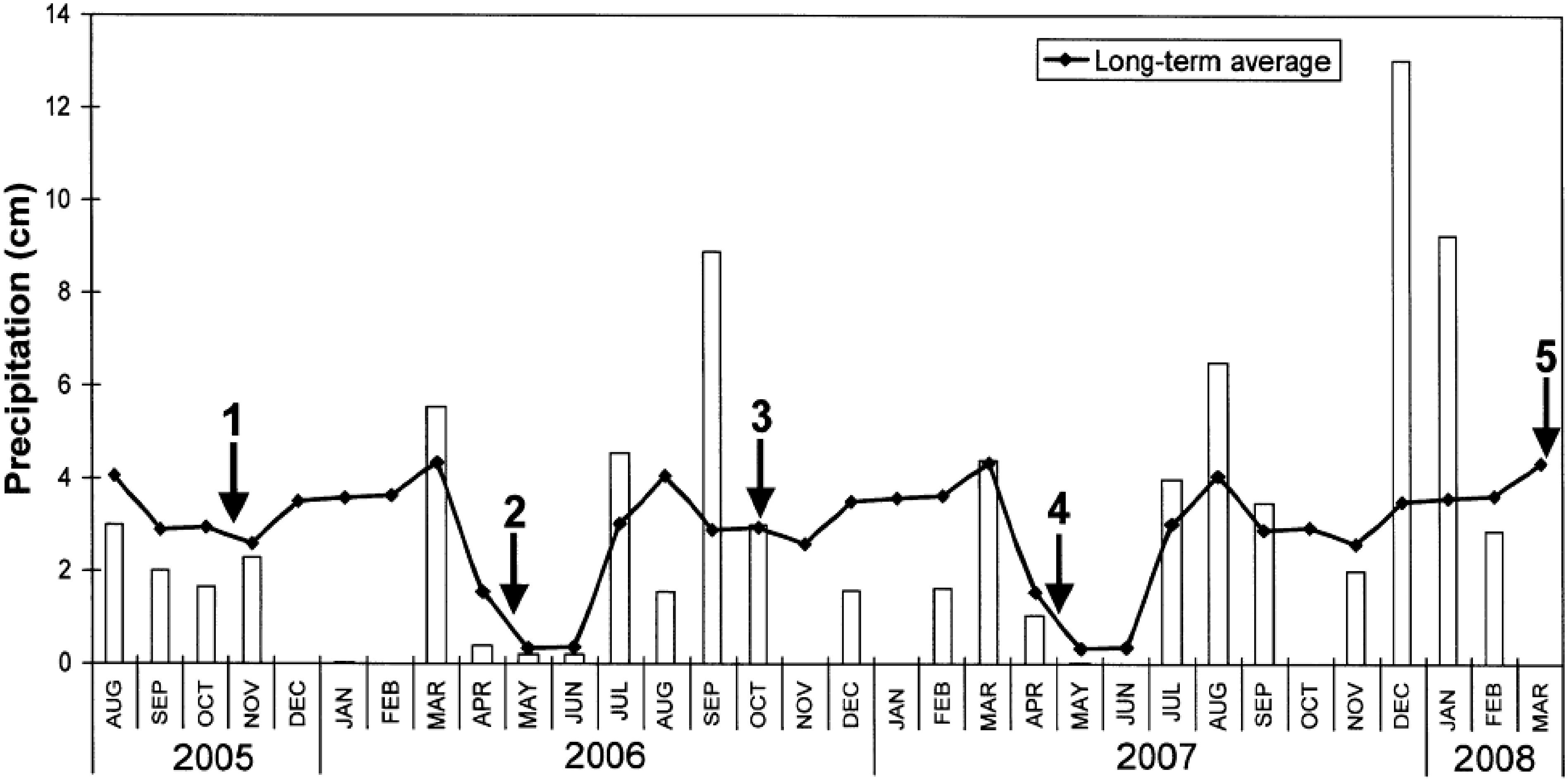


Globemallow

Testing Diverse Seed Mix

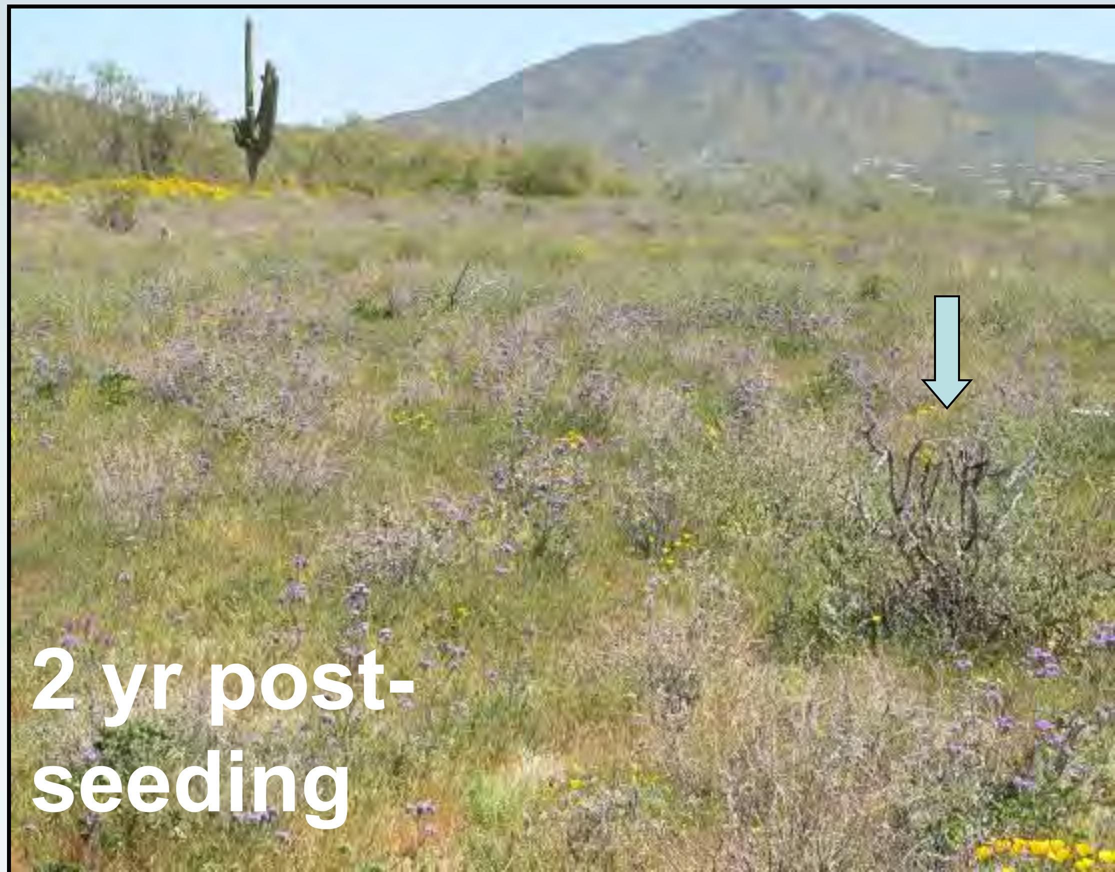
- Cave Creek Regional Park, Sonoran Desert uplands
- 28 natives seeded

Precip. only 67% of "normal"



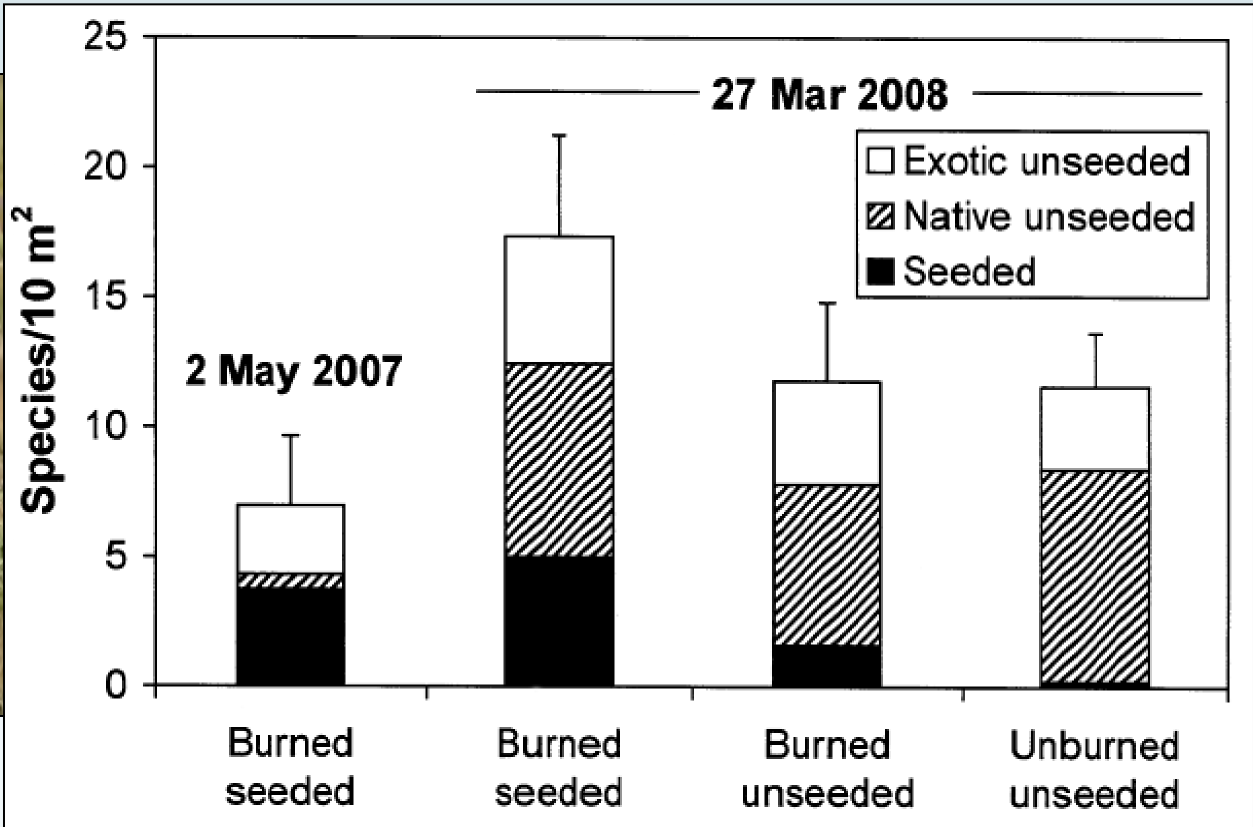
3 mo post-seeding

6 mo post-seeding



Species Establishment

- Of 28 seeded species, highly successful subset of 7 species made seeding successful, at least in the short term (32 months)
- Desert senna, purple threeawn, desert bluebells



Summary of Findings

- Experimental evidence that native vegetation types may exist in southwestern deserts that can reduce the establishment of exotic annual grasses

- Mimic natural successional patterns (e.g., desert senna, marigold)

- Early successional forbs, in particular globemallow, most effective

Implications of Findings

- Approach useful for screening species
- Match to management needs, reducing re-burning
- Seeding is a problem
- Need to understand which species work before propagating and seed increase

Acknowledgements:

<u>Funding.</u> Alice C. Newton and the National Park Service, Lake Mead National Recreation Area (LMNRA), Joint Fire Science Program, and Maricopa County, Arizona, Parks and Recreation Department (J. Gunn).

<u>Set up and sampling.</u> LMNRA plant nursery, UNLV staff, NV Conservation Corps, Northern Arizona University staff

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Scott R. Abella
scott.abella@unlv.edu

School of Environmental and Public Affairs
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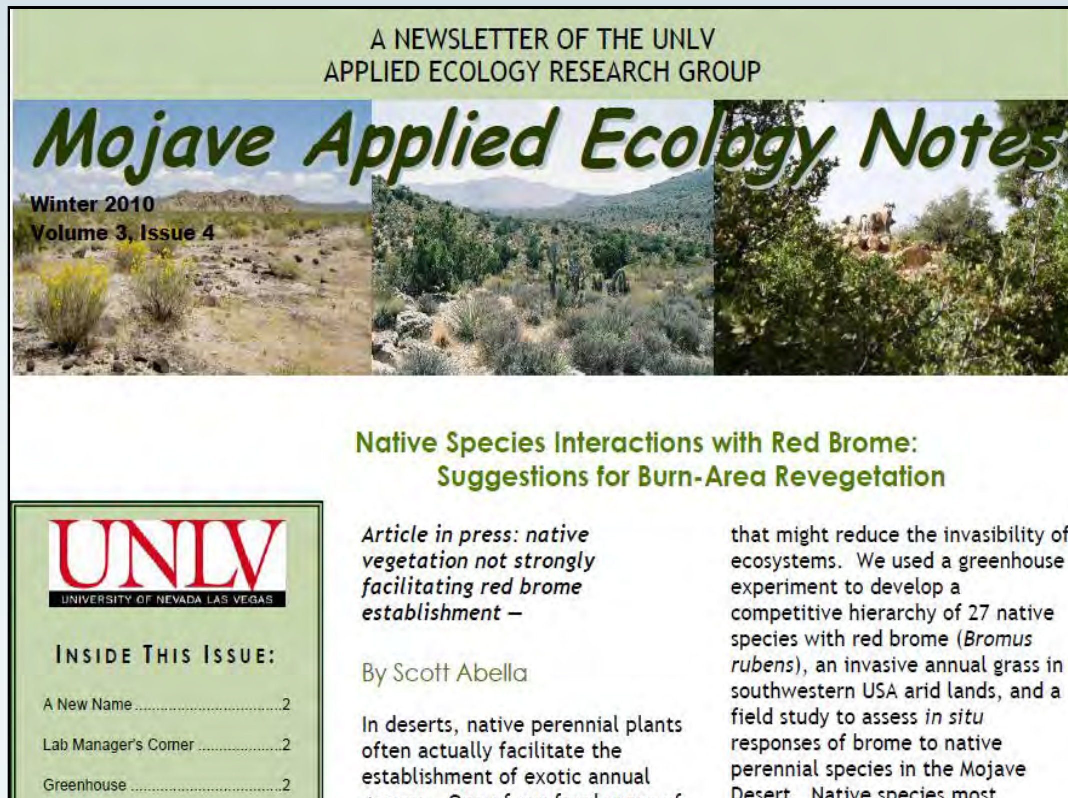
A NEWSLETTER OF THE UNLV
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Mojave Applied Ecology Notes

Winter 2010
Volume 3, Issue 4

Native Species Interactions with Red Brome:
Suggestions for Burn-Area Revegetation

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INSIDE THIS ISSUE:

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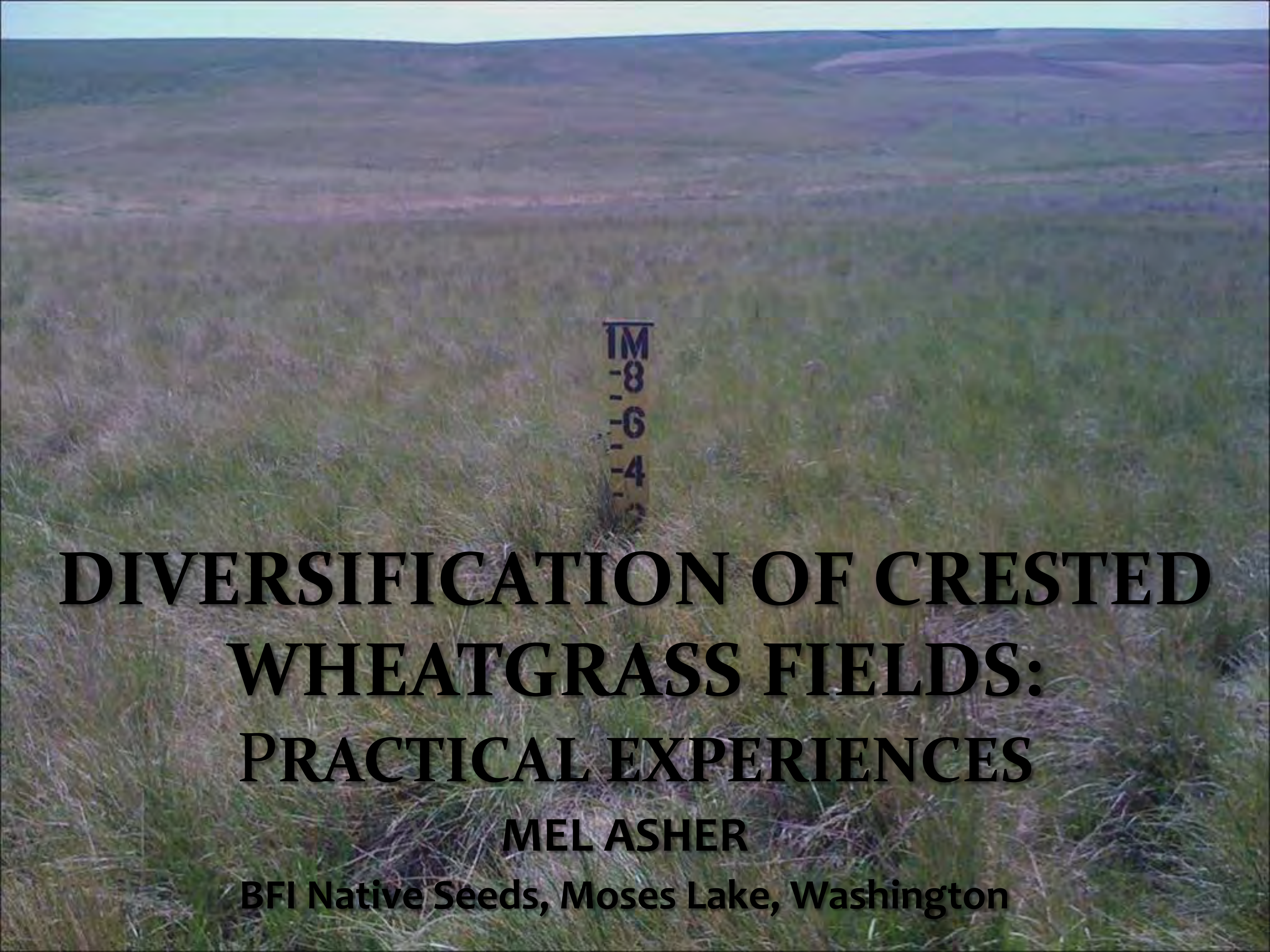
Article in press: native vegetation not strongly facilitating red brome establishment —

By Scott Abella

In deserts, native perennial plants often actually facilitate the establishment of exotic annual grasses. One of our focal areas of that might reduce the invasibility of ecosystems. We used a greenhouse experiment to develop a competitive hierarchy of 27 native species with red brome (*Bromus rubens*), an invasive annual grass in southwestern USA arid lands, and a field study to assess *in situ* responses of brome to native perennial species in the Mojave Desert. Native species most



DIVERSIFICATION OF CRESTED WHEATGRASS FIELDS: PRACTICAL EXPERIENCES

MEL ASHER

BFI Native Seeds, Moses Lake, Washington

Why Diversify?

- Improve habitat for wildlife

Why Diversify?

- Improve habitat for wildlife
  - Sage-grouse broods use areas rich in forbs

    (Drut et al. 1994; Apa 1998)
  - Forbs contributed 20 to 50% to the diet of pre-laying sage-grouse hens

    (Barnett and Crawford 1994)
  - Sharp-tailed grouse use areas that contain a high diversity of forbs and bunchgrasses

    (Hart et al. 1950, Klott and Lindzey 1989, Meints 1991)

Funding Sources

- Public landowners
  - BLM
  - WDFW
- Enrollment in CRP-SAFE
  - Provides cost share to establish 7-8 species, including forbs, grasses, and shrubs

Methods

- Site Preparation – 15 months process starting in summer
  - Mow – Harrow – Spray – Spray
- Staged Planting
  - Grasses – Broadleaf Control – Forbs

Mowing

- Timing – Summer following seed shatter

Rotary Blade Mower

Harrowing

- Timing – Fall; A heavy spring-tine harrow is used

Chemical Fallow

- Mid-Spring Heavy Round-Up
  - 96 oz Round-Up + 12 oz AMS + 1 oz R-11

    (4 lbs a.i. / gallon; e.g. Round-Up Pro)
- Summer Round-Up
  - 20 - 24 oz Round-Up + 10 oz AMS + 1 oz R-11
- Fall Round-Up
  - 12 – 16 oz Round-Up + 10 oz AMS + 1 oz R-11


Ready to Plant...

Deep Tillage

- Dense crested wheatgrass may need tillage
    - Breaks up sod
    - Sweep chisel
    - One week following heavy RU application

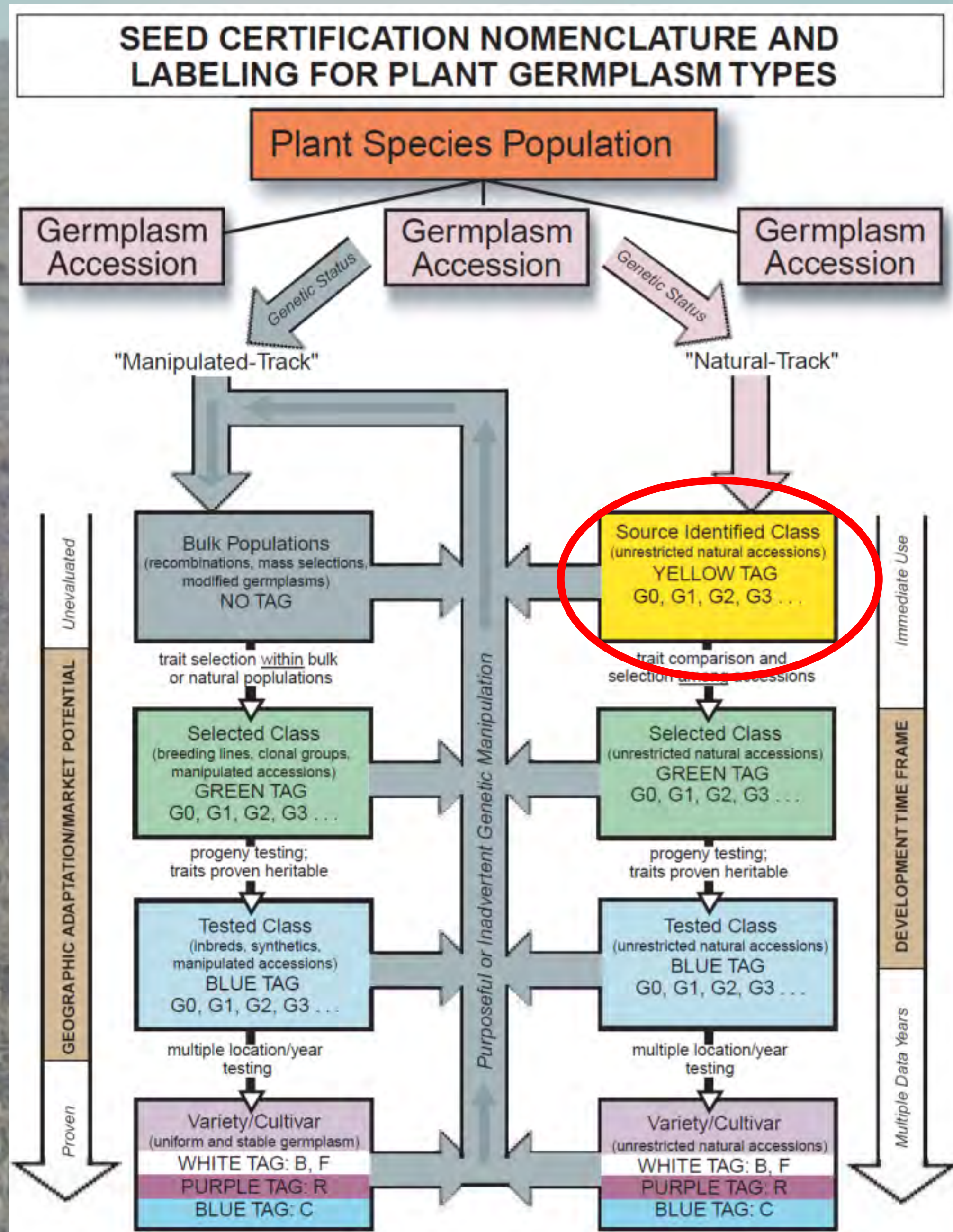
Seeding

- Dormant seeding with TruAx Flex II
- Seeding depth ranges from ¼ - ½ inches

Grass Seed Mixes

Grass Species	Eco-Types	Lbs / Acre
Bluebunch Wheatgrass	Duffy Creek/Hawk Creek	5
Idaho Fescue	Touchet/Tucannon	3
Sandberg Bluegrass	Sprague	1.6
Prairie Junegrass	Zumwalt	1
	TOTAL	10.6

Grass Species	Eco-Types	Lbs/Acre
Bluebunch wheatgrass	Wahluke	3.6
Sandberg's bluegrass	Frenchman Hills	1.6
Indian ricegrass	Nezpar	1.4
Bottlebrush squirreltail	Yakama	1.1
Thickspike wheatgrass	Schwendimar	1.4
	TOTAL	9


SEED CERTIFICATION NOMENCLATURE AND LABELING FOR PLANT GERMPLASM TYPES
Plant Species Population
Germplasm Accession
Germplasm Accession
Germplasm Accession
Genetic Status
Genetic Status
"Manipulated-Track"
"Natural-Track"
Bulk Populations
(recombinations, mass selections, modified germplasms)
NO TAG
Source Identified Class
(unrestricted natural accessions)
YELLOW TAG
G0, G1, G2, G3 . . .
trait selection within bulk or natural poplulations
trait comparison and selection among accessions
Selected Class
(breeding lines, clonal groups, manipulated accessions)
GREEN TAG
G0, G1, G2, G3 . . .
Selected Class
(unrestricted natural accessions)
GREEN TAG
G0, G1, G2, G3 . . .
progeny testing; traits proven heritable
progeny testing; traits proven heritable
Tested Class
(inbreds, synthetics, manipulated accessions)
BLUE TAG
G0, G1, G2, G3 . . .
Tested Class
(unrestricted natural accessions)
BLUE TAG
G0, G1, G2, G3 . . .
multiple location/year testing
multiple location/year testing
Variety/Cultivar
(uniform and stable germplasm)
WHITE TAG: B, F
PURPLE TAG: R
BLUE TAG: C
Variety/Cultivar
(unrestricted natural accessions)
WHITE TAG: B, F
PURPLE TAG: R
BLUE TAG: C
Purposeful or Inadvertent Genetic Manipulation
Unevaluated
GEOGRAPHIC ADAPTATION/MARKET POTENTIAL
Proven
Immediate Use
DEVELOPMENT TIME FRAME
Multiple Data Years

Spring After Grass Planting

Spring After Grass Planting

- Timing – Later spring – 50% of rosettes are 2-3 inches
- 10 oz MCPA + 8 oz Buctril + 1 oz R-11
  - Add 0.2 oz Express for purple mustard control

Summer After Grass Planting

- Depending spring rain, a follow-up application or mowing is often required to control weed flushes

Forb Inter-seeding

- Forbs are drilled the fall after grass seeding

Forb Seed Mixes

Forb Species	Ecotypes	Lbs/Ac
Arrowleaf balsamroot	Spokane River	0.8
Silky lupine	Spokane River	0.4
Threadleaf fleabane	Duffy Creek	0.2
Nineleaf biscuitroot	Columbia Basin	0.3
Lewis' flax	Columbia	0.8
Sulfur buckwheat		0.4
Western Yarrow	Methow	0.1
	TOTAL	3

Forb Species	Ecotypes	Lbs/ac
Big sagebrush	Columbia Basin	0.2
Arrowleaf balsamroot	Red Mountain	0.5
Shaggy fleabane daisy	Duffy Creek	0.2
Creamy buckwheat	Duffy Creek	0.2
Lewis' flax	Columbia	0.2
Nineleaf biscuitroot	Columbia Basin	0.2
Silky lupine	Columbia Basin	0.3
Tapertip Hawksbeard		0.2
	TOTAL	2

Follow-Up Weed Control

- Spot spraying
- Mowing

Three Years Post Seeding

Notes on Forb/Shrub Inter-seeding

- Species readily established by seed include:
  - Fleabane daisies
  - Balsamroot
  - Yarrow
  - Silky lupine
  - Lewis' flax
  - Sagebrush

Notes on Forb Inter-seeding

- Unlike most grasses, many forb seeds are dormant
  - Balsamroot – 90 day cold-stratification

Carey's balsamroot

Estimated Cost Per Acre

TREATMENT	Per Acre Cost
Summer mowing	$18
Fall harrowing	$12
Spring Spraying (Chemical + Application)	$27
Summer sweep chisel	$14
Summer Spraying (Chemical + Application)	$17
Year 1 Planting (Grass seed + Drill Seeding)	$100 - 115
Spring Spraying (Chemical + Application)	$17
Year 2 Planting (Forb/Shrub Seed + Drill Seeding)	$120+

Summary

- Involves a multi-year, aggressive process
- Site preparation takes approx 15 months, and involves at least 4 steps
- Staged plantings are encouraged
- More forbs needed!!
- Once established, have patience….


Questions??

On-farm needs and post-fire fates of bees that pollinate our restoration forbs

James H. Cane
U.S. Department of Agriculture
Agricultural Research Service
Pollinating Insect Research Unit
Utah State University, Logan, Utah, USA


Wind-pollinated
Sagelands
VINEYARD
FOUR CORNERS
CABERNET SAUVIGNON
COLUMBIA VALLEY

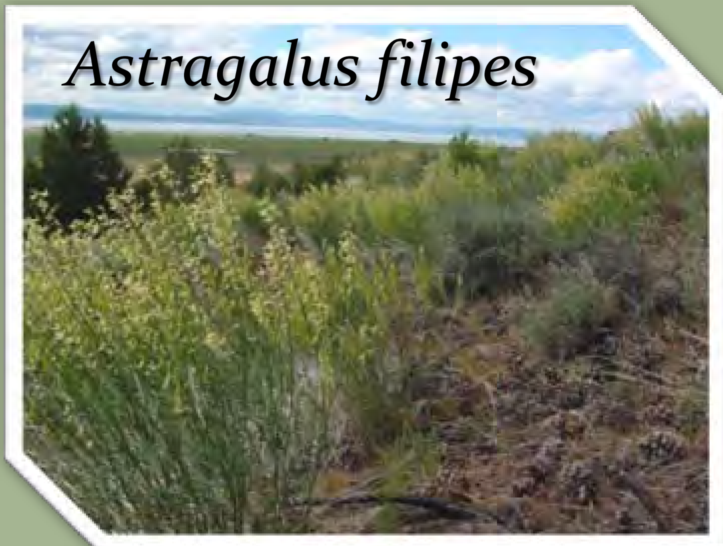
"The management implications are that sustainability of these [sagebrush] eco-systems will depend on maintaining or restoring the perennial herbaceous species."

Chambers et al. 2007. Ecological Monographs 77:117-145.


Hedysarum boreale seed field


Penstemon cyaneus
seed production field

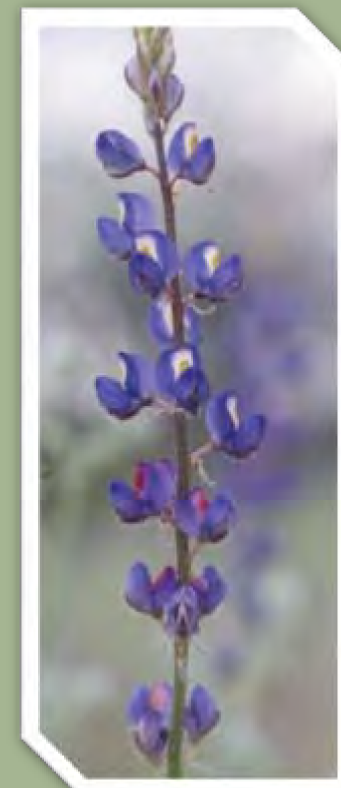
Fabaceae (legumes)



Astragalus filipes

Hedysarum boreale

Lupinus



Dalea

Asteraceae

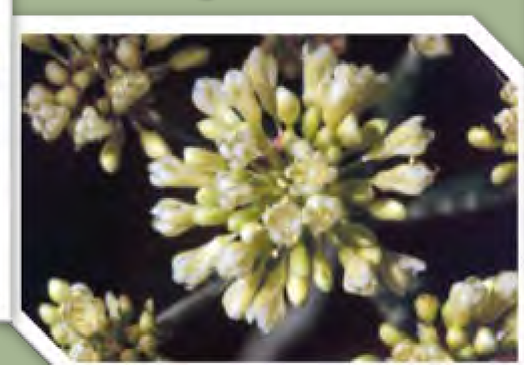

Crepis
(Asteracae)


Balsamorhiza
sagittata

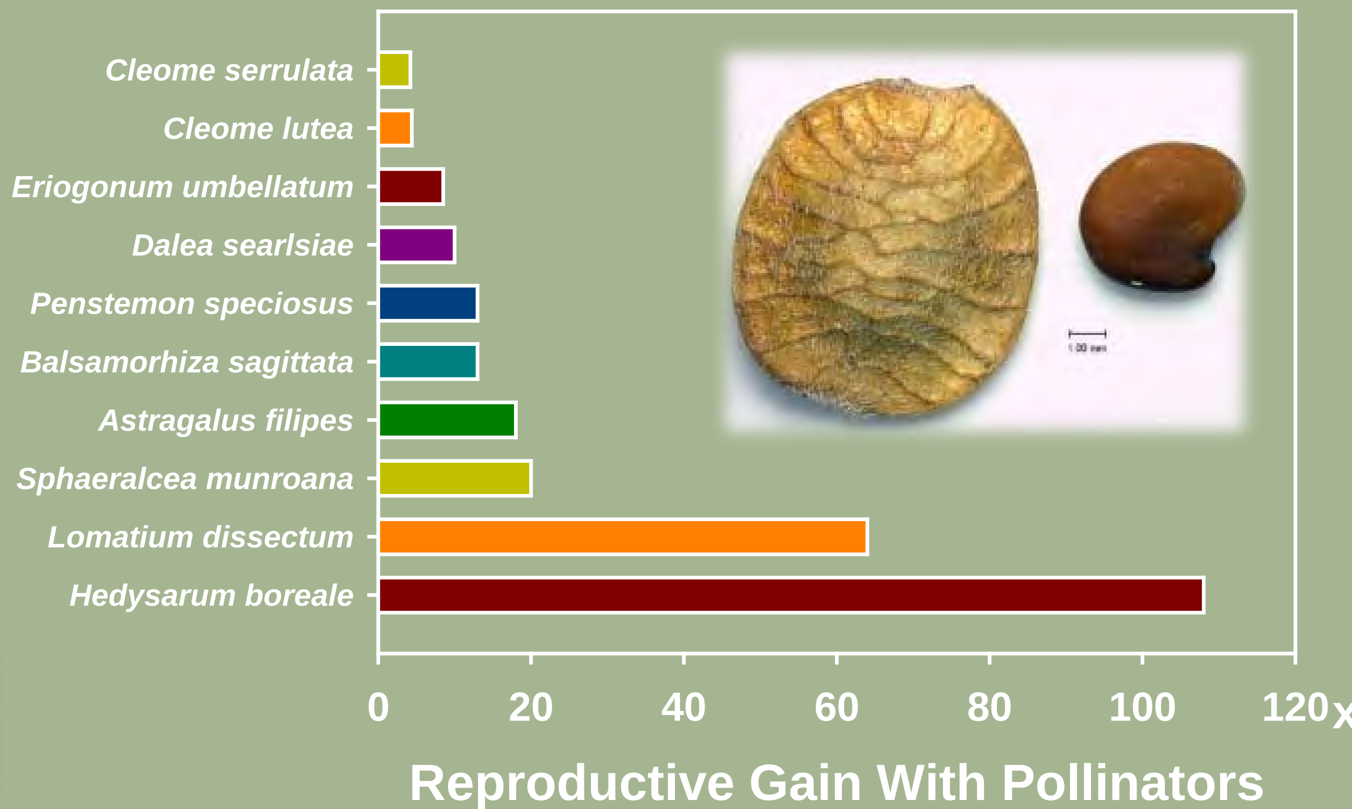

Chaenactis
douglasii

Familial hodgepodge

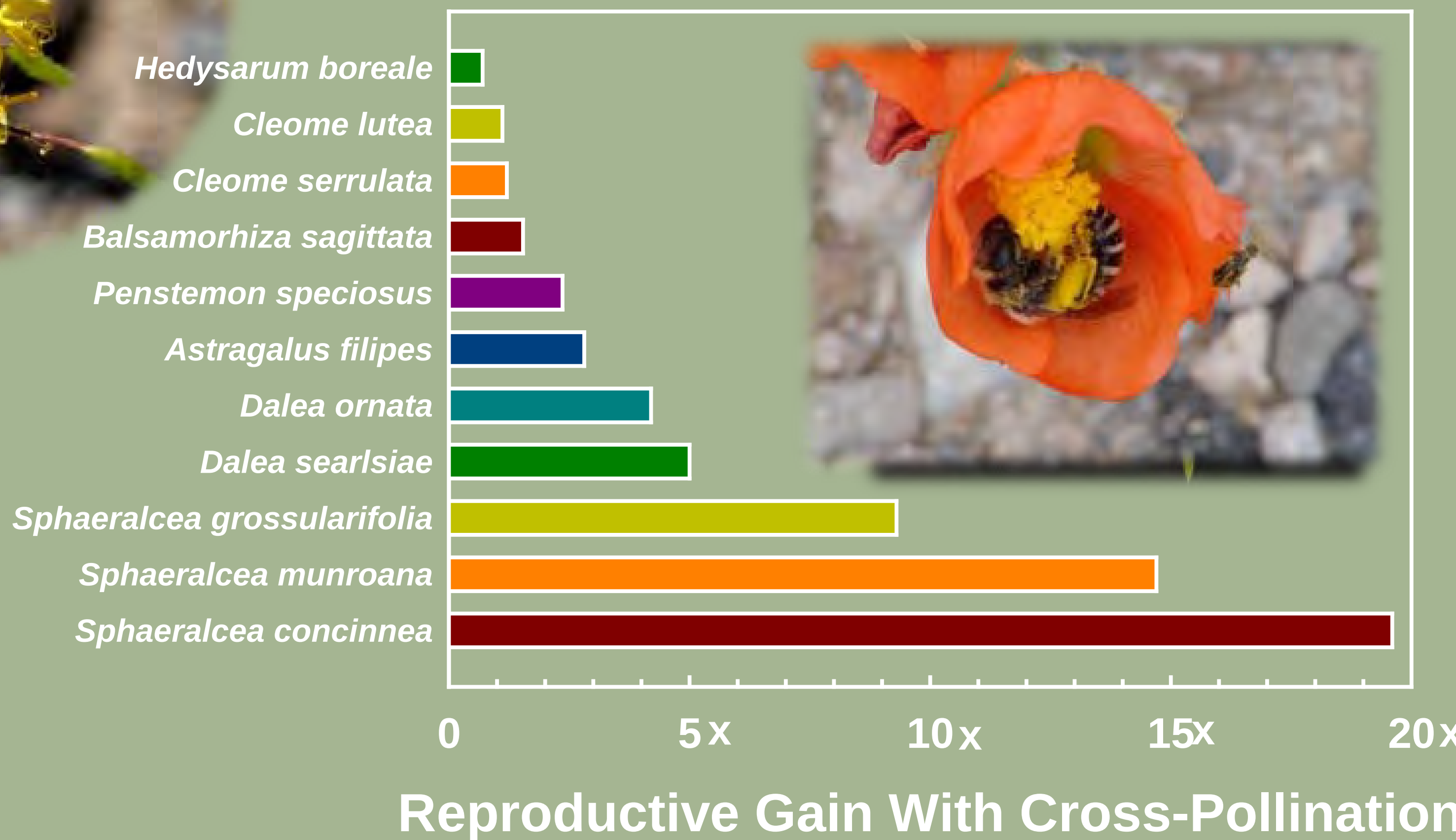
Eriogonum



Need for pollinators



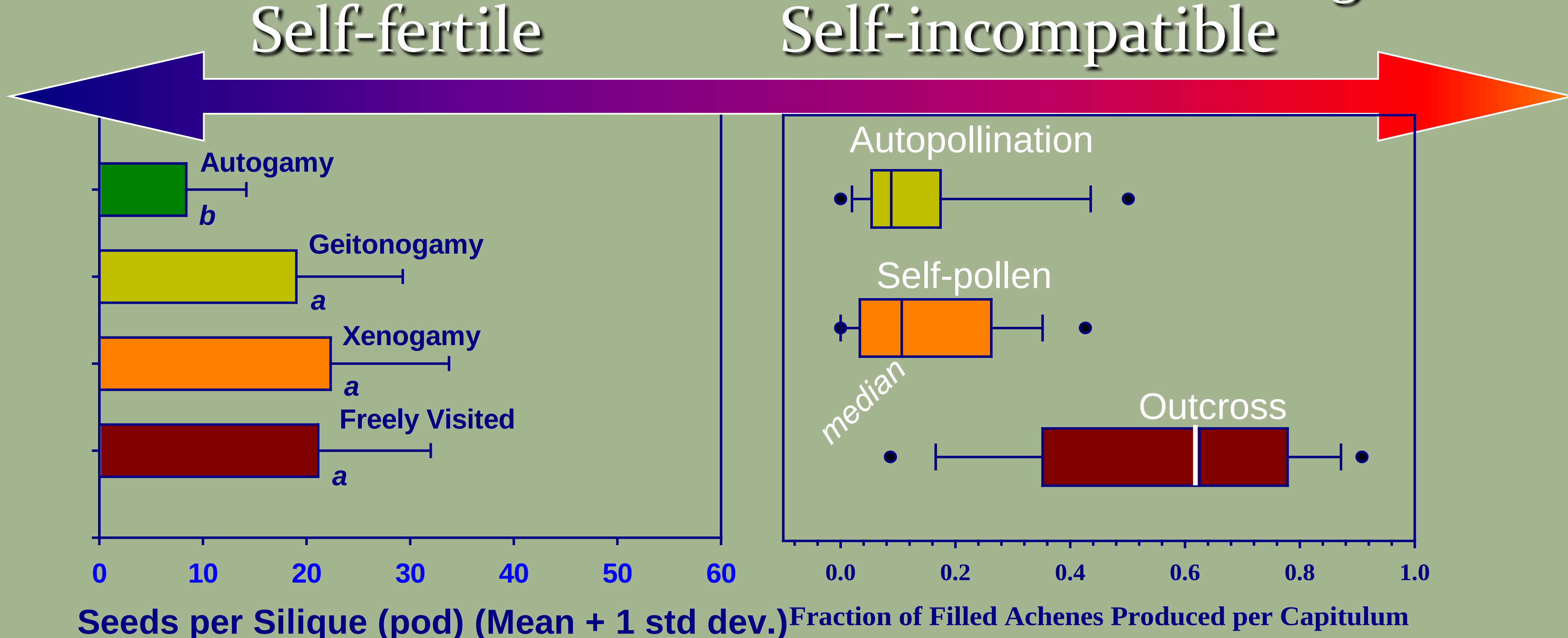
Benefits of cross-pollination



Outcrossing Advantage

Cleome serrulata

Chaenactis douglasii



Bees Rule, but with exceptions

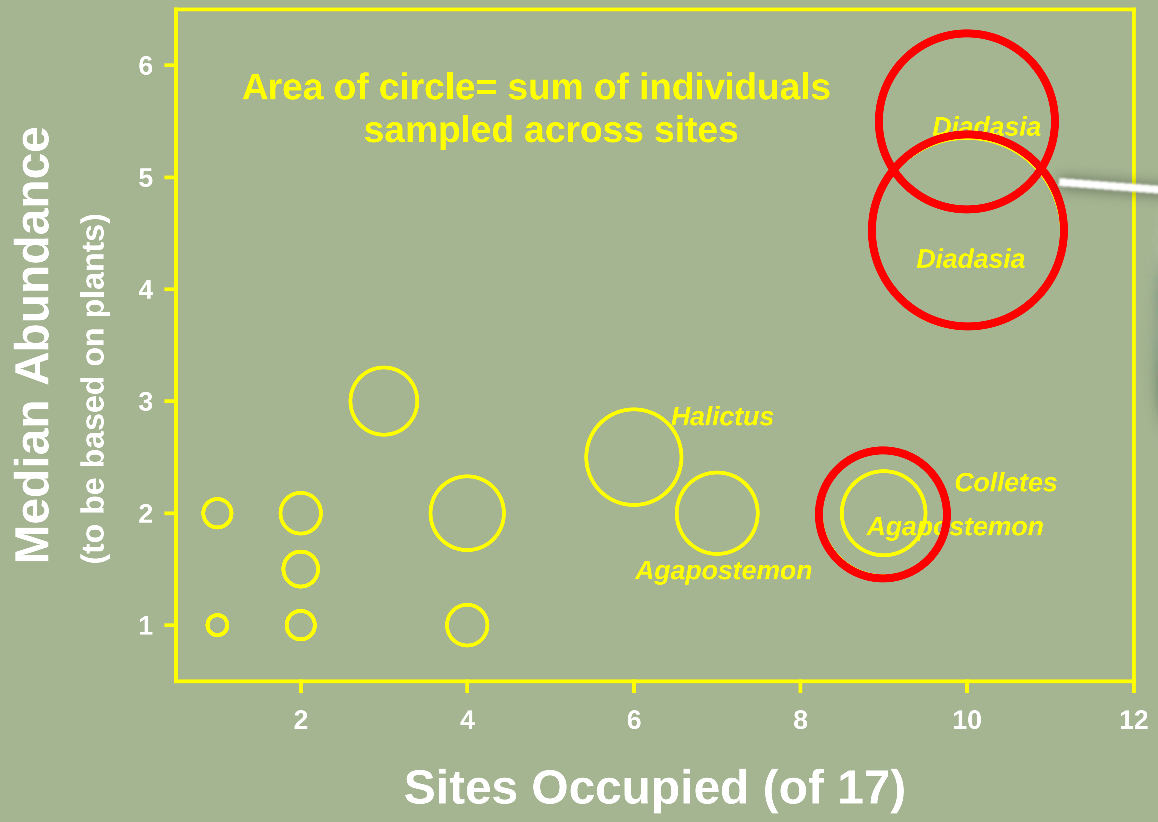
Pseudomasaris pollen wasps at *Penstemon*

Syrphids, other flies at *Lomatium*

Plants share some bees

Hedysarum boreale

Other plants depend on specialist bees



Diadasia diminuta at *Sphaeralcea*

Multiplying wild specialists : *Diadasia*

Deliver 33-45 pollen grains per stigma

Bees for Farming Native Forbs

- Hived **honeybees**, useful for pollinating several wildflower species
- Often not best, but usually much better than no bees

Bees for Farming Native Forbs

- **Alfalfa leaf-cutting bees** useful for several summer-blooming species such as *Dalea*

Wild Bees for Farming Native Forbs

- **Other *Osmia*** bees can be managed to pollinate various Fabaceae, Asteraceae and more

Osmia sanrafaelae nest in straw

17,000 progeny in 2010

Nesting shelter with nesting holes

Bees for Farming Native Forbs

- ***Stewardship of wild bees that you can't manage***

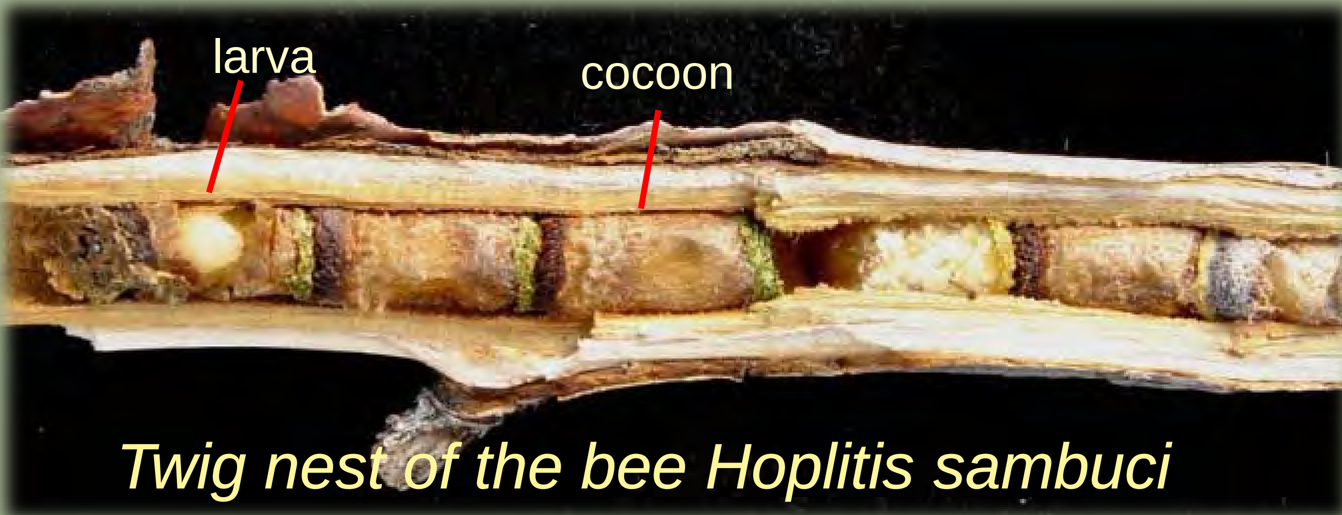
- May multiply on other cultivated flowering species

Seed predators (weevils , other beetles)

Weevil exit hole in seed of *Hedysarum*

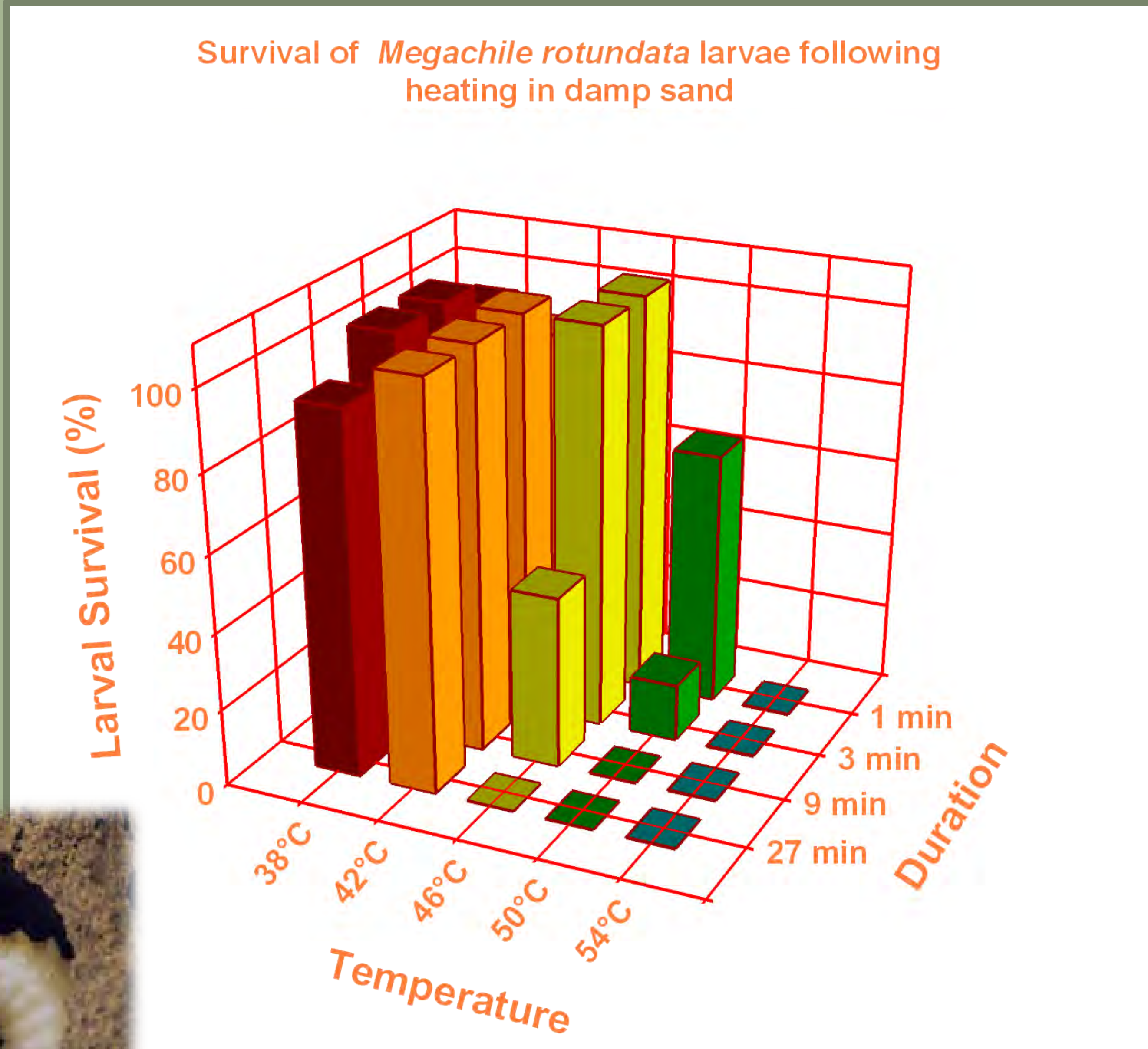
Weevils that attack *Dalea* seed


Fates of wild bee
communities after fire

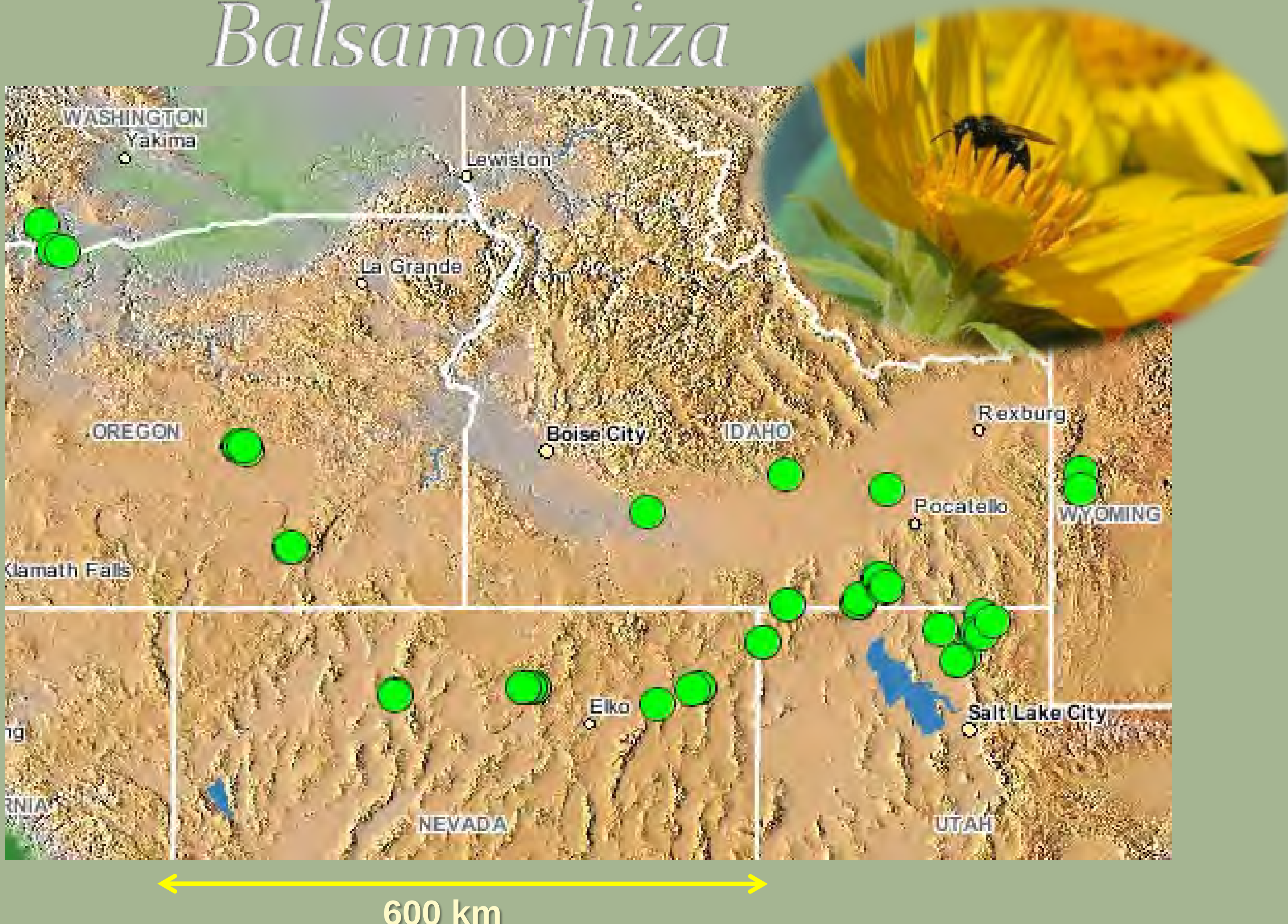


Twig nest of the bee Hoplitis sambuci

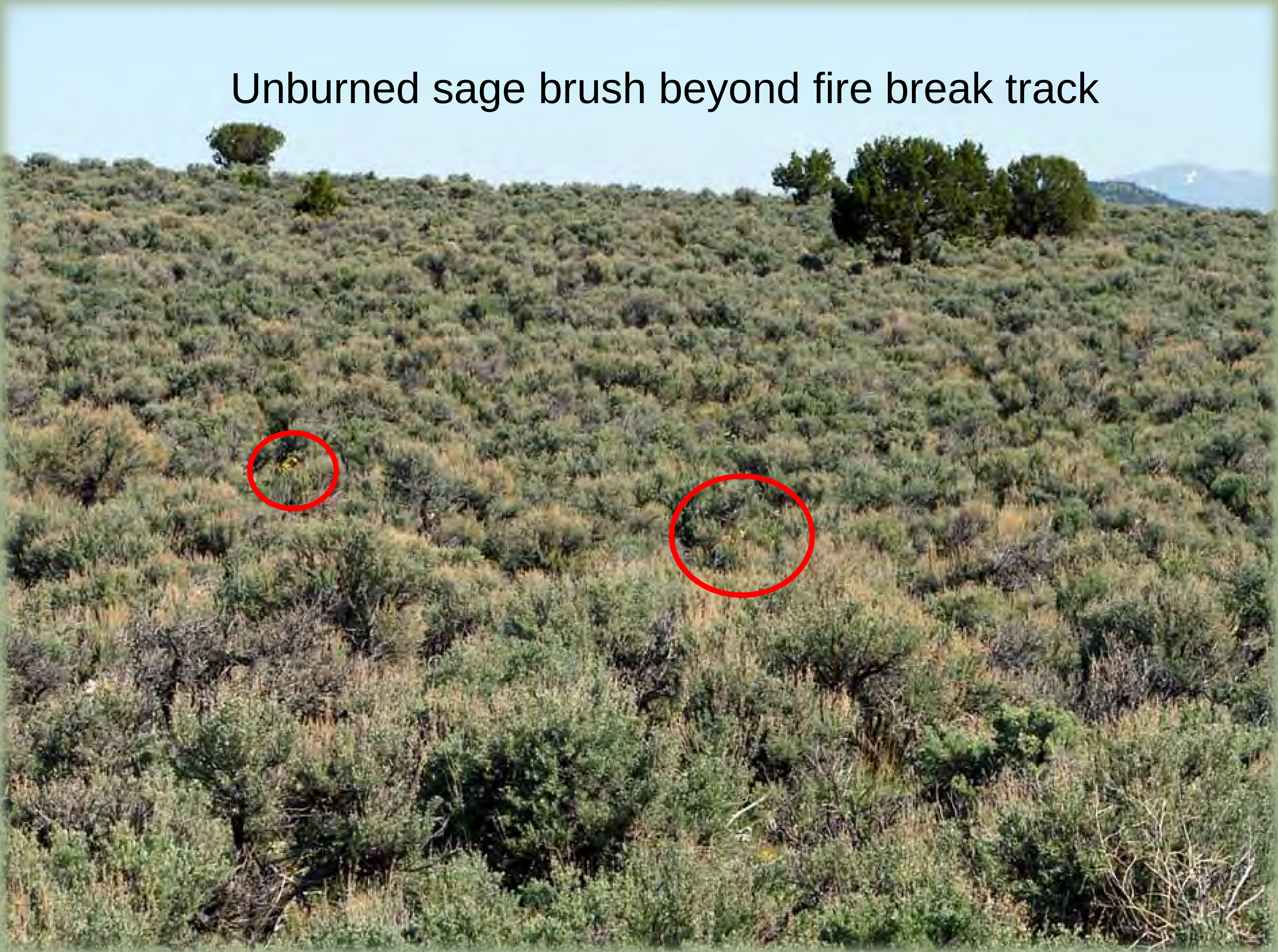
>85% of bee species nest in the ground

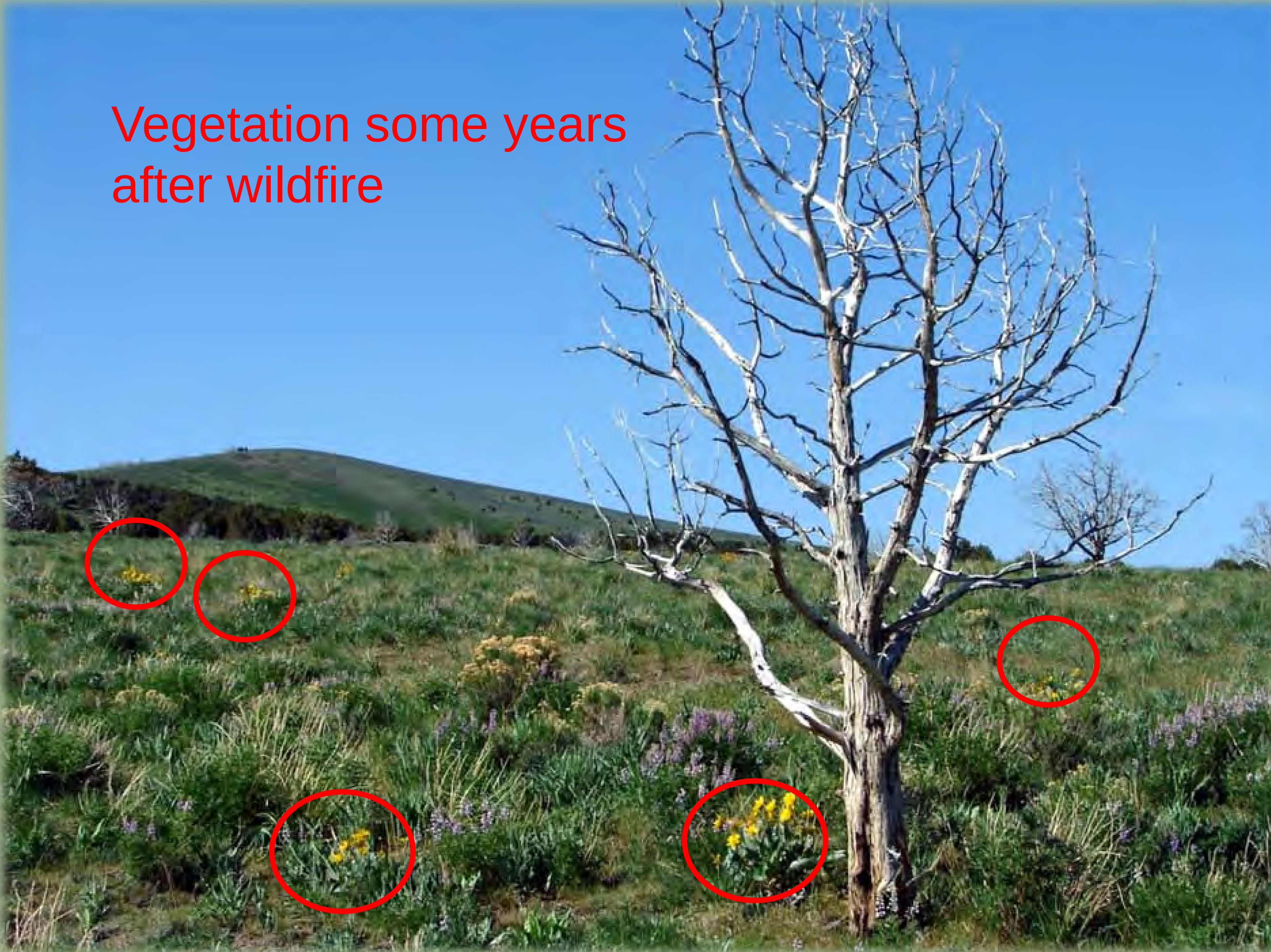


Balsamorhiza



Unburned sage brush beyond fire break track



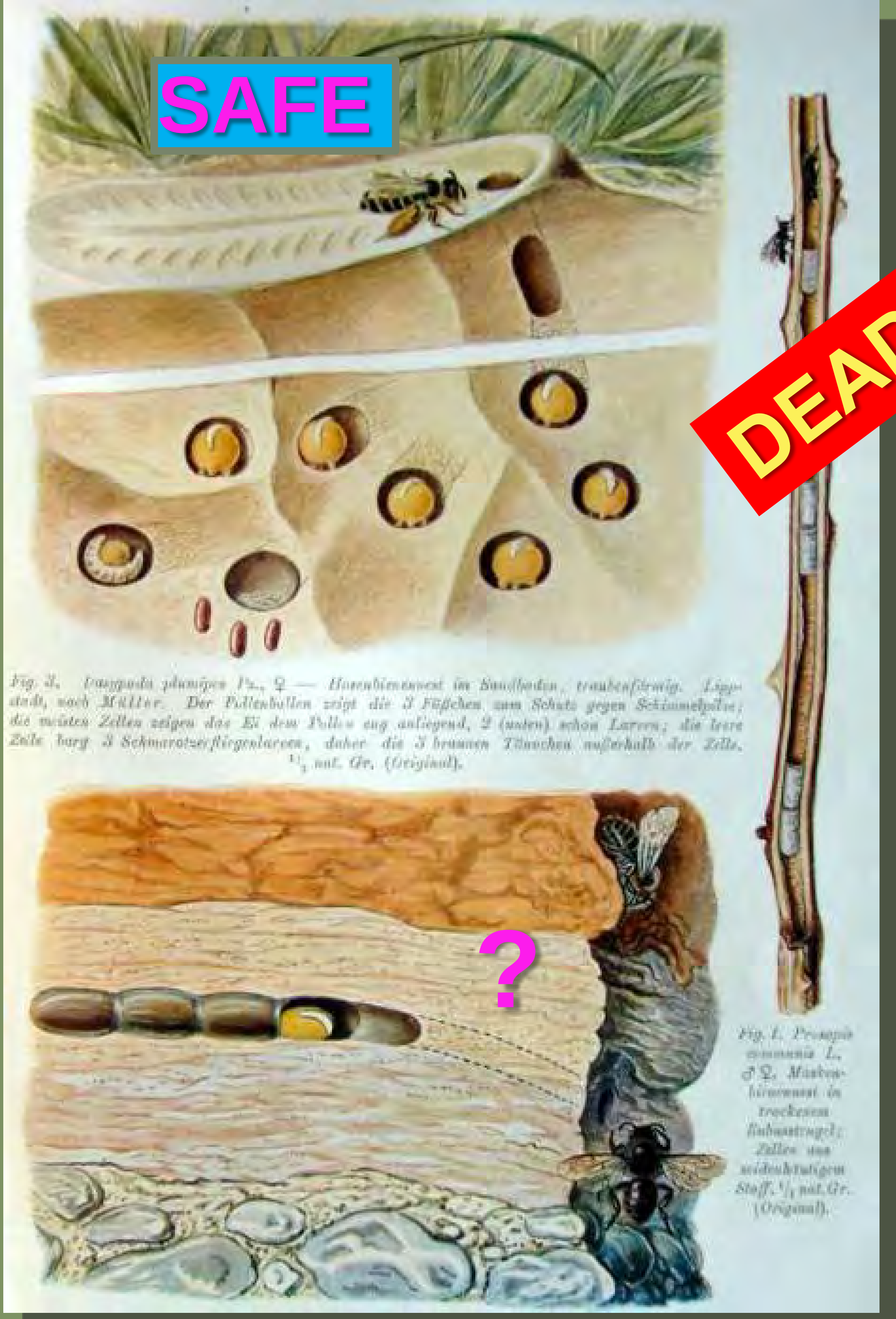

Vegetation some years
after wildfire

	Intact	Burned '08
Bees sampled	40	39
Plants surveyed	71	65
% *Osmia*	70%	77%

Osmia californica

- 54 native bee species in total
- 20 other paired sites in 5 state region
- fire chronosequence of 20 years

For much much more, see poster by Byron Love



Fates of Bees after Fire

Conclusions for American sage-steppe

- Dominant wildflowers need bees for pollination
- Cannot predict pollination needs or pollinators
- Seed growers need bees
  - honey bee, sometime cases alfalfa leaf-cutting bee
  - managed cavity-nesting native *Osmia*
  - wild bees
- Ground-nesting bees predominate, survive fire
- Bee communities need bloom year after fire

Indispensable Worker Bees

- Stephanie Miller
- Byron Love
- Melissa Weber
- Katie Swoboda
- Kristal Watrous
- Glen Trostle
- Summer students

GREAT BASIN
Restoration Initiative

Does Plant Taxonomy Represent Toxic Risk?

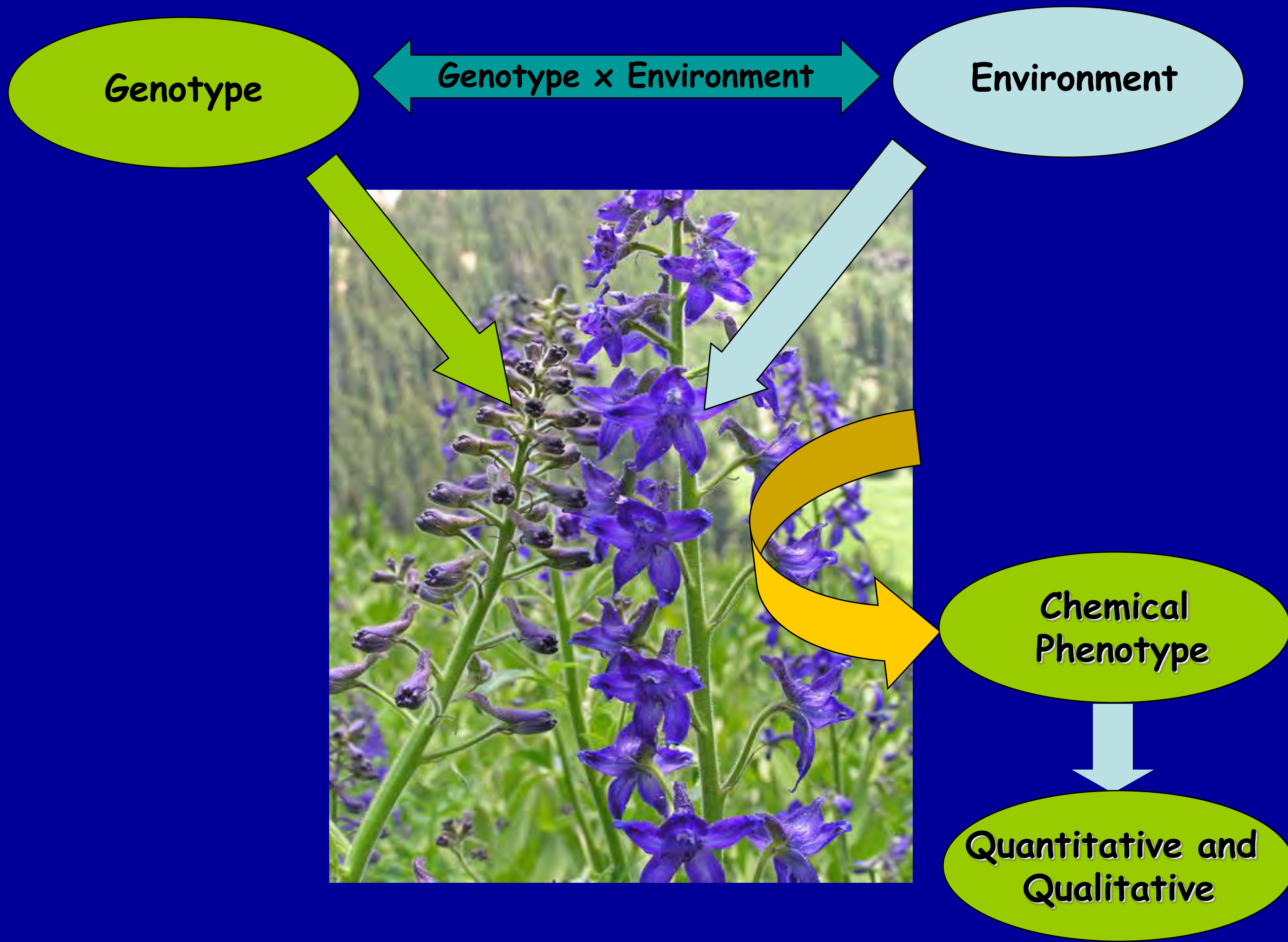
Daniel Cook

USDA ARS
Poisonous Plant Research Laboratory
Logan, UT

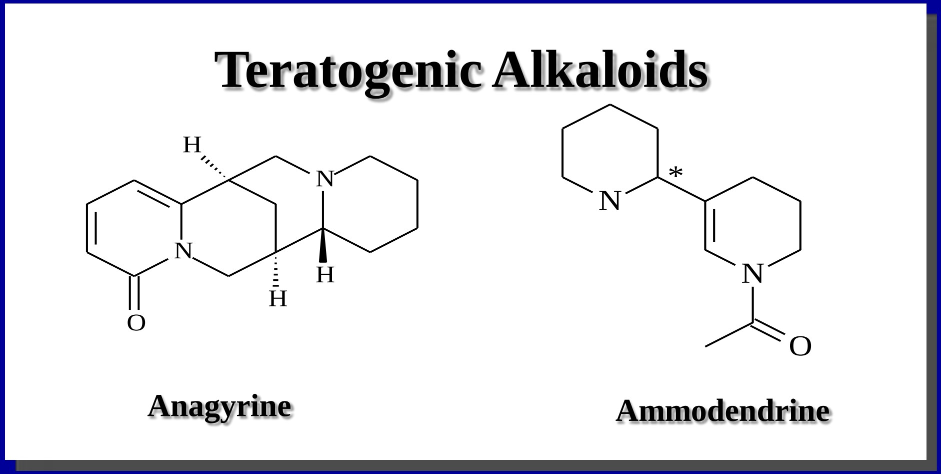
The Dose Makes the Poison

"All substances are poisons;
there is none which is not a poison.
The right dose differentiates a poison from a remedy."

Paracelsus (1493-1541)


Genotype
Genotype x Environment
Environment
Chemical Phenotype
Quantitative and Qualitative

Lupine Induced Crooked-Calf Disease



-Not all Lupine species contain the teratogenic alkaloids

-Species are not uniform in their alkaloid composition

Malformations occur during days 40-100 of gestation

Lupine Induced Crooked-Calf Disease

Teratogenic Effects

Torticollis

Cleft Palate

Kyphosis

Objective

To characterize the alkaloids profiles of *L. sulphureus* throughout its geographical distribution

Experimental Design

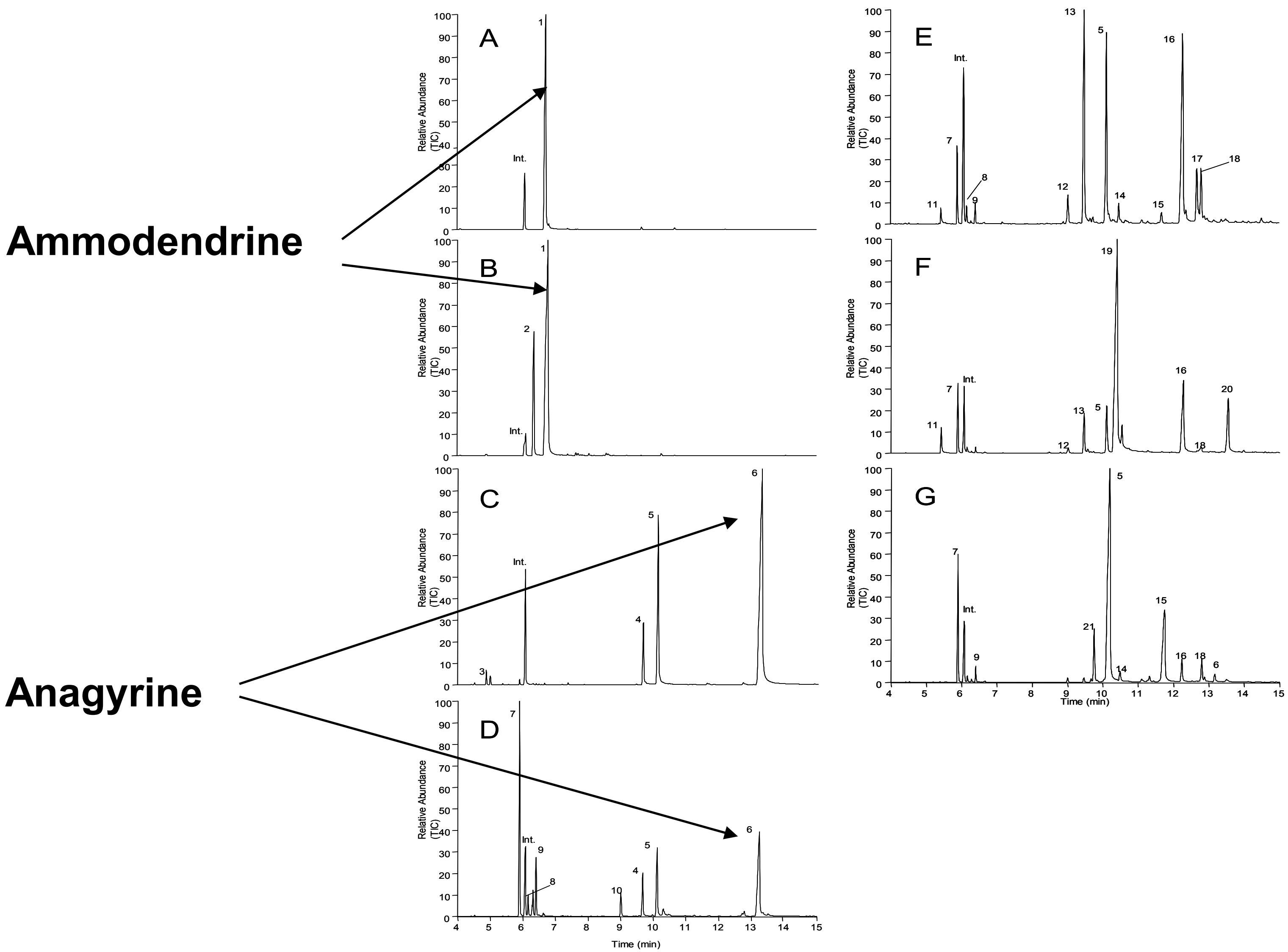
-Plant Material
- -Field Collections – 4 to 6 plants per population
- -Herbarium Specimens from cooperating herbaria

-Alkaloids Extracted and analyzed
- -GC/FID for fingerprint determination
- -GC/MS for alkaloid identification

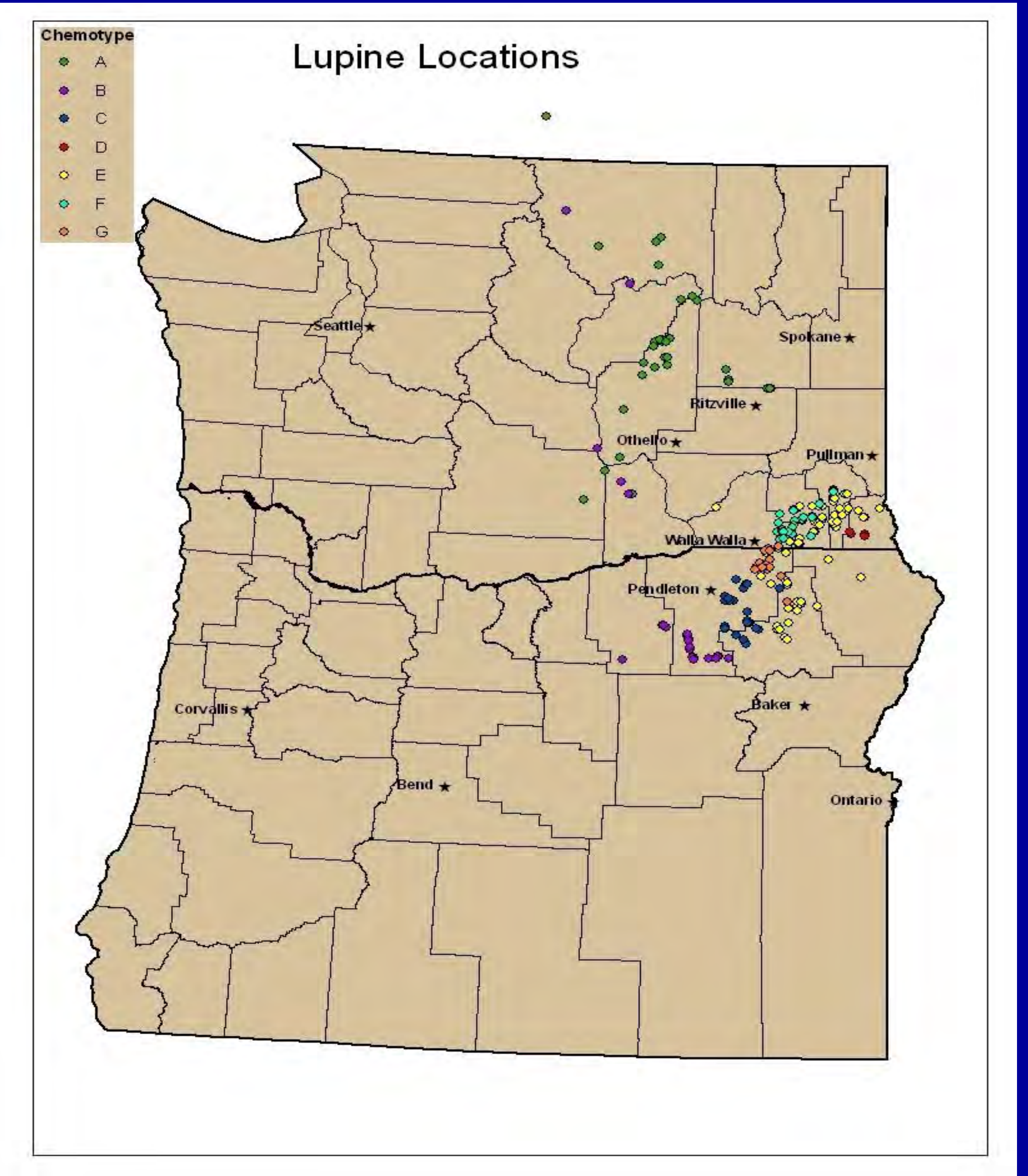
-Fingerprints were defined by presence or absence of major alkaloids

Chemotypes of *Lupinus sulphureus*

Teratogenic | **Non-Teratogenic**



Distribution of *Lupinus sulphureus* chemotypes



Tall larkspurs

-Tall larkspurs: found in mountain habitat in the western U.S. - generally moist sites - 6,000 to 10,000 feet elevation

-Tall larkspur sites typically snow-covered during winter

-Tall larkspurs grow in forb-dominated sites; very nutritious forage and high carrying capacity

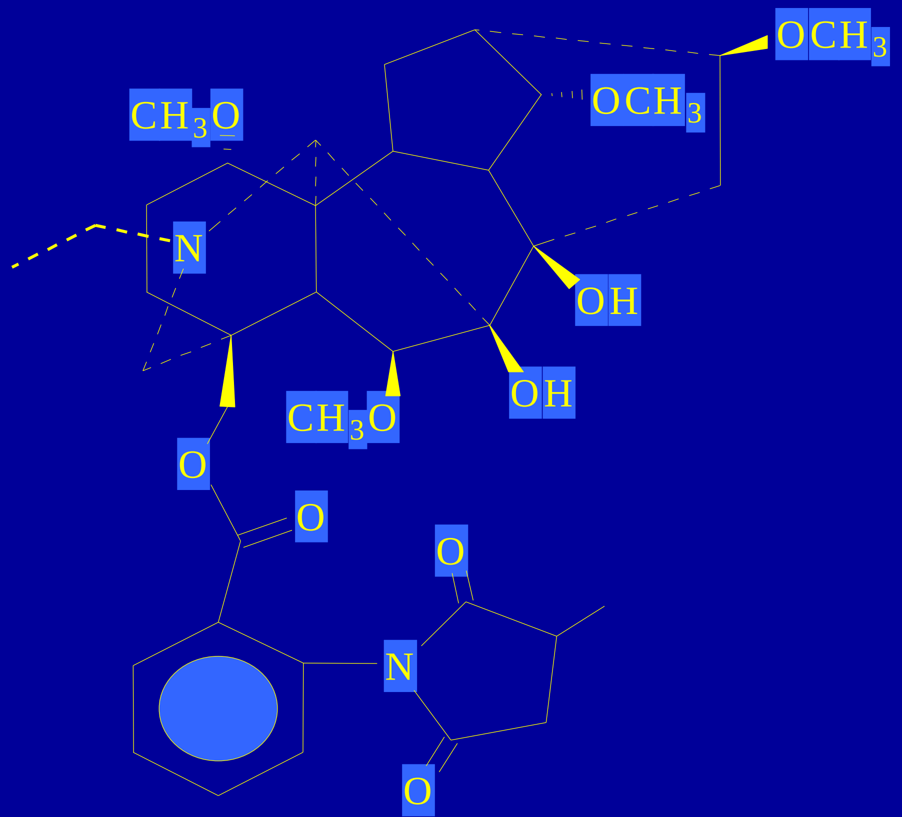
Clinical signs of larkspur poisoning

-Staggering gait
-Muscular trembles
-Periodic sternal then lateral recumbency (this can lead to death for various reasons)
-Difficulty breathing (rapid and shallow)
-Death occurs from respiratory paralysis and/or bloat

How Does Larkspur Kill cows?

Answer: Neuromuscular paralysis

Dominant toxic alkaloid in larkspurs



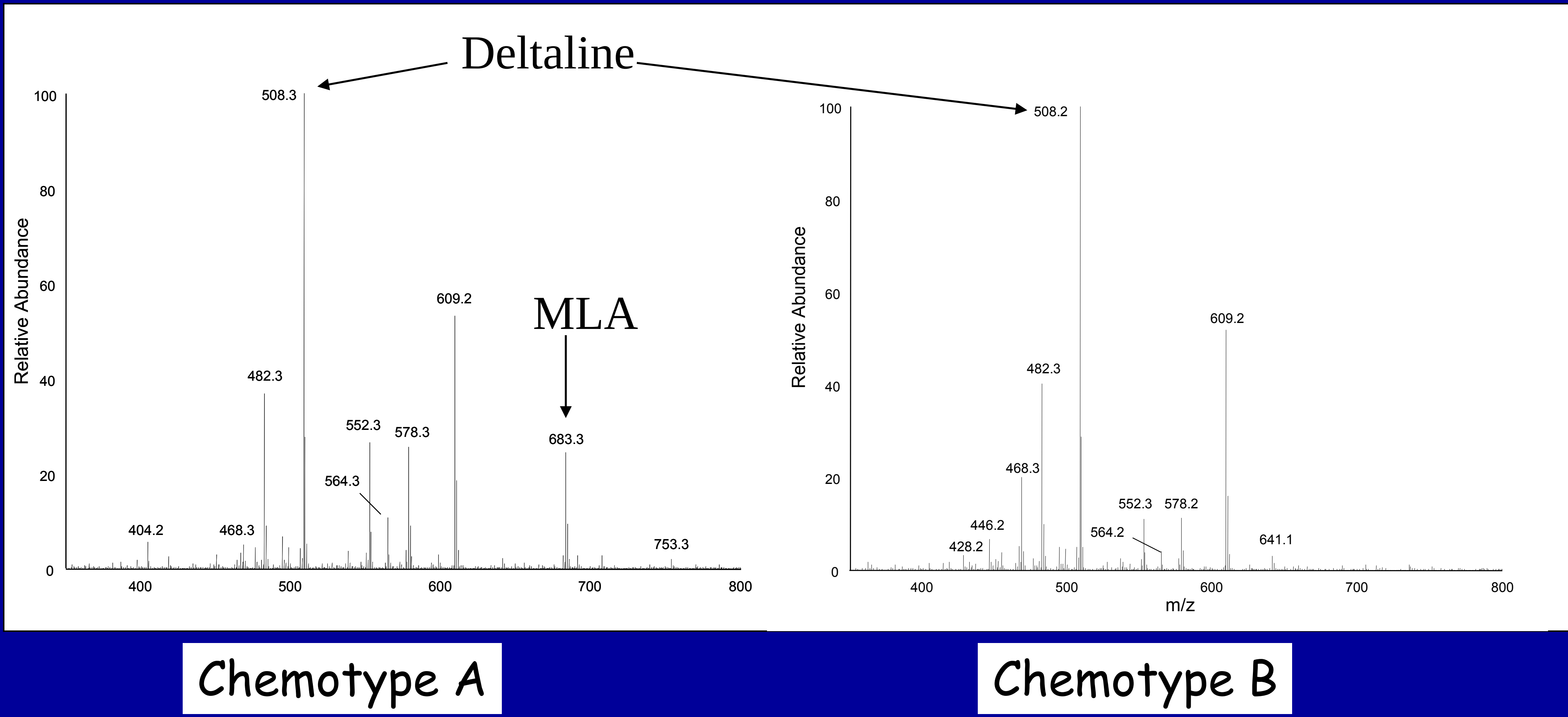
Methyllycaconitine

- There are numerous diterpenoid alkaloids in larkspurs (> 20)
- Ester function at C18 is very important for toxicity
- Deltaline most common alkaloid in tall larkspurs but not very toxic
  LD_{50}=110 mg/kg
- Methyllycaconitine = MLA
  LD_{50}=4 mg/kg

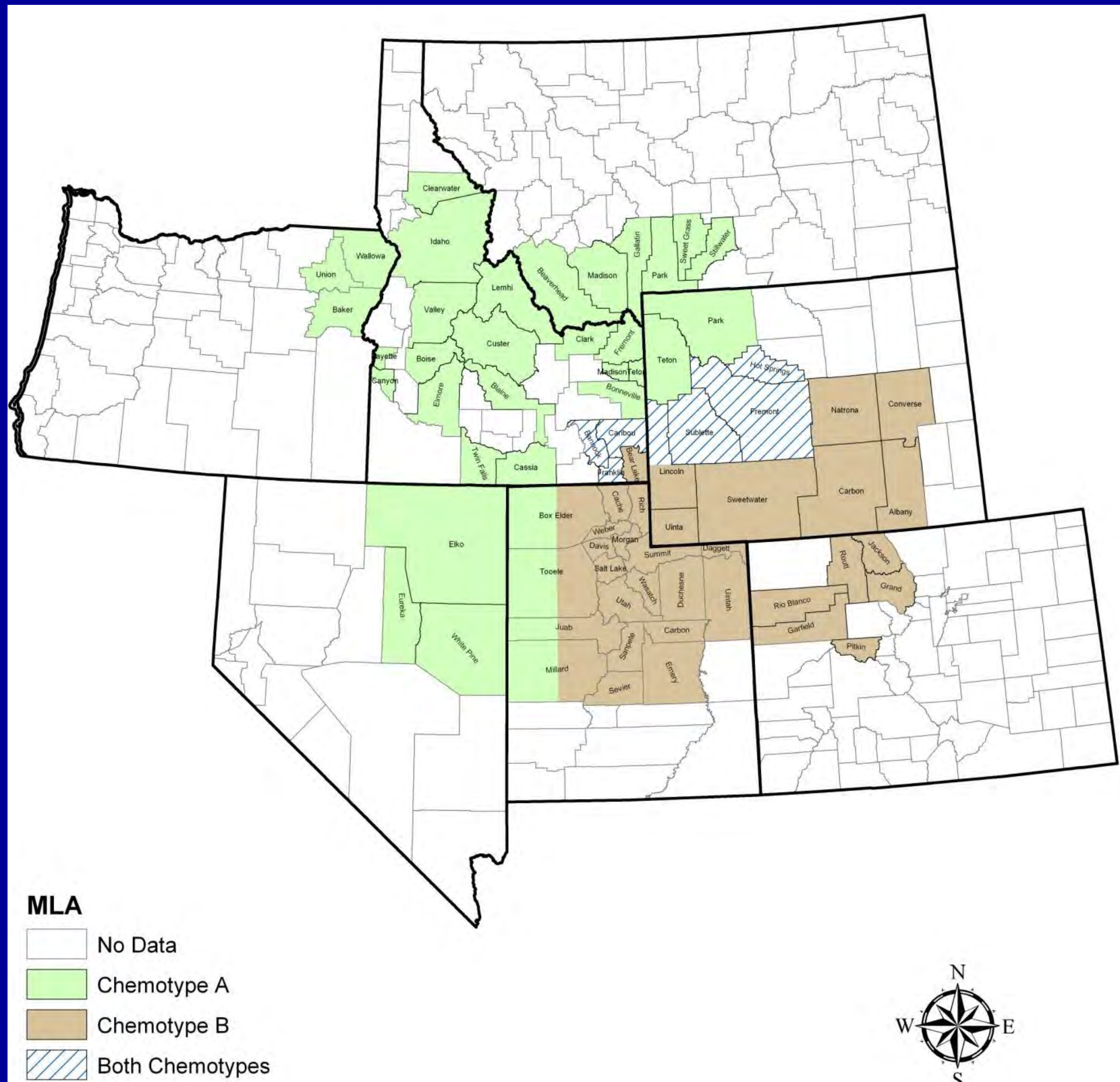
Objective:

To characterize the alkaloid profiles of *D. occidentale* throughout its geographical distribution.

Electrospray mass spectra from samples representing each chemotype of *D. occidentale*



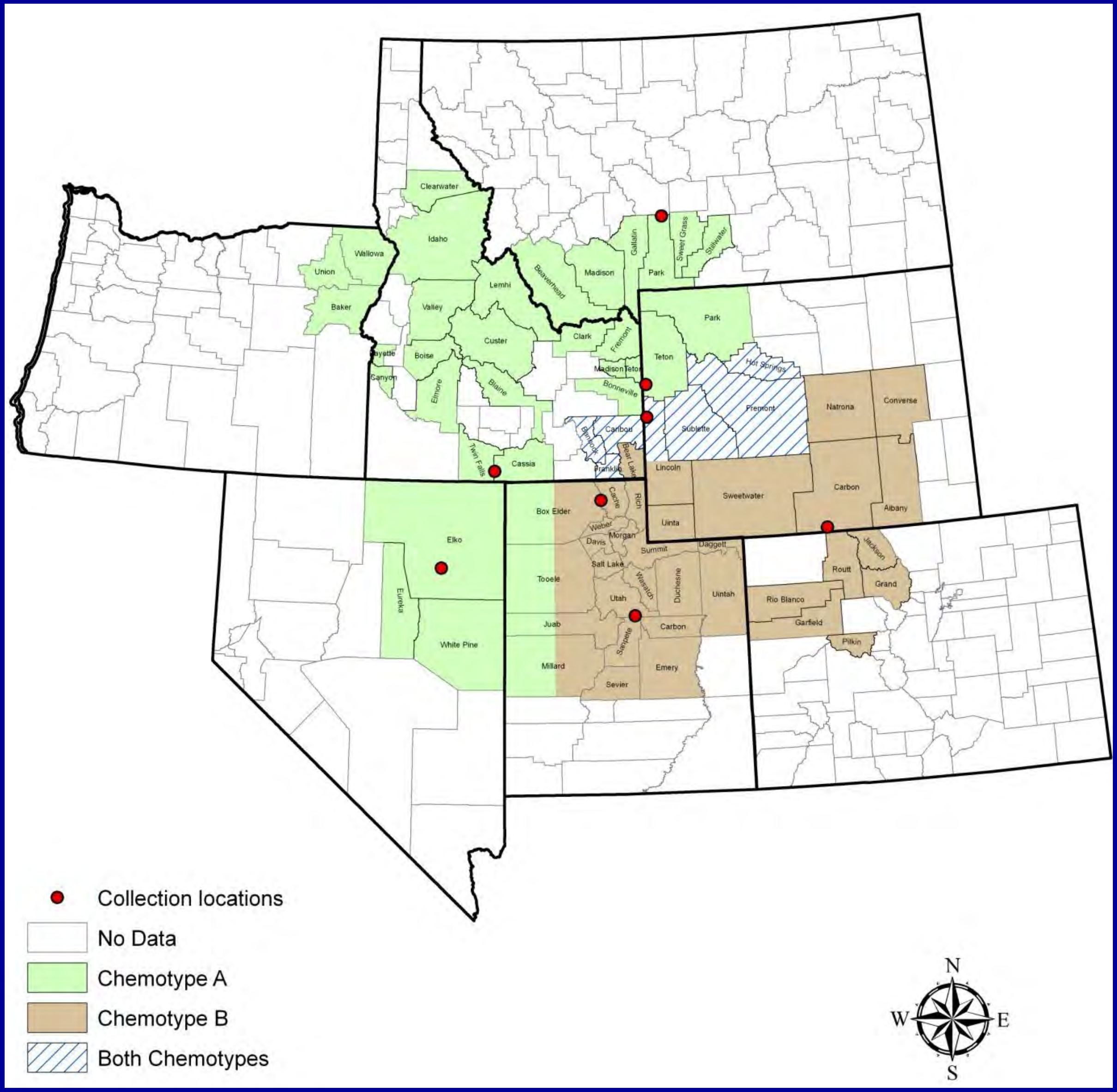
Distribution of chemotypes A and B of *D. occidentale*



Objective:

Do the chemotypes *A* (+MSAL) and B (-MSAL) of *D. occidentale* differ in their toxicity?

Collection Locations of chemotypes A and B of *D. occidentale*



Alkaloid composition of collections representing chemotypes A and B of *D. occidentale*

D. occidentale (City, State)	MSAL, mg/g	MDL, mg/g	Total Alkaloid, mg/g	MDL : MSAL
Wilsal, MT	2.7	8.0	10.7	3.0
Twin Falls, ID	2.9	5.3	8.2	1.8
Victor, ID	4.5	13.8	18.3	3.1
Elko, NV	6.3	11.1	17.4	1.8
Baggs, WY	0	14.7	14.7	
Fairview, UT	0	21.3	21.3	
Logan, UT	0	20.2	20.2	
Afton, WY	0	15.1	15.1	

Differential toxicity of chemotypes A and B of *D. occidentale* in mice

D. occidentale	LD_{50}		
(City, State)	mg Total Alkaloid / kg BW	mg MSAL / kg BW	plant material (g) / kg B.W.[2]
Wilsal, MT	9.6±0.8[c]	2.4 ±0.2[a]	0.9
Twin Falls, ID	6.2±0.6[d]	2.2 ±0.2[a]	0.8
Victor, ID	9.8±0.4[c]	2.4 ±0.1[a]	0.5
Elko, NV	6.2±1.4[d]	2.2 ±0.5[a]	0.4
Baggs, WY	60.8 ±2.8[a]	N.A.	4.1
Fairview, UT	58.1 ±2.4[a]	N.A.	2.7
Logan, UT	55.3 ±7.1[a]	N.A.	2.7
Afton, WY	42.7 ±6.0[b]	N.A.	2.8

Differential toxicity of chemotypes A and B of *D. occidentale* in cattle

D. occidentale		Dose (mg/kg BW)	Heart Rate (bpm)[2]		Exercise to Collapse[3]	
(City, State)	Animals (#)	Total Alkaloid (MSAL)	Time (0)	Time (24)	Y/N (#)	Time (min)
Victor, ID	8	37.6 (8.8 MSAL)	74.5 ±7.7	99.8 ±13.5[a]	Y (12)	17 ±9.9
Logan, UT	8	37.6 (0 MSAL)	77.4 ±11.2	84.2 ±8.7	N (12)	N.A.

Locoweeds

Astragalus and *Oxytropis* species that contain the toxin swainsonine

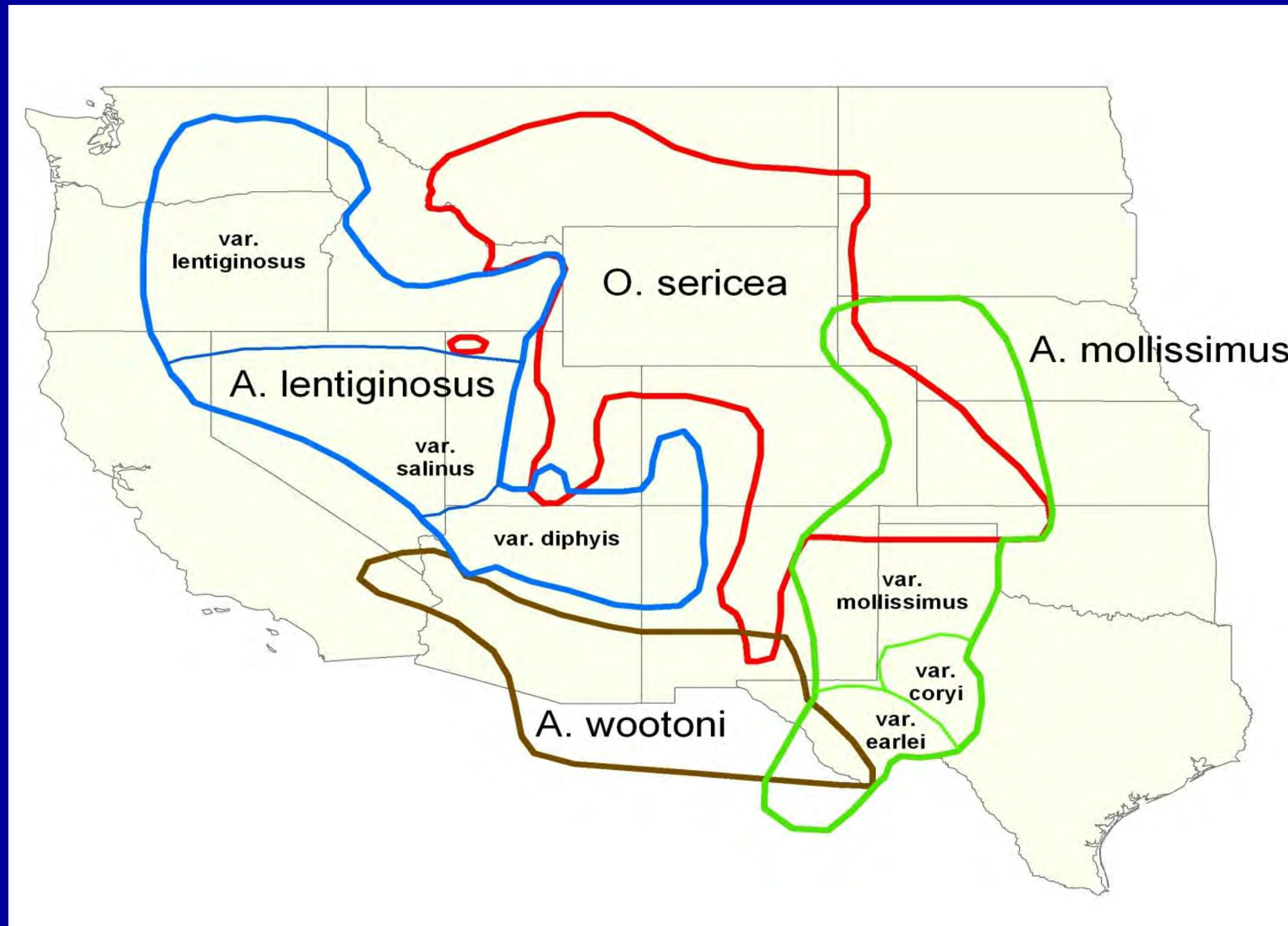
Oxytropis sericea
"White Point Loco"

Astragalus mollissimus
"Wooly Loco"

Astragalus lentiginosus
"Spotted Loco"

Two other toxic syndromes associated with Astragalus species: Selenium poisoning and nitrotoxins

Distribution of the Major Locoweed Species



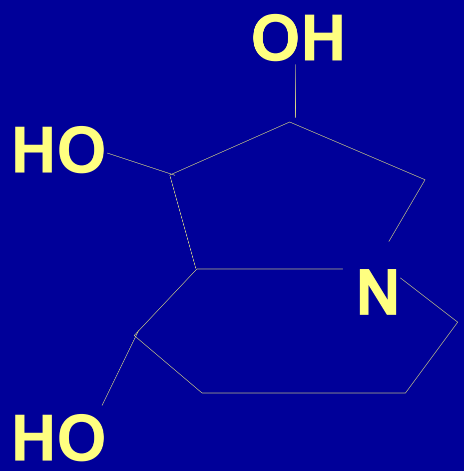
Rank Order of toxicity:

A. wootoni > A.mollissimus = A. lentiginosus > O. sericea

(garbancillo) (wooly loco) (spotted loco) (white point loco)

Locoweed Toxicology

Swainsonine



Inhibits

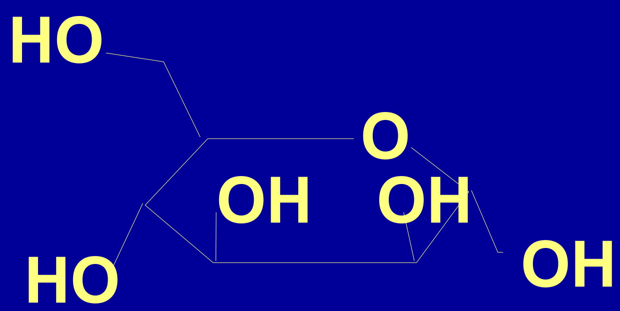
α -Mannosidase

Mannosidase II

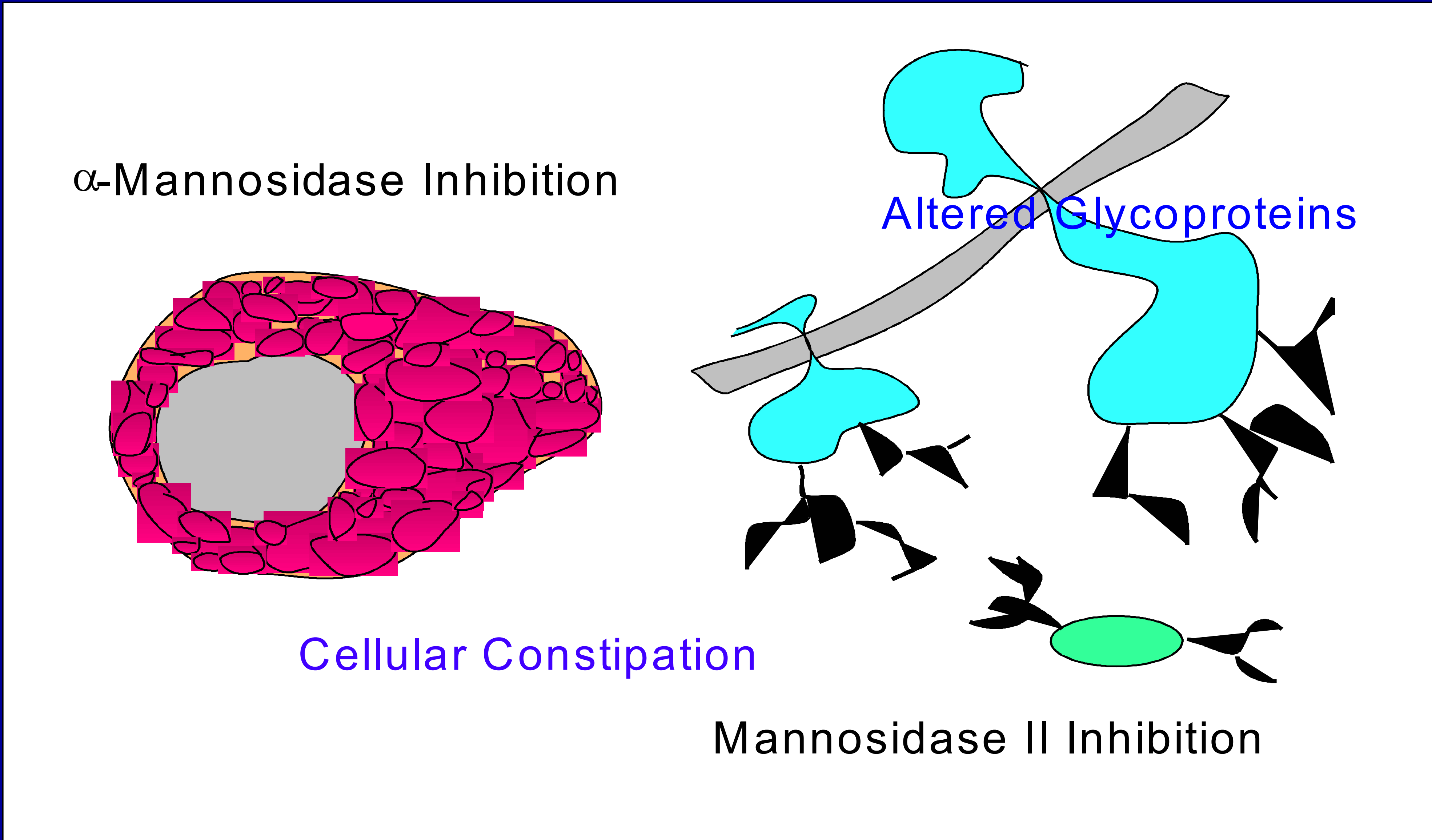
Lysosomal Storage Disease

Altered Glycoprotein Synthesis

D-Mannose



Locoweed Toxicology



Clinical Signs of Locoism

-Weight Loss

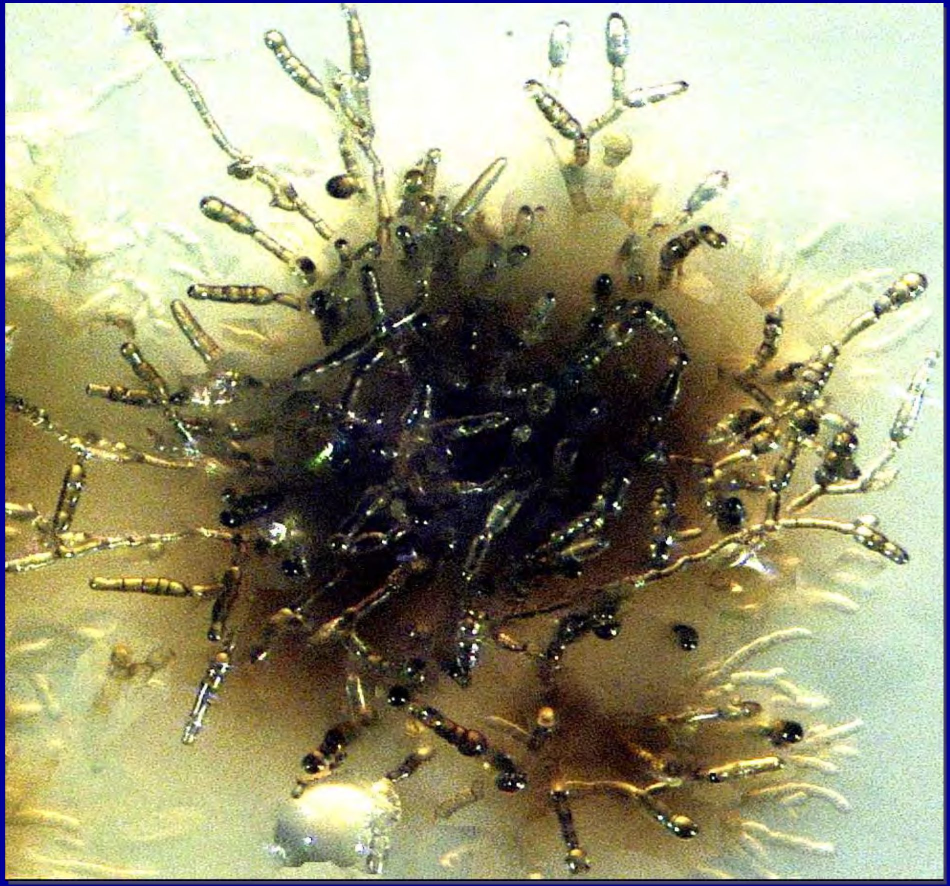
-Abnormal Behavior

-Reproductive Problems

-Wasting Type Condition

Locoweed Endophyte (*Undifilum oxytropis*)

- Fungal endophyte isolated from toxic locoweeds
- Produces swainsonine in culture
- Cultured from stems, leaves, seeds, and flowers of toxic field plants
- Localized to seed coat
- Embryo culture produces plants without swainsonine



Oxytropis lambertii and swainsonine

Table 3. *O. lambertii* Populations and Mean Swainsonine Concentration

location	*O. lambertii* var.	stage[a]	GPS coordinates	voucher no.[b]	mean[c] (% dry wt ± SD)	range
Meade, KS	*articulata*	pod	37° 10′ 09 N; 100° 23′ 03 W	27698	<0.0001	
Knowles, OK	*articulata*	early pod	36° 55′ 15 N; 100° 18′ 23 W	27689	<0.0001	
Buffalo, OK	*articulata*	pod	30° 48′ 44 N; 99° 46′ 22 W	27697	<0.0001	
Flagstaff, AZ	*bigelovii*	vegetative	35° 23′ 41 N; 111° 34′ 46 W	27665	0.054 ± 0.027	0.022–0.106
Springerville, AZ	*bigelovii*	vegetative	34° 00′ 49 N; 109° 10′ 48 W	27667	0.026 ± 0.021	0.0–0.065
Kingston, NM	*bigelovii*	vegetative	32° 52′ 51 N; 107° 51′ 55 W	27668	0.016 ± 0.013	0.0–0.043
Winston, NM	*bigelovii*	flower	33° 21′ 43 N; 107° 34′ 41 W	27669	0.038 ± 0.035	0.0–0.068
Kanab, UT	*bigelovii*	vegetative	37° 06′ 19 N; 111° 51′ 28 W	27661	0.008 ± 0.016	0.0–0.047
Ferron, UT	*bigelovii*	flower	39° 06′ 57 N; 111° 17′ 36 W	440983	<0.0001	
Fort Collins, CO	*bigelovii*	flower	40° 56′ 39 N; 105° 15′ 33 W	440980	0.0002	
Ocate, NM	*bigelovii*	pod	36° 15′ 11 N; 105° 02′ 32 W	27672	0.0006	
Capulin, NM	*bigelovii*	flower	36° 41′ 25 N; 104° 08′ 35 W	440981	0.0001	
Sophia, NM	*bigelovii*	flower	36° 28′ 06 N; 103° 59′ 54 W	440982	<0.0001	
Sidney, NE	*lambertii*	flower	41° 09′ 18 N; 103° 05′ 27 W	27704	0.0007	
Hot Springs, SD	*lambertii*	flower	43° 24′ 35 N; 103° 26′ 23 W	27717	0.0001	
Lusk, WY	*lambertii*	flower	43° 05′ 12 N; 104° 19′ 36 W	27721	<0.0001	

[a] Phenological growth stages. [b] Voucher specimens deposited in Monte L. Bean Herbarium, Brigham Young University, Provo, UT. [c] For those samples with initial swainsoine levels at <0.001%, a separate bulk sample was analyzed with quantitation down to 0.0001% (1 ppm) and the presence of swainsonine confirmed by GC-MS.

Oxytropis lambertii and swainsonine

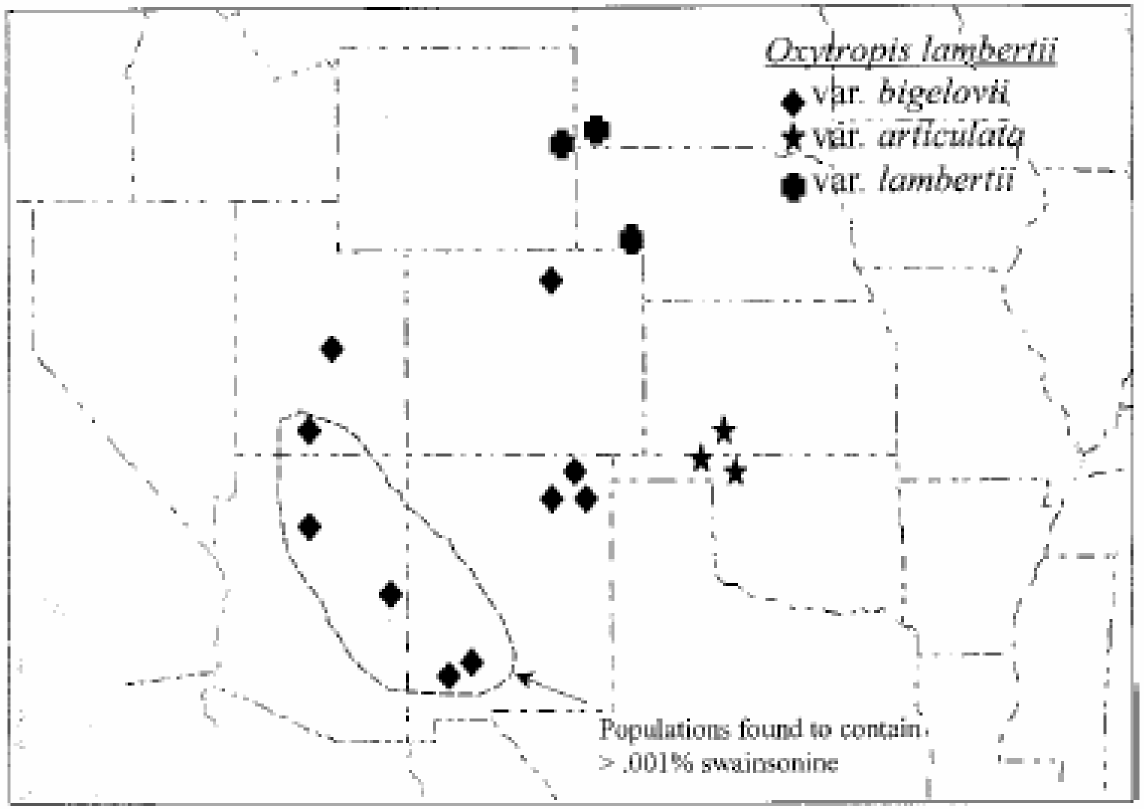


Figure 3. Map showing the 16 locations for collection of *O. lambertii* var. *lambertii*, *articulata*, and *bigelovii* from western United States.

Acknowledgements

-USDA ARS

-The PPRL staff

Maternal effects in *Poa secunda*: harnessing plasticity for maximum success

Erin K. Espeland
USDA ARS NPARL
Pest Management Research Unit
Erin.Espeland@ars.usda.gov

Outline

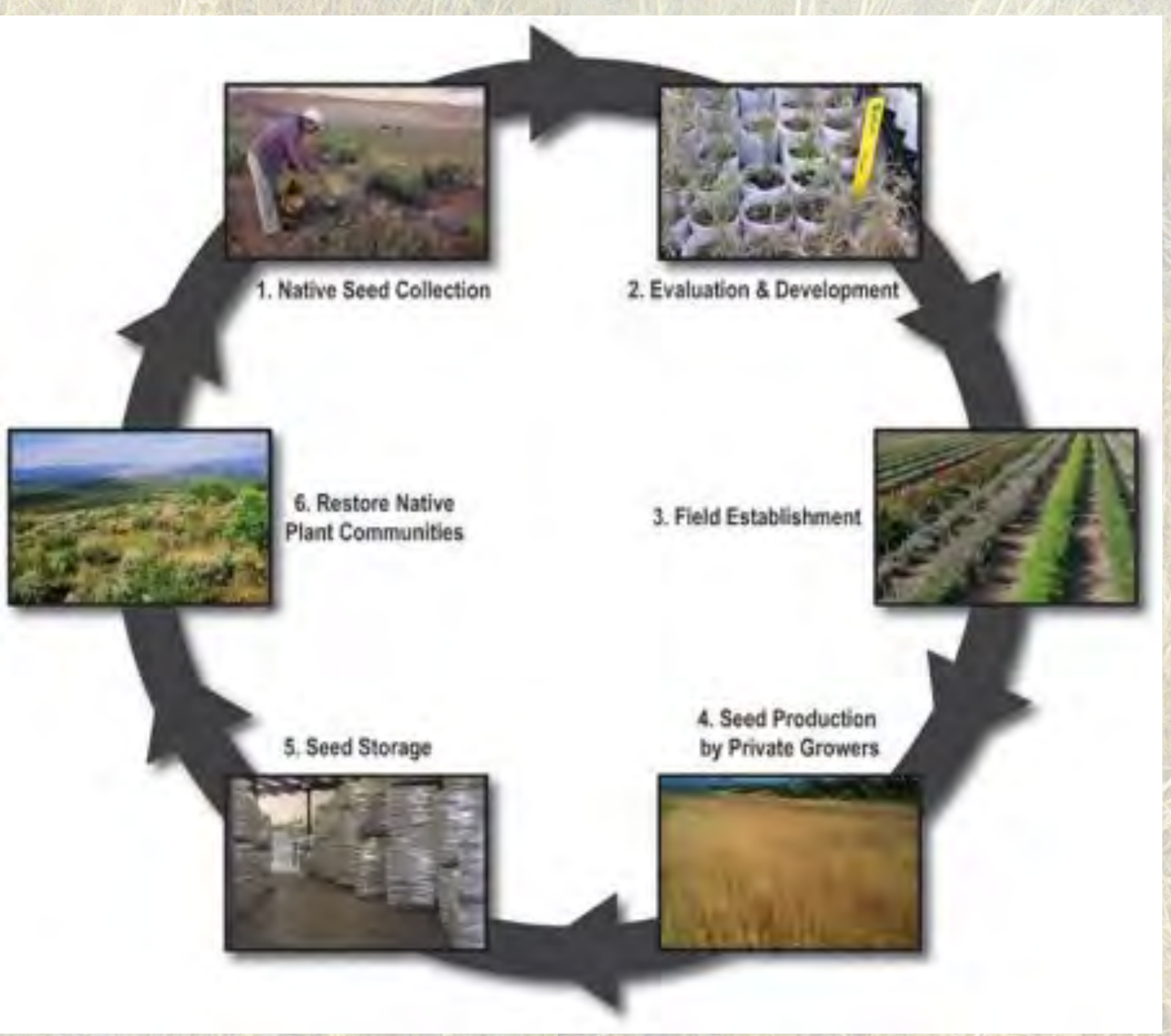
Background

What are maternal effects?

Examples of maternal effects

Specific research on *Poa secunda* (Sandberg's bluegrass)

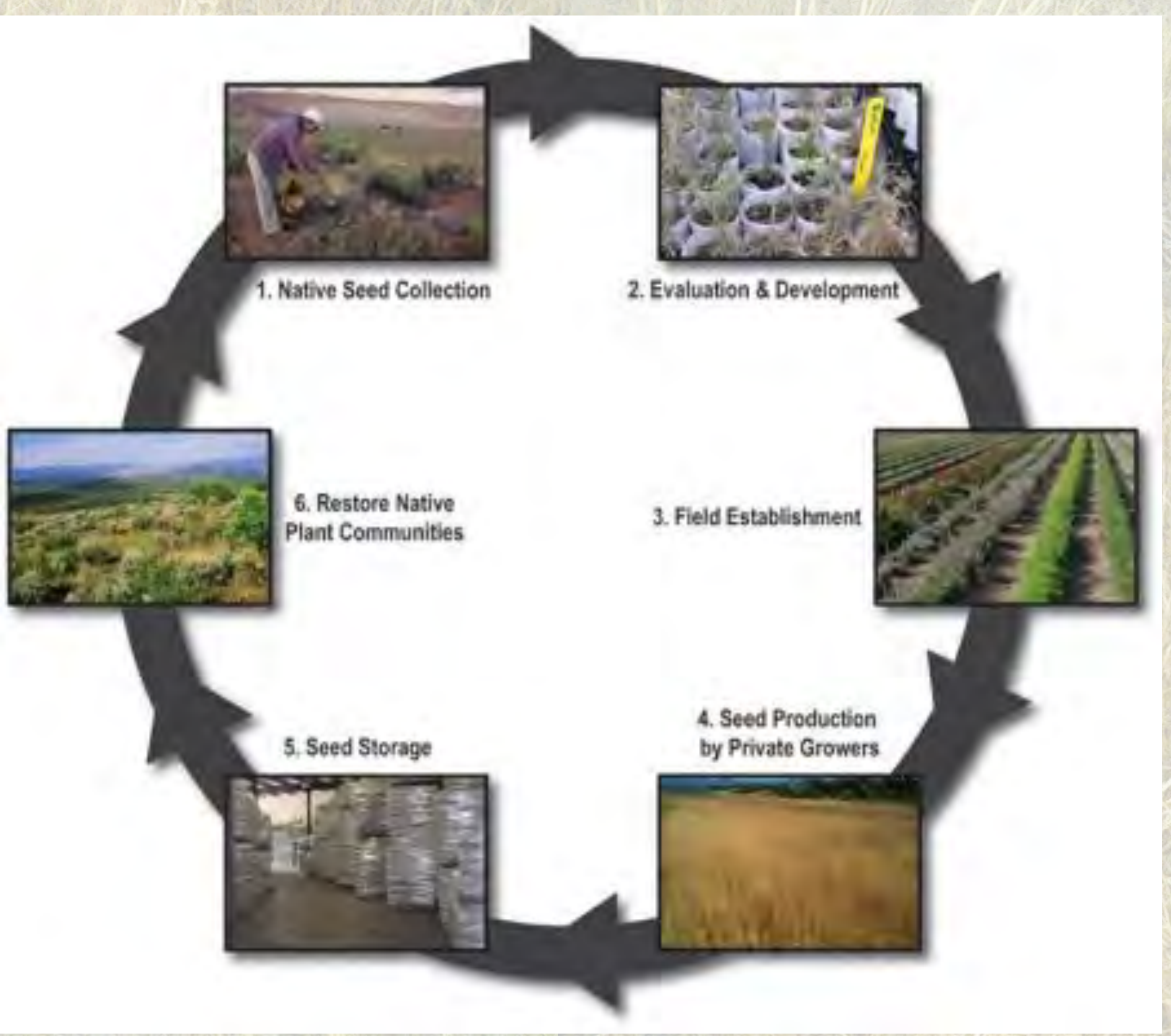
Seed development process for maximum success



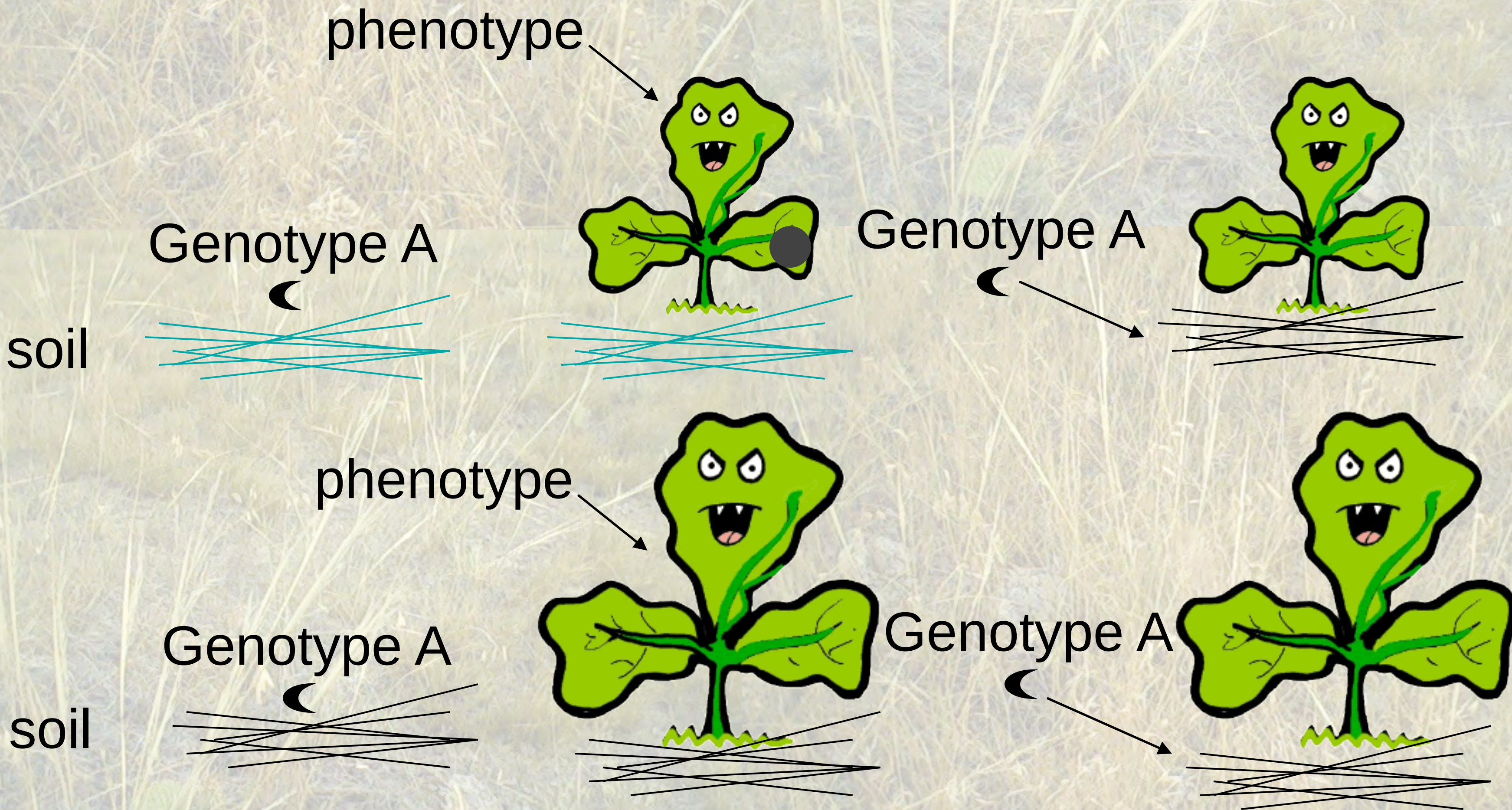
(1 year post-seeding)

There are may failures

Using plant materials to maximize success



Maternal environment affects progeny



Maternal environment affects progeny

- Two genetically identical moms growing in different environments will produce different-appearing progeny
- Paternal environment also affects progeny (transgenerational plasticity)
    - Etterson and Galloway 2002
- Maternal environment may be easier to manipulate and track

Drought tolerance

- Moms drought stressed
- Progeny grew faster below ground and more biomass when planted on dry sites (32% effect size)
- Mechanism: increased seed provisioning
- Application: drought stressed moms may lead to drought tolerant progeny

Polygonum
(Spotted ladysthumb)

Sultan et al. 2009 Ecology

Drought tolerance (flip side)

- Moms drought/edaphically stressed
- Progeny flowered earlier
- Mechanism: **decreased** seed provisioning
- Application: drought stressed moms may lead to drought tolerant progeny

goatgrass

Dyer et al. 2010 Evol. Apps.

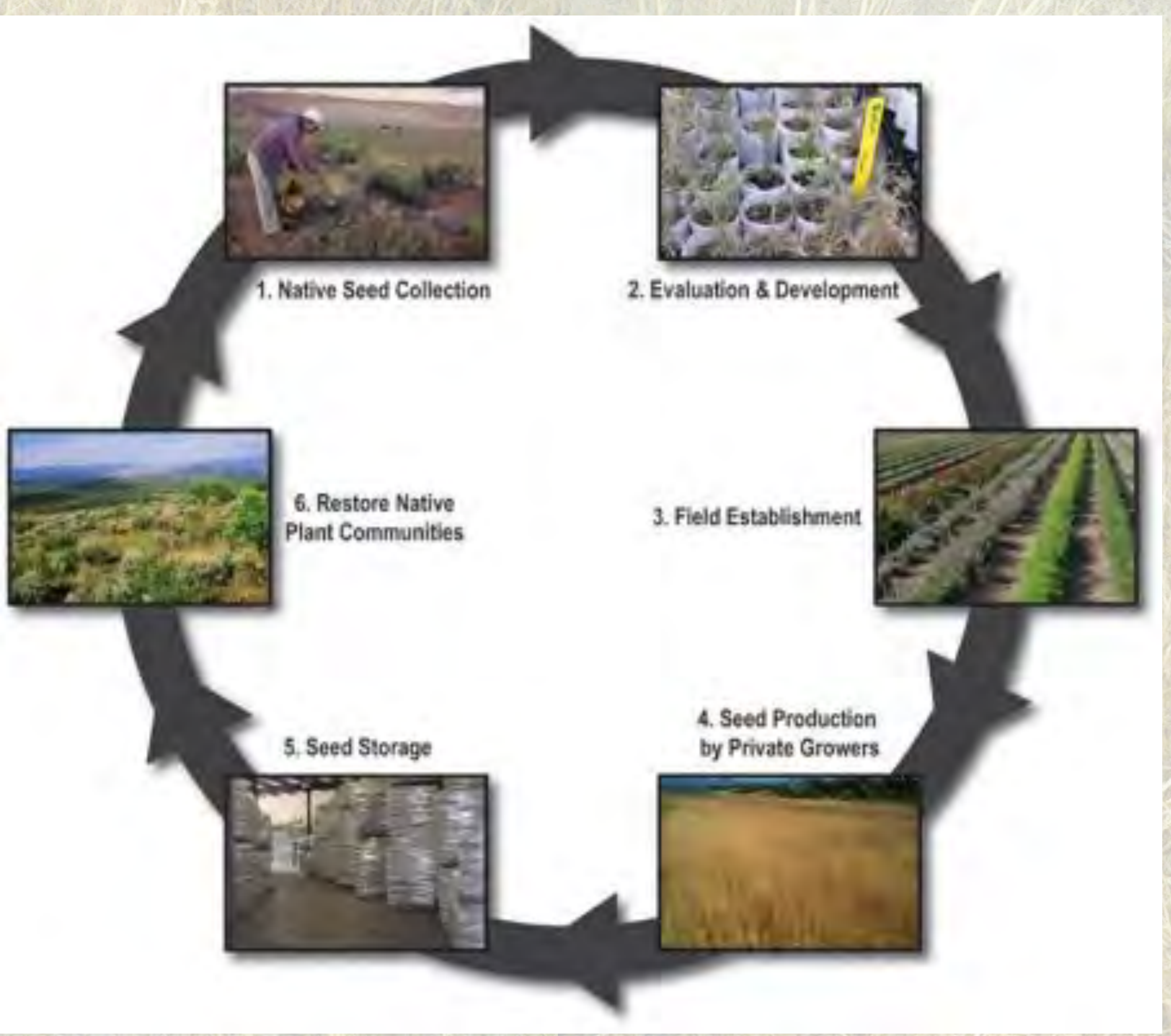
Herbivory tolerance

- Herbivorized moms
- Progeny tolerate herbivory better
- Mechanism: higher concentrations of defensive chemicals
- Application: grazing/herbivory may be used to create grazing/herbivory tolerant materials

Agrawal 2002 Science, Agrawal et al. 2009 Nature

Wild radish

Seed development process



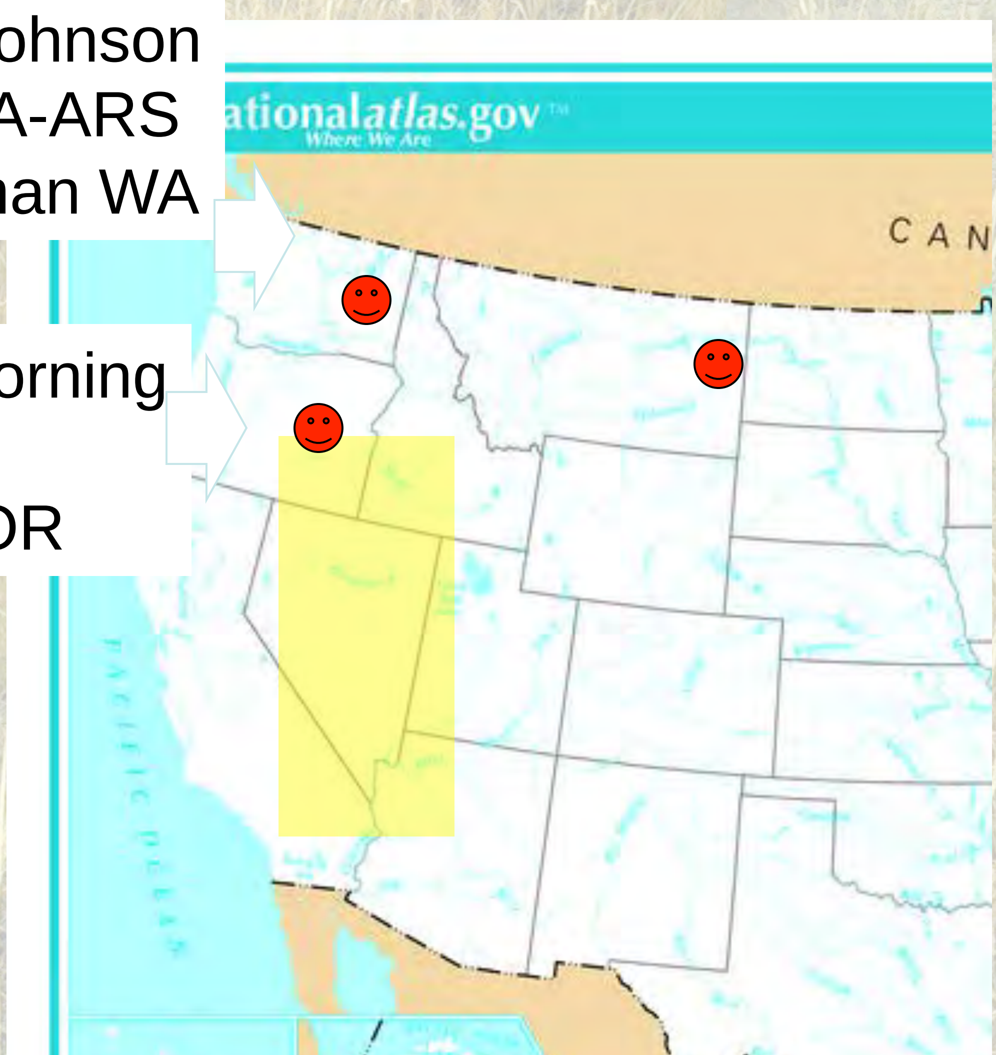
Research on *Poa secunda*

- Adaptive maternal effects in
  - Germination
  - Growth
  - Competition from cheatgrass
    - Work beginning this year

Genecology of *P. secunda*

RC Johnson
USDA-ARS
Pullman WA

Matt Horning
USFS
Bend OR



Seeds collected from Great Basin (yellow)

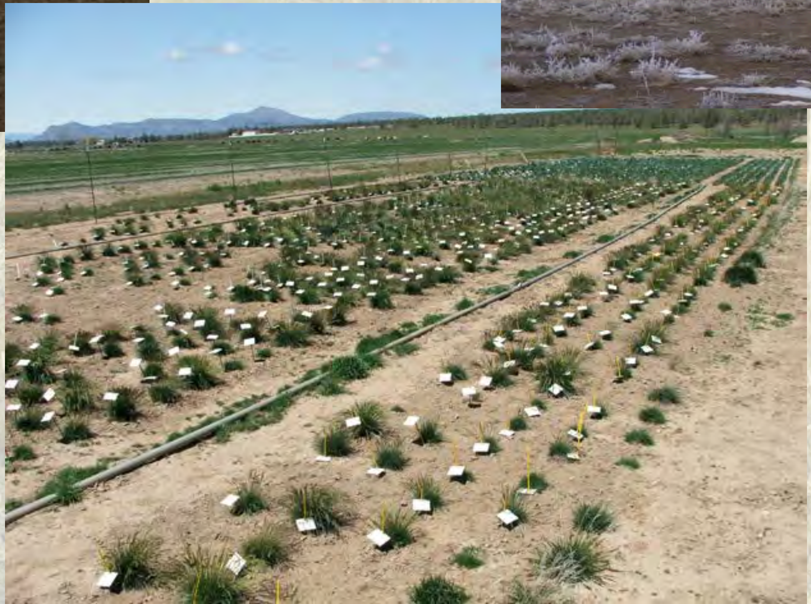
Plants grown in three gardens (red)

Do plants from similar habitats share similar traits?

Garden locations

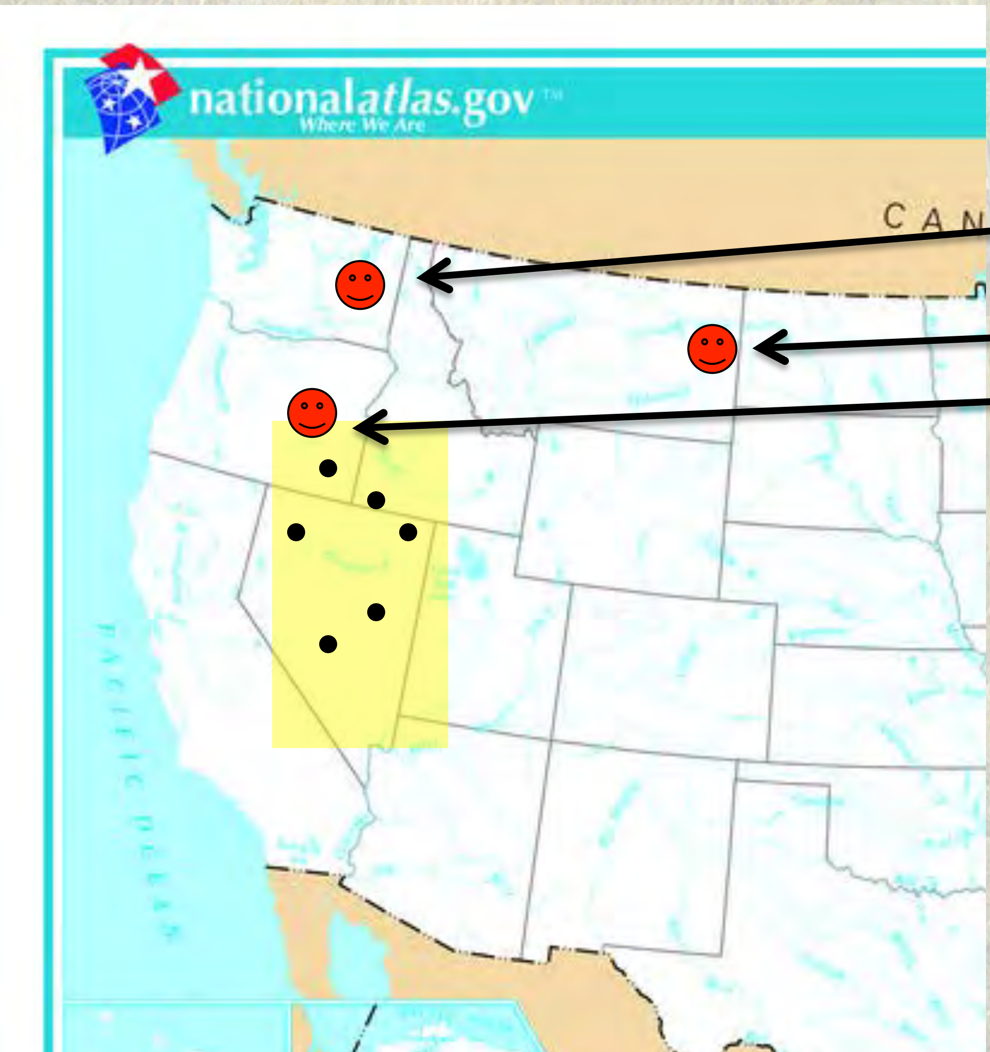
WA

MT



OR

Use this for TGP* research



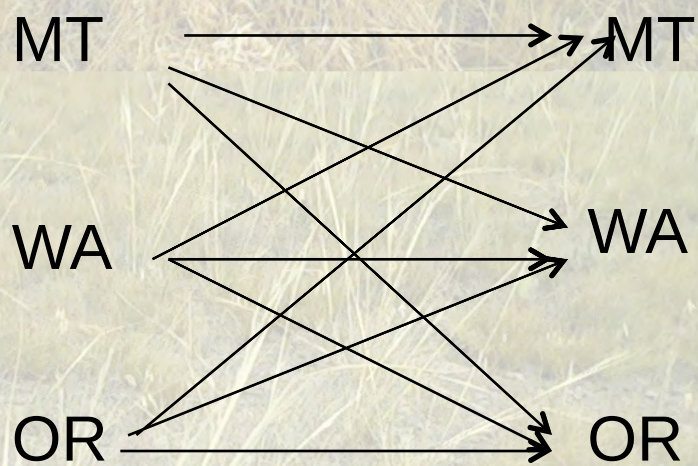
Take seeds from same genotypes grown in three gardens, grow under different temperature regimes

* Transgenerational plasticity

Germination experiment

Seeds from

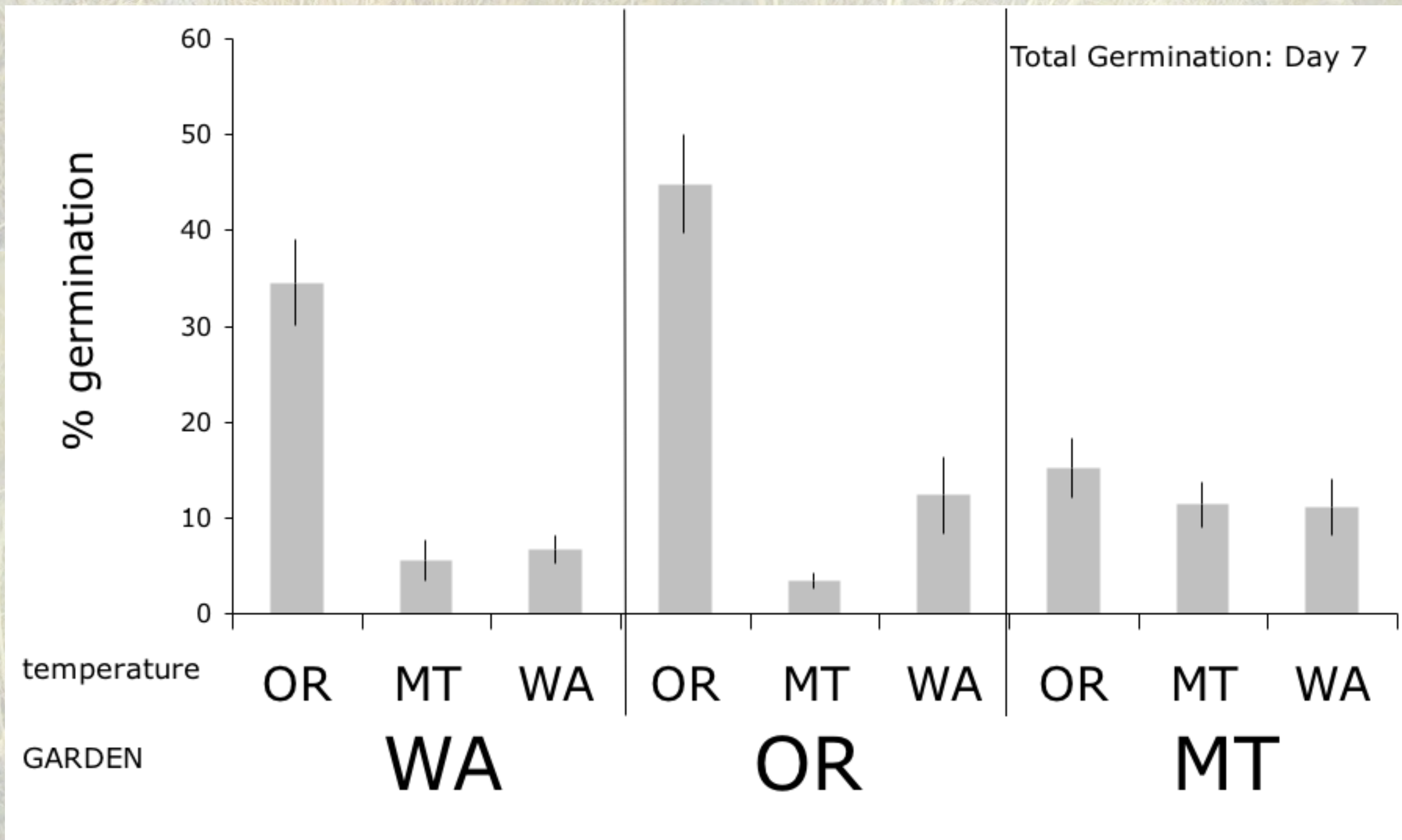
Grown in temps reflecting



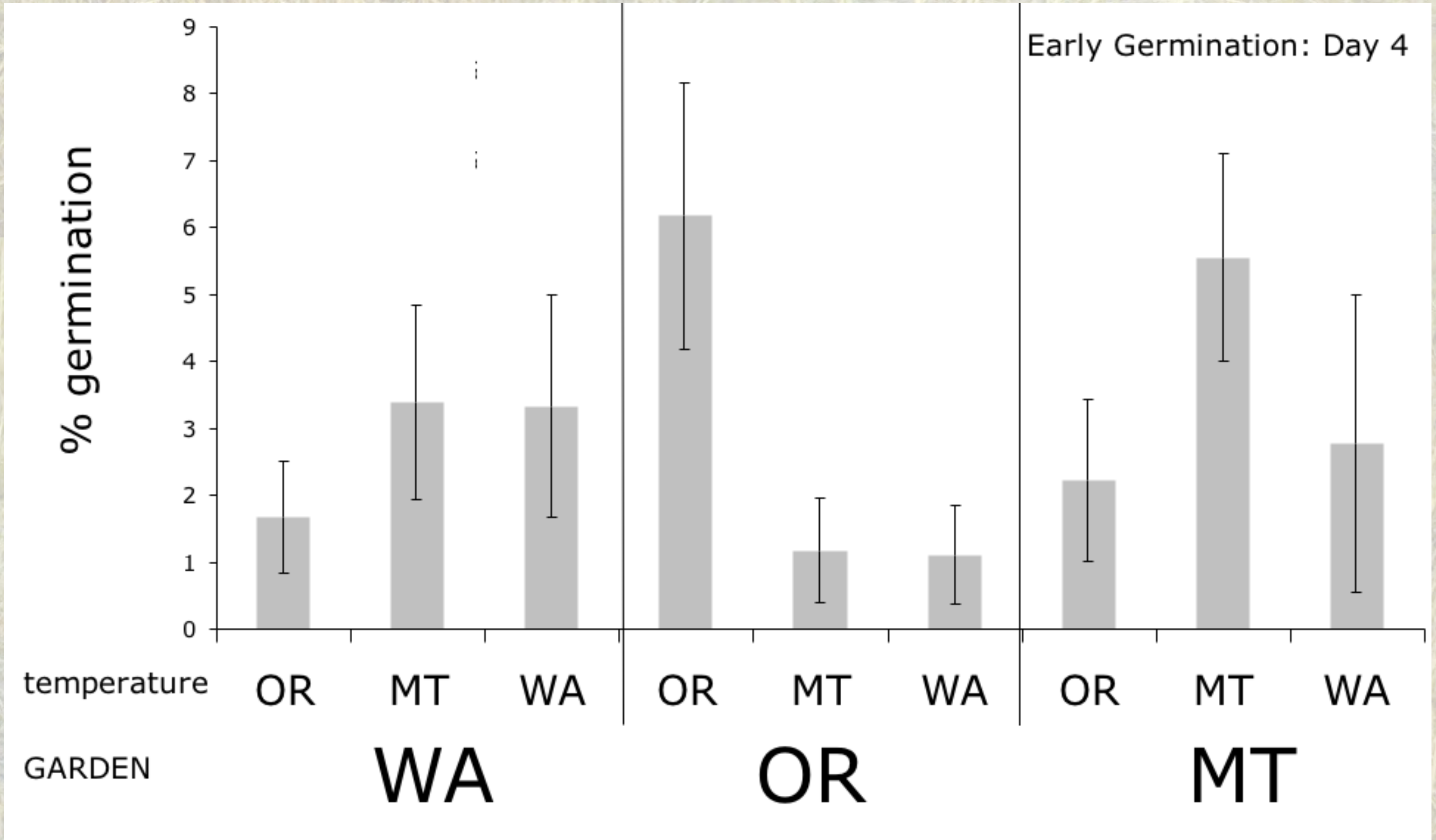
Do seeds perform better under maternal conditions?

This was a lot of seeds!

No adaptive TGP found in total germination



Adaptive TGP found in EARLY germination



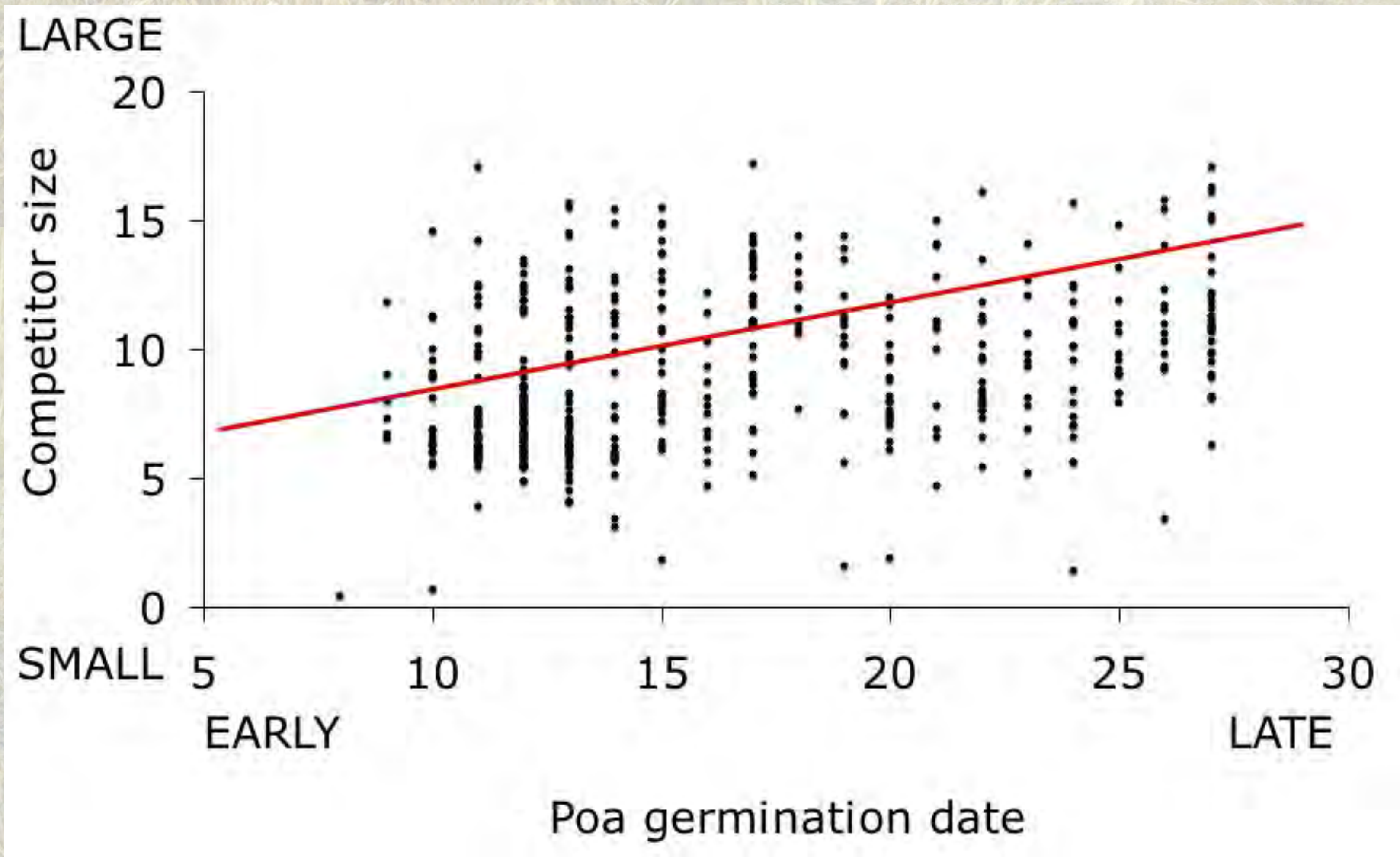
Why germinate fast?

- Escape predation
- Start growth earlier
  - Get bigger
  - Get ahead of your competitors
- Is this true for *P. secunda*?

Growth experiment

- Do adaptive TGP effects mean that seeds will be more competitive?
- Growth chamber experiment
  - In pots with light/dark cycles
  - April temperatures
    - Simulated three gardens
  - Two soil types
  - Cheatgrass or
  - Crested wheat

Earlier germination = less competitor growth



Summary so far

- Adaptive maternal effects occur in germination rate
  - Locally-grown is better
- Germination rate improves competitive ability
  - Faster germination means smaller competitors

Forthcoming work

- TGP and competitive environment
  - Adaptive TGP in *P. secunda* with cheatgrass competition?
- Do seeds grown in agronomic conditions perform differently than wild-collected seeds?
  - Western wheatgrass
  - Green needlegrass

Incorporate research into roadside hydroseeding: western wheatgrass and green needlegrass

Agronomically-grown vs. wild-collected

Does one generation of agronomic grow-out affect seed performance?

Western wheatgrass

Green needlegrass

How does one generation of agronomic grow-out affect seed performance?

Western wheatgrass

Green needlegrass

Let's get quantitative

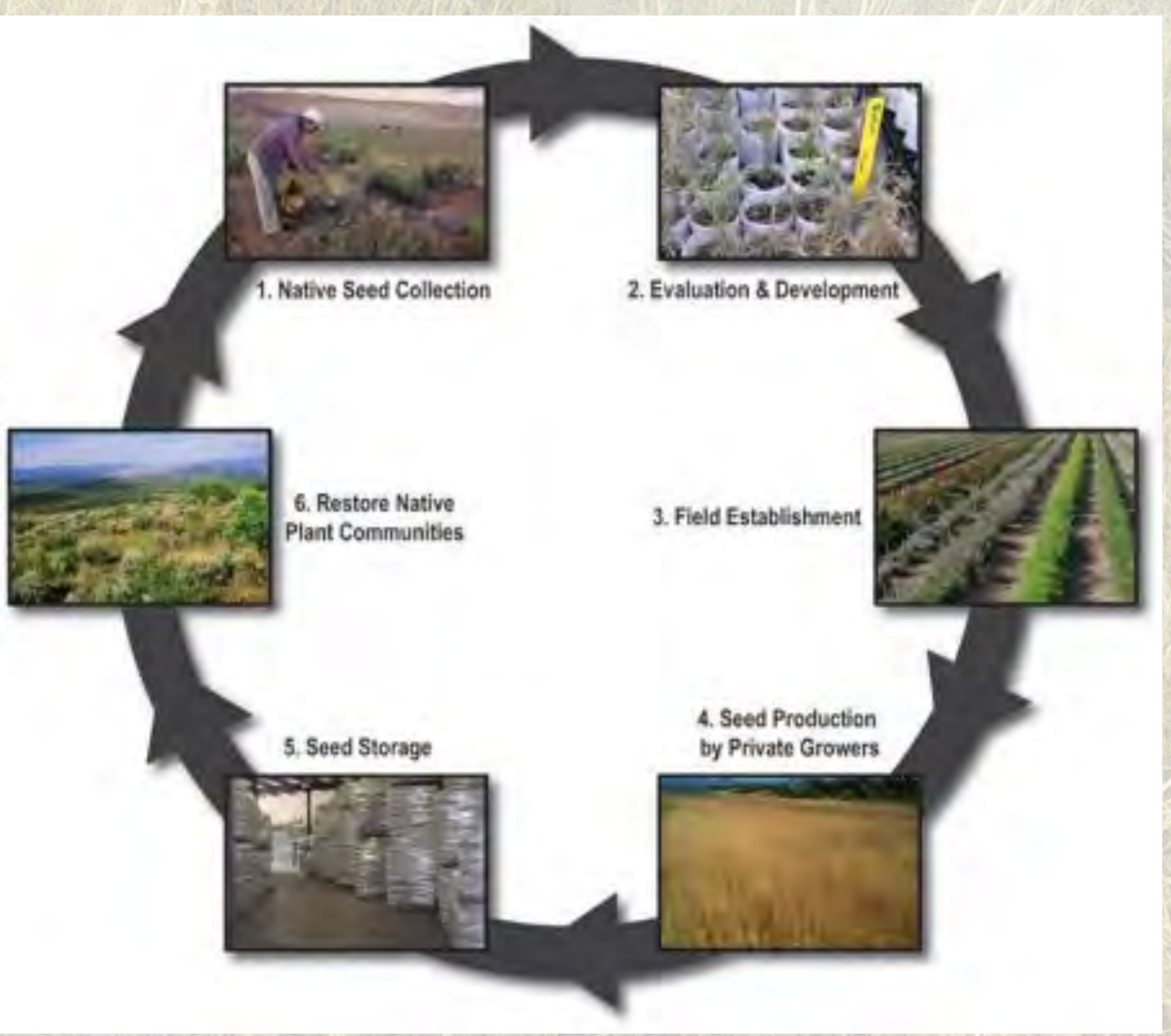
- Two groups have done agronomic vs. wild-grown comparisons
  - Population sources were different
- Findings: agronomically-grown had
  - Better establishment
  - Less drought tolerance
  - Less persistence
- Forthcoming study of Kulpa et al.

Let's use the findings to maximize seed performance!

Western wheatgrass

Green needlegrass

Maternal effects and the seed development process



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Growth
experiment

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Bureau of Land Management
Idaho Seeds of Success
Idaho State Office

Rehab and Restoration in Sandy Soils in the Snake River Plain

DOI, Bureau of Land Management

Susan Filkins
Idaho State Office
Seeds of Success Coordinator

SEEDS OF SUCCESS

Native Plant Materials and Plant Conservation Program

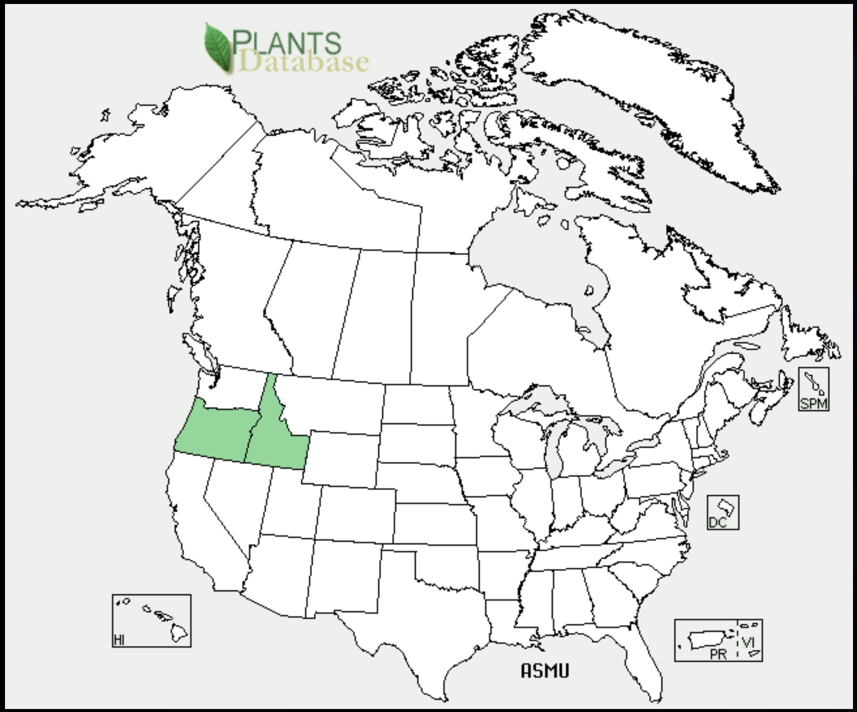
Mulford’s Milkvetch

(*Astragalus mulfordiae*)

Mulford’s Milkvetch Exclosure Restoration Project, Owyhee Resource Area, Idaho

- Unique habitat
- It is endemic to the western Snake River Plain
- 100 years of livestock grazing
- Trash dumping
- Road scarring from OHV

(site is within ¼ mile of OHV park)



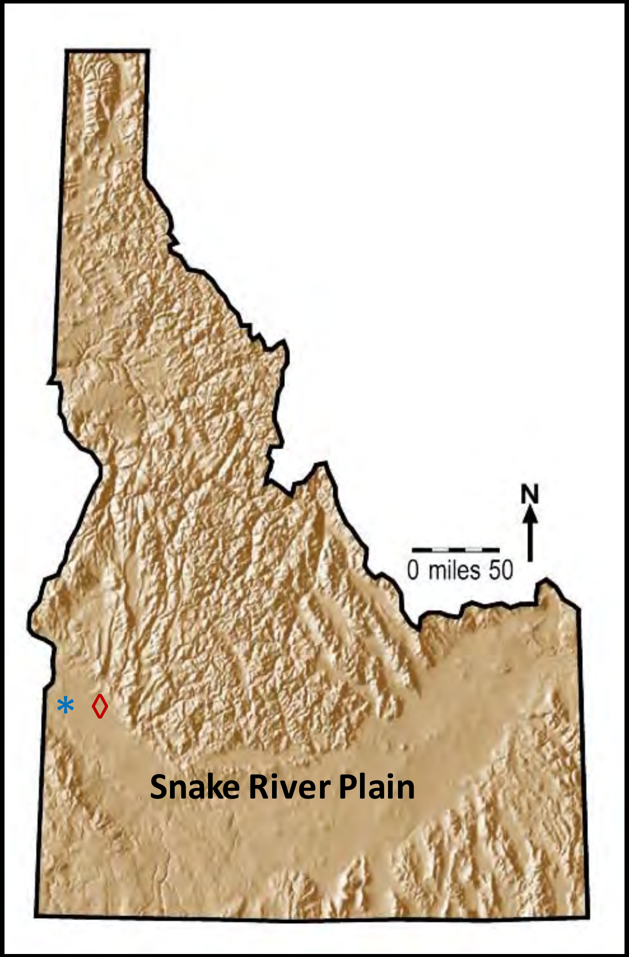
What are the Threats?

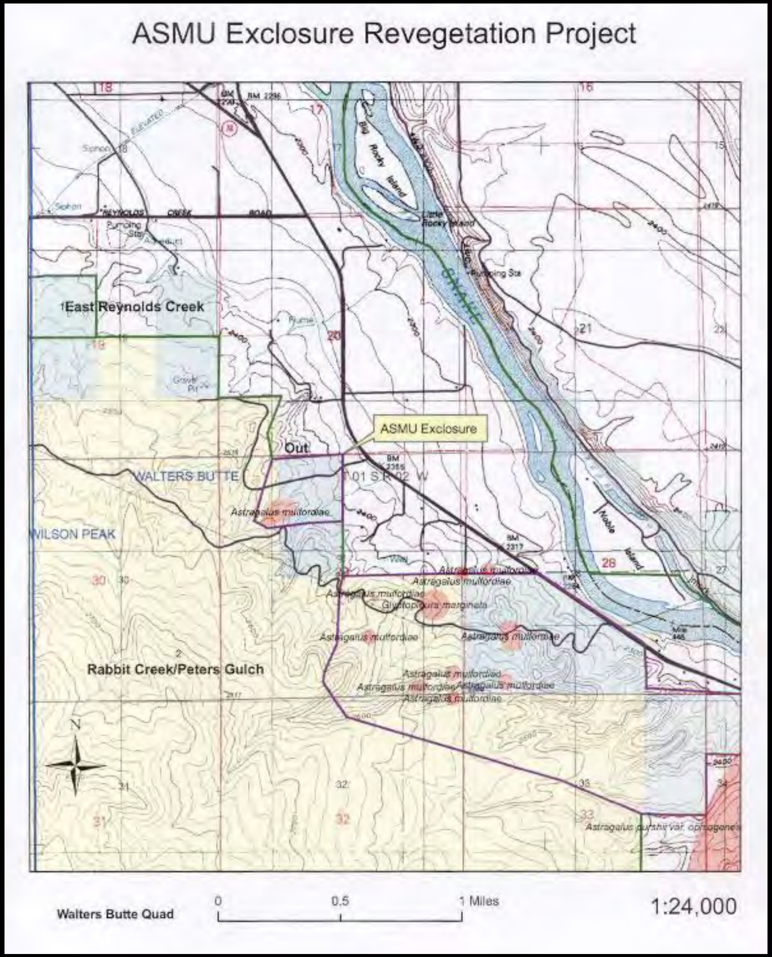
- Habitat degradation
- Weed invasion
- Off-highway-motorized vehicles
- Livestock grazing
- Wildfires

Conservation

- Fencing protects from livestock
- Protected from OHV (not 100%)
- Noxious weed control (mechanical)
- Seed and plant plug restoration

Snake River Plain





Understory ?

- Habitat is characterized by loose, sandy substrate derived from lacustrine and alluvial sediments
- In Owyhee Cty. is more often associated with a mix of desert shrub species. (Fourwing saltbrush, horsebrush, gray rabbit brush, prickly phlox, Needle-and-thread grass, Indian rice grass)
- Few Antelope bitterbrush and Sand dune penstemon.

What makes it unique?

Seeds planted

Indian ricegrass

Munro's globemallow

Basin wildrye

Shadscale saltbush

Fourwing saltbush

Fernleaf biscuitroot

Sandberg Bluegrass

Arrowleaf Balsamroot

Needle and Thread grass

Plugs Planted

Blue flax

Bitterbrush

Sandberg bluegrass

Globemallow

Post Seeding monitoring

Cassondra Skinner. BLM ID

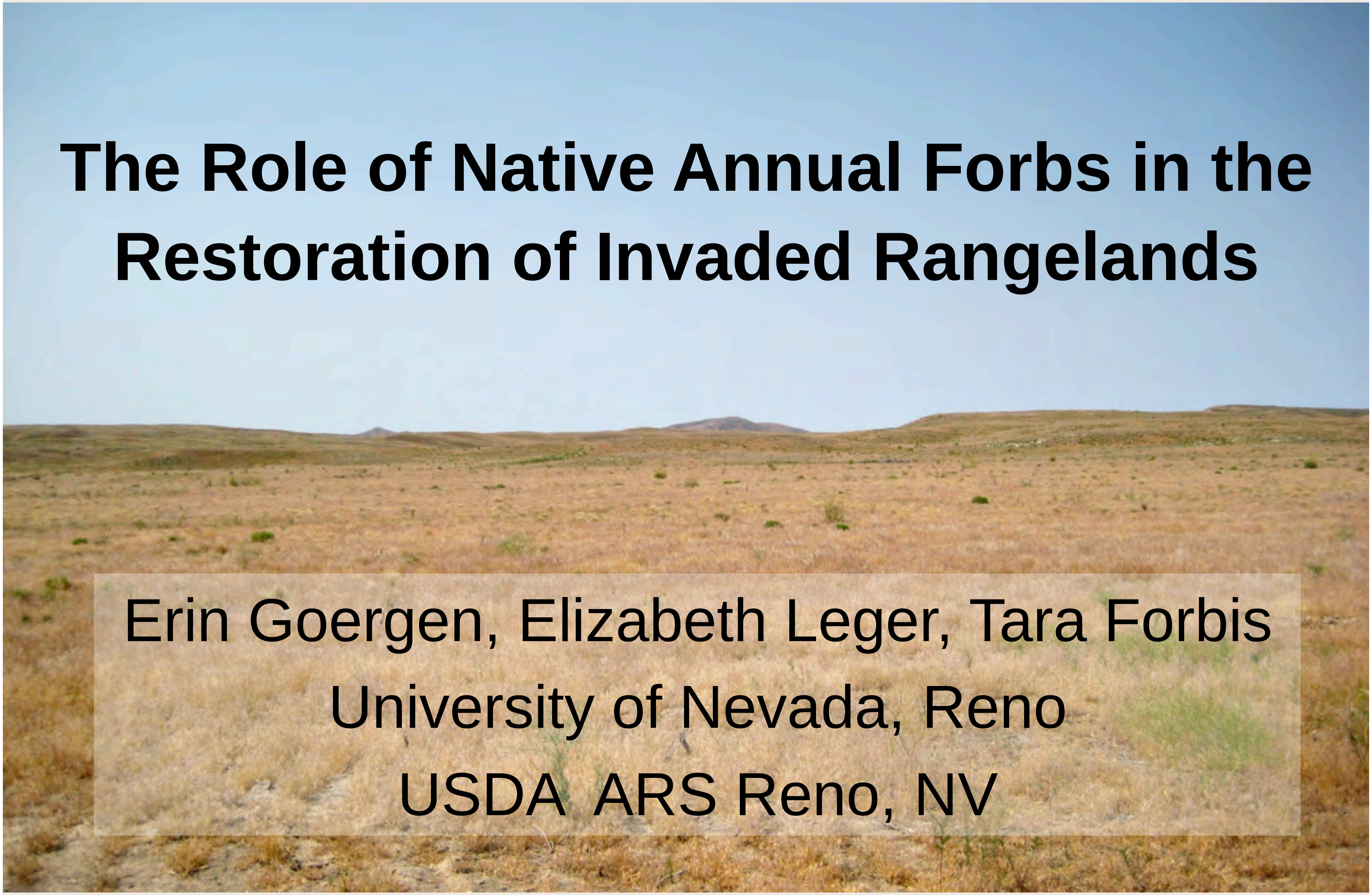
Early Results

- Increased plant vigor
- Indian Ricegrass establishment on roadscars
- Remnant plants increasing

Other Challenges


Mulford's Warriors

Susan Filkins-Idaho State Office, BLM
Idaho Seeds of Success Coordinator
Sfilkins@blm.gov



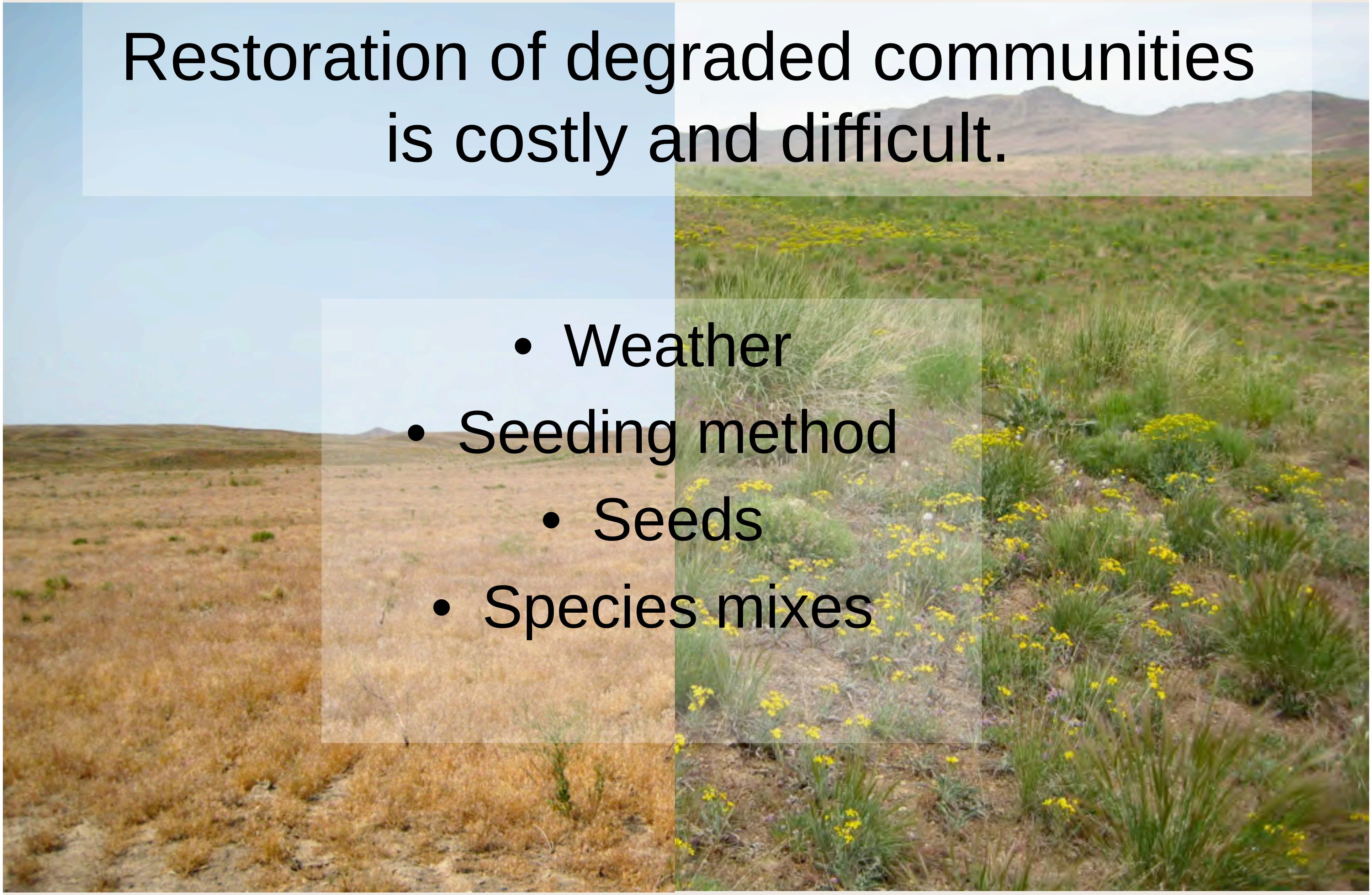
The Role of Native Annual Forbs in the Restoration of Invaded Rangelands

Erin Goergen, Elizabeth Leger, Tara Forbis

University of Nevada, Reno

USDA ARS Reno, NV

Restoration of degraded communities is costly and difficult.



- Weather
- Seeding method
- Seeds
- Species mixes

Natural Succession

Disturbance → Annuals → Early seral perennials → Late seral perennials & shrubs




Seed Mix 1

- *Artemisia tridentata*
- *Elymus lanceolatus*
- *Leymus cinereus*
- *Poa secunda*
- *Pseudoroegneria spicata*
- *Achillea millefolium*

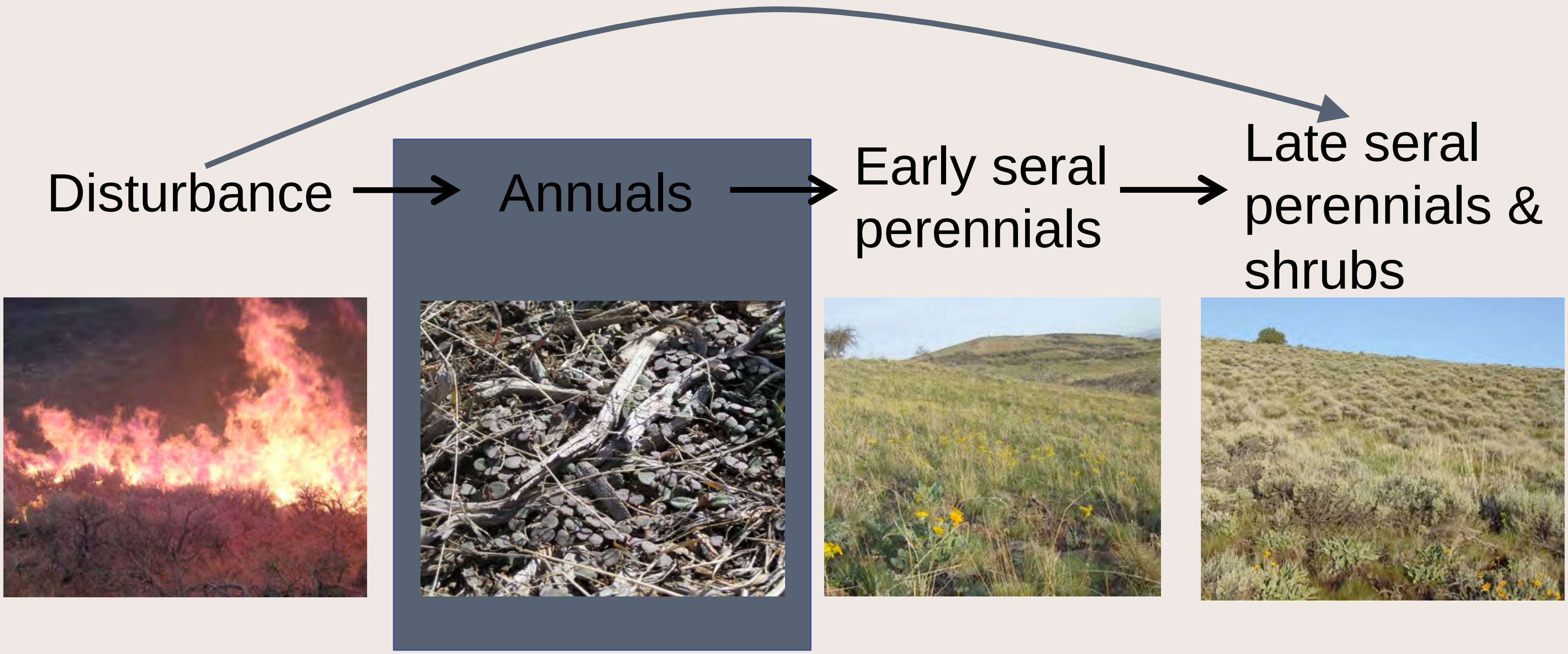
Seed Mix 2

- *Artemisia tridentata*
- *Achnatherum hymenoides*
- *Elymus lanceolatus*
- *Poa secunda*
- *Pseudoroegneria spicata*

Seed Mix 3

- *Artemisia tridentata*
- *Purshia tridentata*
- *Achnatherum hymenoides*
- *Agropyron crestatum*
- *Elymus lanceolatus*
- *Leymus cinereus*
- *Pascopyrum smithii*
- *Poa secunda*
- *Pseudoroegneria spicata*
- *Achillea millefolium*
- *Medicago sativa*

Can we improve restoration success by more closely following natural successional patterns?

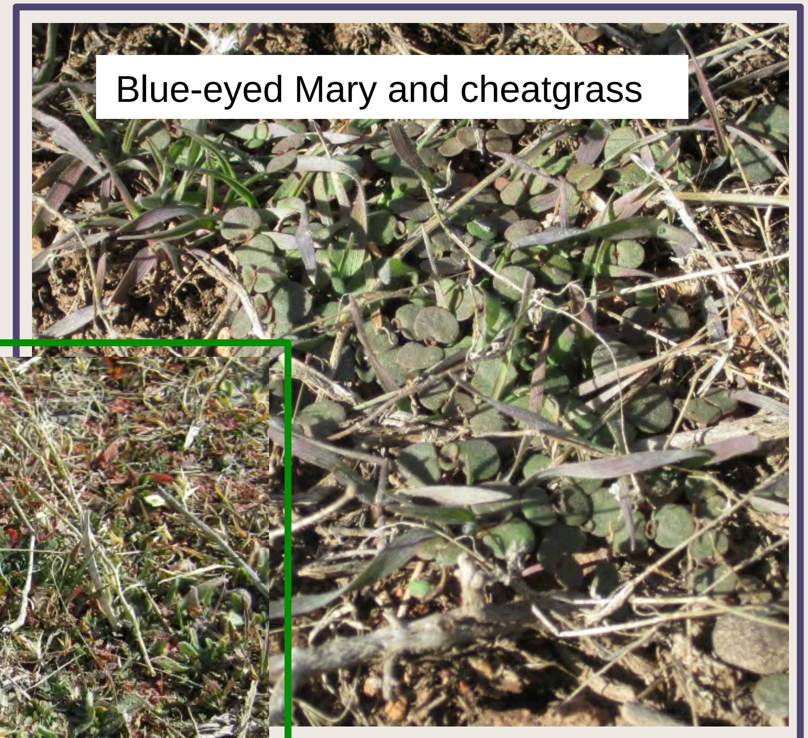


Native annual forbs may be valuable restoration species for multiple reasons

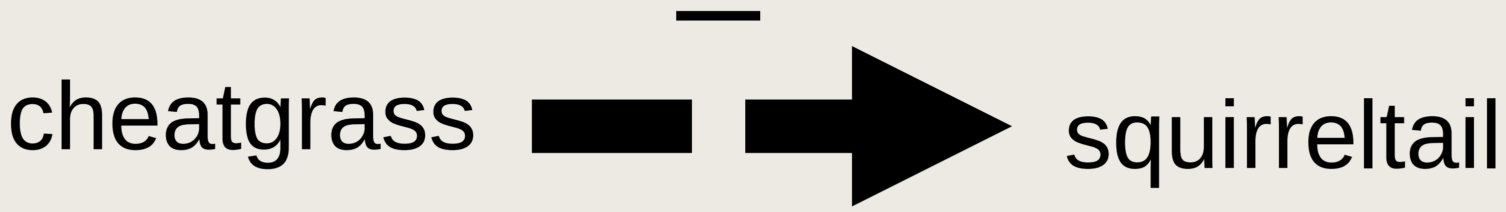
1. Adapted to post-disturbance environmental conditions.
2. Likely to be phenologically similar to and competitive with cheatgrass.
3. Contribute to plant diversity and habitat in rangelands.

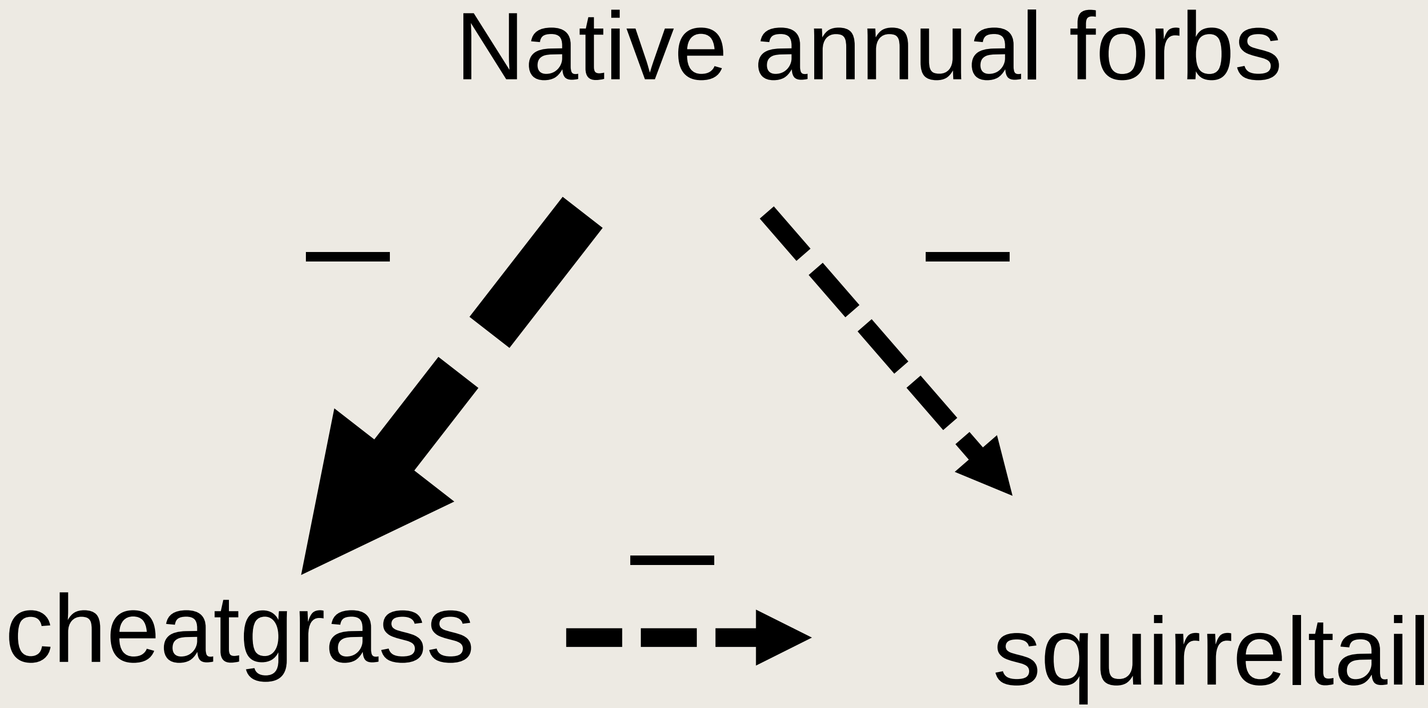
There is overlap in growth between native and introduced annuals!


Woollystar and tumble mustard

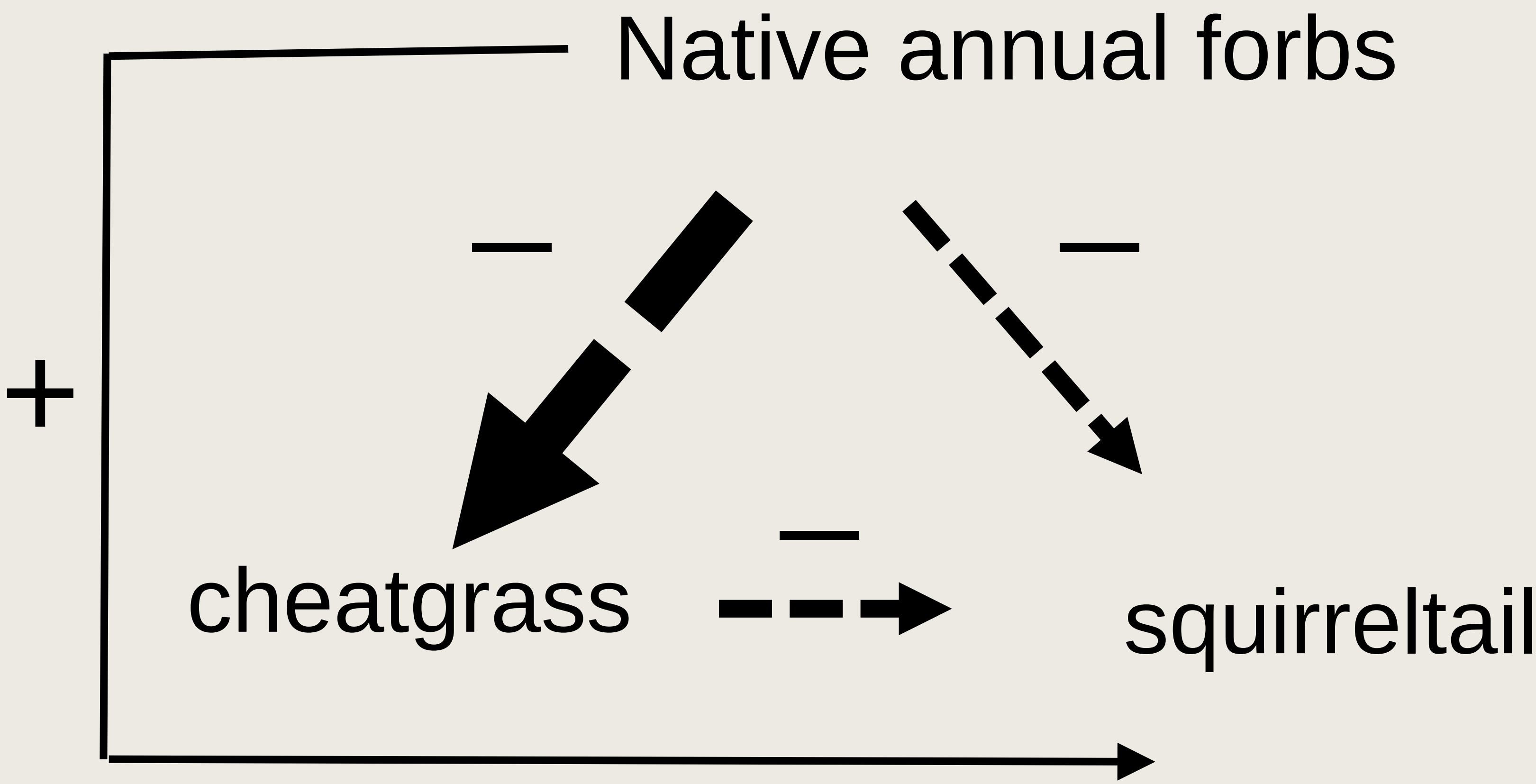

Blue-eyed Mary and cheatgrass


Fiddleneck and stork's bill


cheatgrass
–
squirreltail



Early interactions between native annual forbs and cheatgrass may reduce its early growth and vigor.



Early interactions between native annual forbs and cheatgrass may reduce its early growth and vigor.

Questions

1. What is the **direct** effect of native annual forbs on cheatgrass performance?

2. What are the **direct** and **indirect** effects of native annual forbs on squirreltail performance?

Greenhouse Experiments

Experiment 1: Direct effect of native annuals on cheatgrass.

Amsinckia tesellata
Bristly fiddleneck

Mentzelia veatchiana
Veatch's blazingstar

cheatgrass	cheatgrass+ fiddleneck	cheatgrass+ blazing star	cheatgrass + Mixed Forbs

Greenhouse Experiments

Experiment 2: Direct and indirect effects of native annuals on squirrel tail.

Amsinckia tesellata
Bristly fiddleneck

Mentzelia veatchiana
Veatch's blazingstar

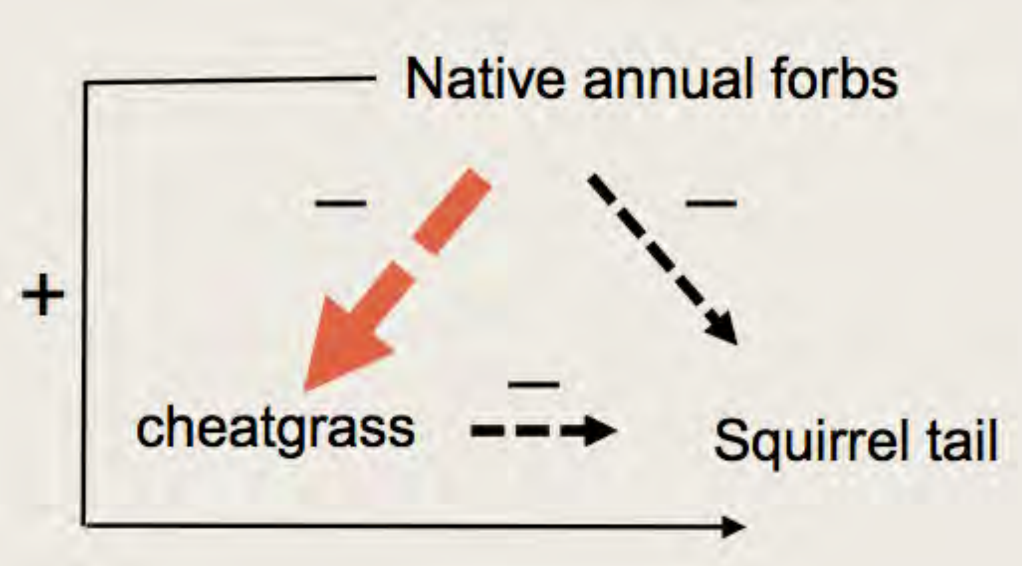
Cryptantha pterocarya
Wingnut cryptantha

Eriastrum sparsiflorum
Great Basin Woollystar

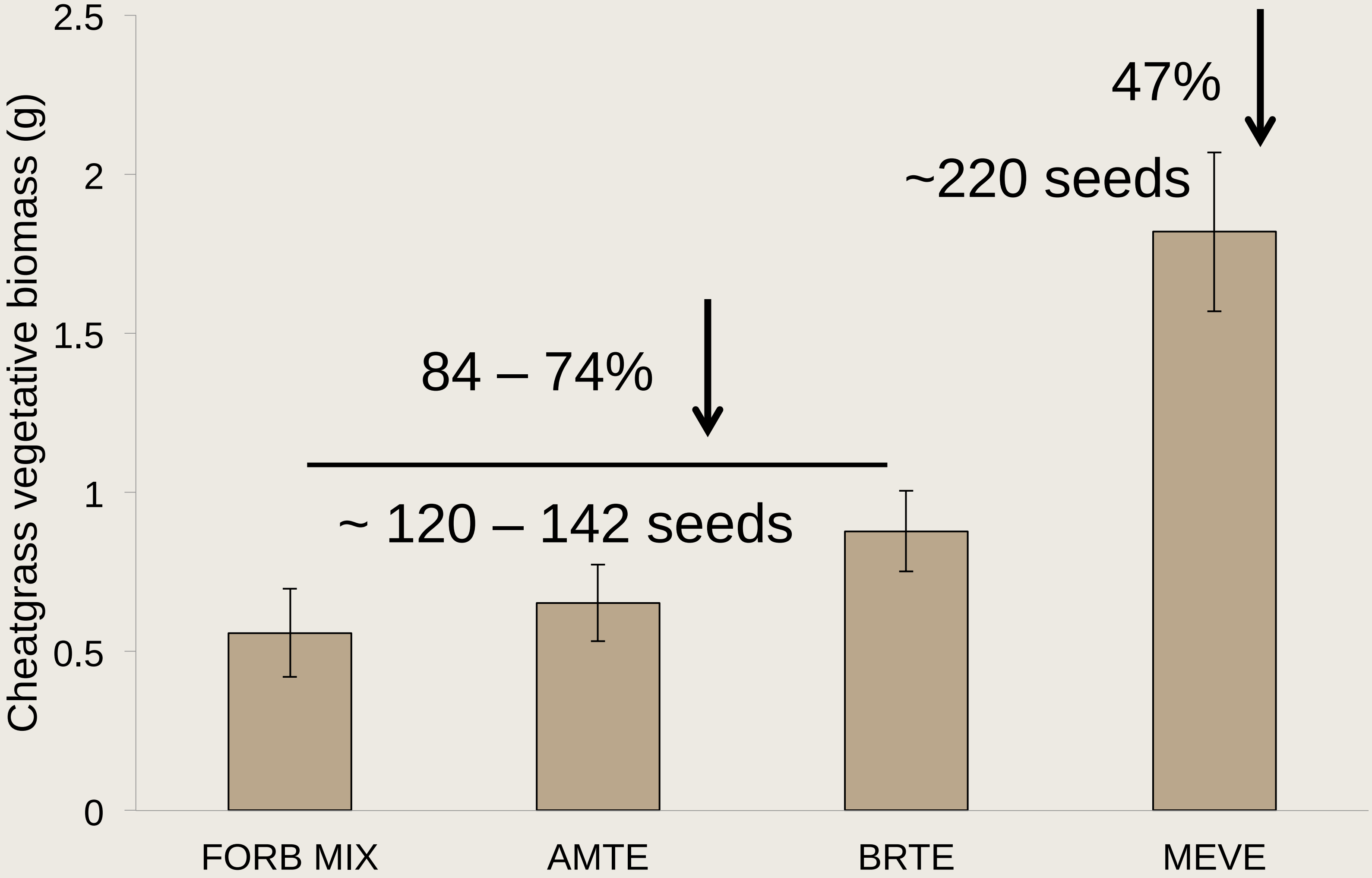
squirreltail	squirreltail+ fiddleneck	squirreltail+ blazing star	squirreltail+ Mixed Forbs
squirreltail + cheatgrass	squirreltail+ cheatgrass + fiddleneck	squirreltail+ cheatgrass+ blazing star	squirreltail+ cheatgrass+ Mixed Forbs

Questions

1. What is the **direct** effect of native annual forbs on cheatgrass performance?

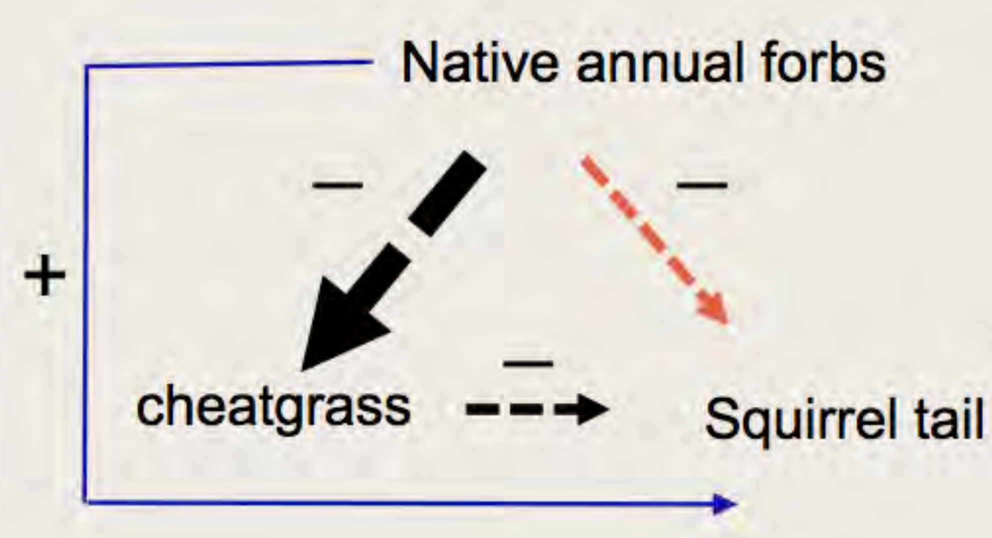


1. Fiddleneck is a good competitor against cheatgrass!

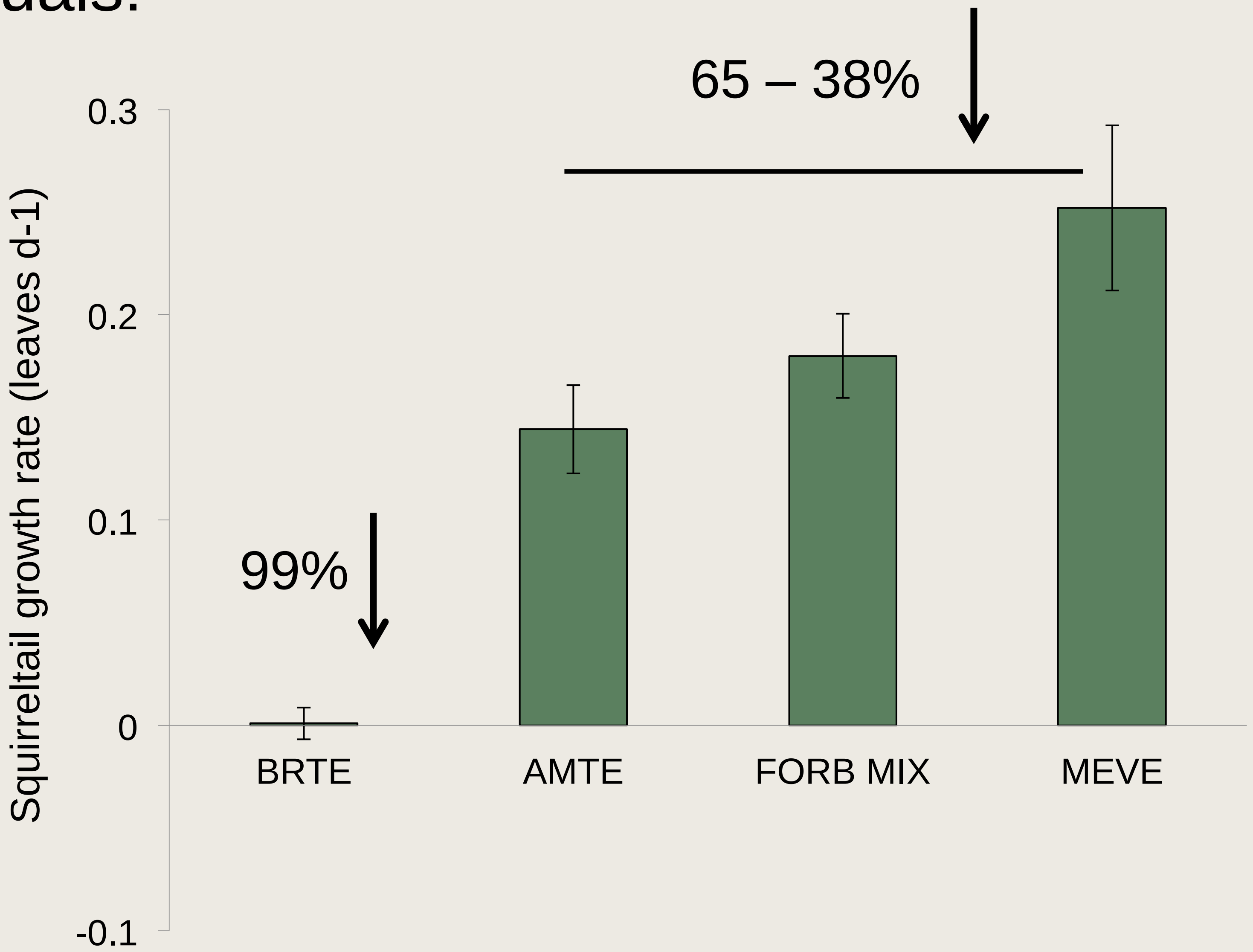


Questions

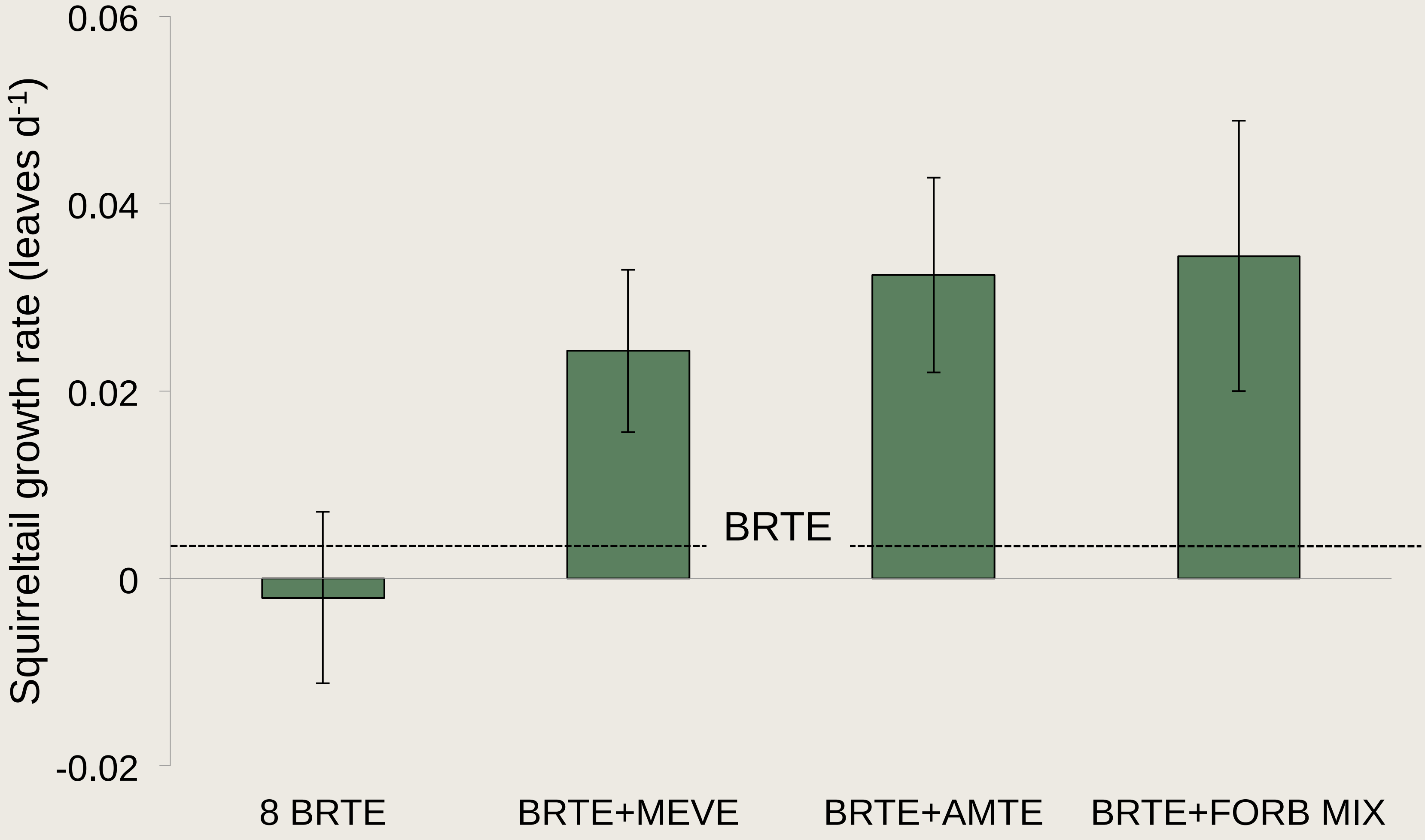
2. What are the **direct** and **indirect** effects of native annual forbs on squirreltail performance?



2. Direct Effect: Squirreltail does better with native annuals!



2. Indirect Effects: When grown with cheatgrass, squirrel tail does better when native annuals are also present!



Greenhouse summary

- Fiddleneck shows promise as a good competitor against cheatgrass.

- Squirreltail grew better with native annuals, and native annuals also indirectly improve performance of squirreltail when cheatgrass is present.

Next steps

- Promote annual forbs!
- We need to learn more about our native annual forbs!
  - Germination strategies
  - Dormancy issues
  - Competitive abilities

Acknowledgements

- Great Basin Native Plant Selection and Increase Project
- University of Nevada, Reno


Questions?

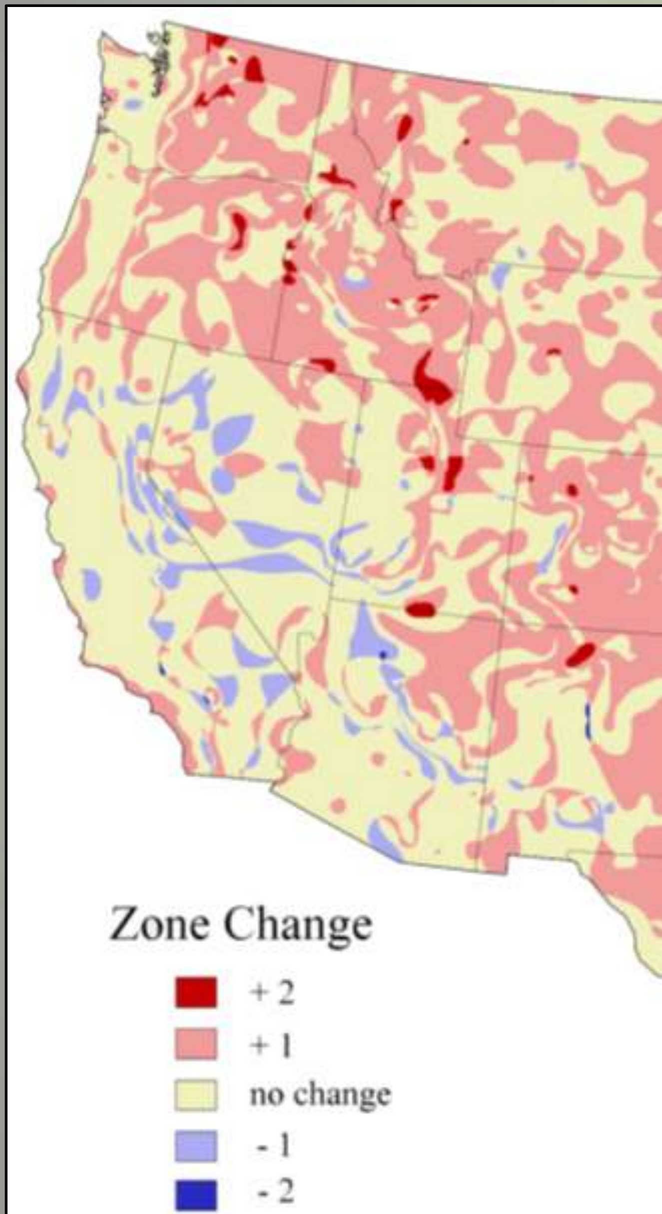
Seed-transfer guidelines in the context of climate change: a Forest Service perspective

Matt Horning

Seed-transfer guidelines in the context of climate change: a Forest Service perspective

- Skipping doom-n-gloom (nuts and bolts of climate change)
- Who is at risk (winners v losers)
- Suggested action items
- Decision support tools

"Climate" is a moving target



- Rapid change
- High uncertainty
- Not the means but the extremes
- Future environmental conditions many not exist right now?
  - Warmer winters but still late frosts
  - Photoperiod vs heat sums
  - Different disease triangle relationships

http://www.arborday.org/media/map_change.cfm

Will plants naturally adapt to rapid climate change?

Three possibilities when environments change:

1. **Move**
   - **Migrate** to new habitats
2. **Stay**
   - **Acclimate** by modifying individuals to new environment (phenotypic plasticity)
   - **Evolve** through natural selection
3. **Disappear**
   - **Extinction** of local population

Aitken et al. 2008. Evolutionary Applications 1: 95-111.

Species/Populations most threatened by climate change:

- Long-lived species
- Genetic specialists
- Low dispersal potential
- Low genetic variation
  - Inbreeding species
  - Small populations
  - Fragmented, disjunct populations
- Rare/Threatened
- "Nowhere to go"

Calamagrostis breweri

Photo: Kristen Chadwick

Pinus albicaulis

Tree Species of Concern

Eastern regions:

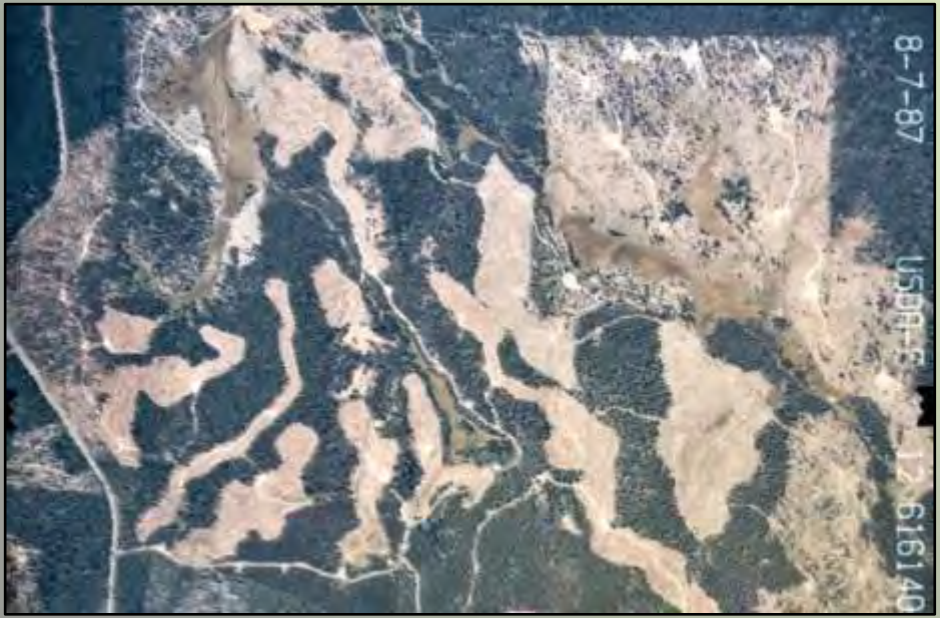
- butternut
- oak spp.
- ash
- eastern hemlock

Western regions:

- 5-needle pines: white pine, sugar pine, whitebark, bristlecone, limber, pinyon, foxtail
- Port-orford cedar
- Western red cedar
- Subalpine fir
- Mountain & western hemlock
- Englemann spruce
- Tanoak
- Monterey pine, knobcone pine
- Cupressus spp.
- Torrey pine
- Brewer spruce
- Coast redwood
- Alder spp., cottonwood, aspen, birch

Management implications for forested lands

- Variety of management objectives
  - Timber production/Ecosystem Health
- Long rotation time for harvests
  - Very difficult for planning
  - Potential implications for harvests



Forest Service Genetics Workshop in Corvallis Oregon March 2010

- **National Forest System geneticists**
- **Some Forest Service R&D geneticists**
- **Others… Oregon State University, University of British Columbia, BC Ministry of Forestry, Climate Change Research Institute & Oregon Climate Service**

Forest Service Geneticists

"Studying climate since 1908"

Agreement Among Participants: Four Principles

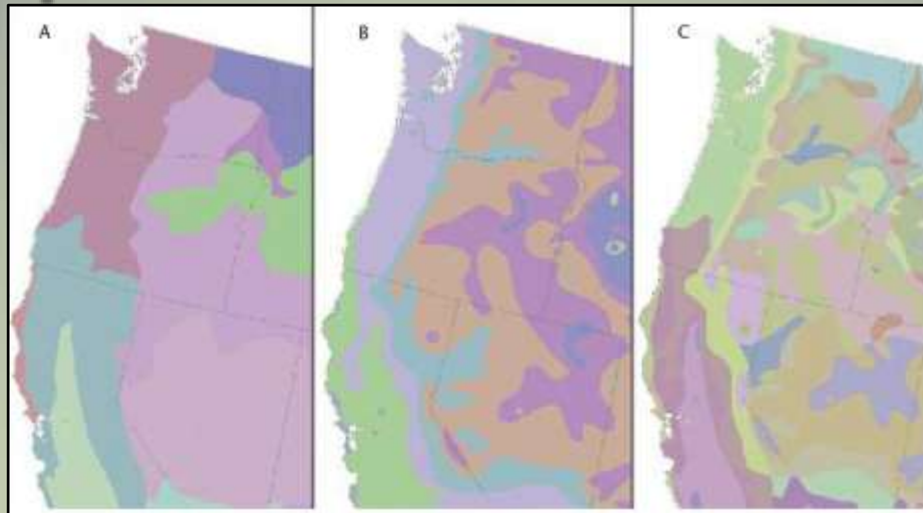
1. **Start with what has been working:**

   locally-adapted regionally-appropriate seed sources

2. **Genetic diversity is a good thing**
3. **Take large risks on small areas, and small risks on large areas**
4. **Need for genetic conservation**

Not prescriptions, but concepts

Principle 1: Stick with what works



2010 Native Plants Journal 11: 117-132

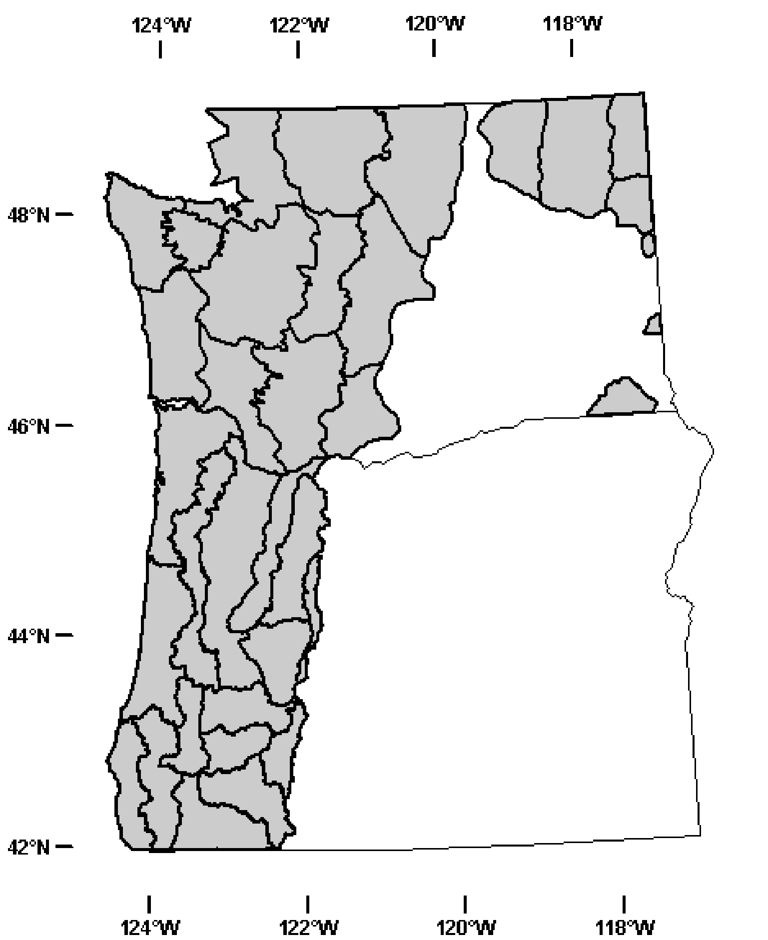
What are the best seed sources for ecosystem restoration on BLM and USFS lands?

Randy Johnson, Larry Stritch, Peggy Olwell, Scott Lambert, Matthew E Horning, and Richard Cronn

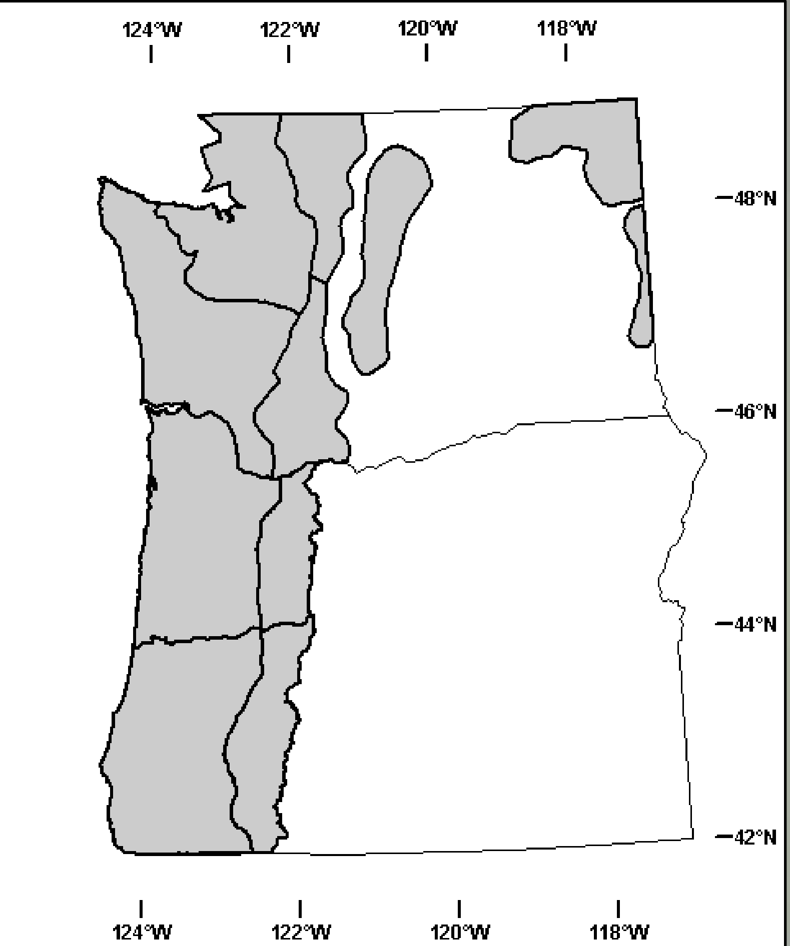
- **Native species**
- **Genetically appropriate**
- **Locally adapted**

But how 'local' is 'local'?

Differential adaptation to environment



Douglas-fir; *Specialist*
655ft, 18 FFDs



Western redcedar; *Generalist*
1968ft, 54 FFDs

- **Species differ in their level of adaptation to local environment**

Adaptation in other forest species

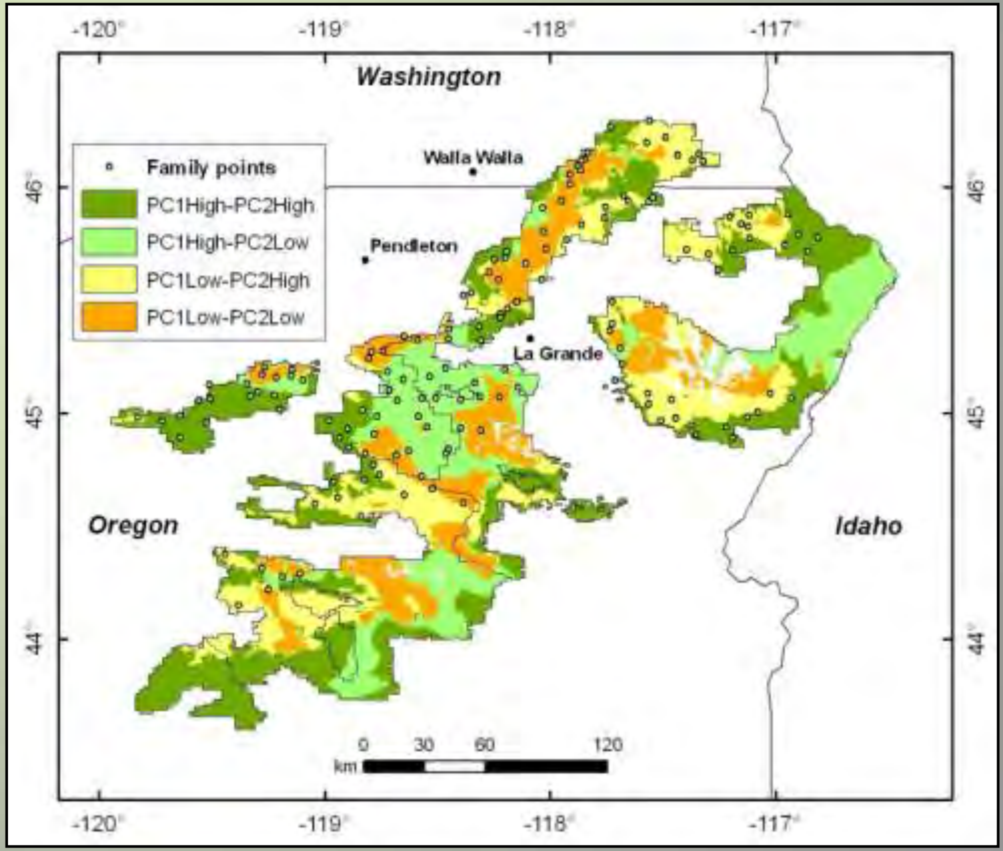
- Growing evidence for local adaptation
- Different species show different patterns and scales of adaptation
- Moderate degree of adaptation (generalists)





But…is 'local' still 'local'?
or
Where will the climate values that currently explain observed genetic variation move to given future predictions?"

Bromus carinatus; Johnson et al 2010 Botany



- Previous studies typically based on historical climate data (1960's – 1990)
- "Climate smart" data are now available
- Allows us to explore how seed movement guidelines might be adjusted

Principle 2: Diversity (Genetic Variation) provides insurance

Phenological variation in Prairie junegrass

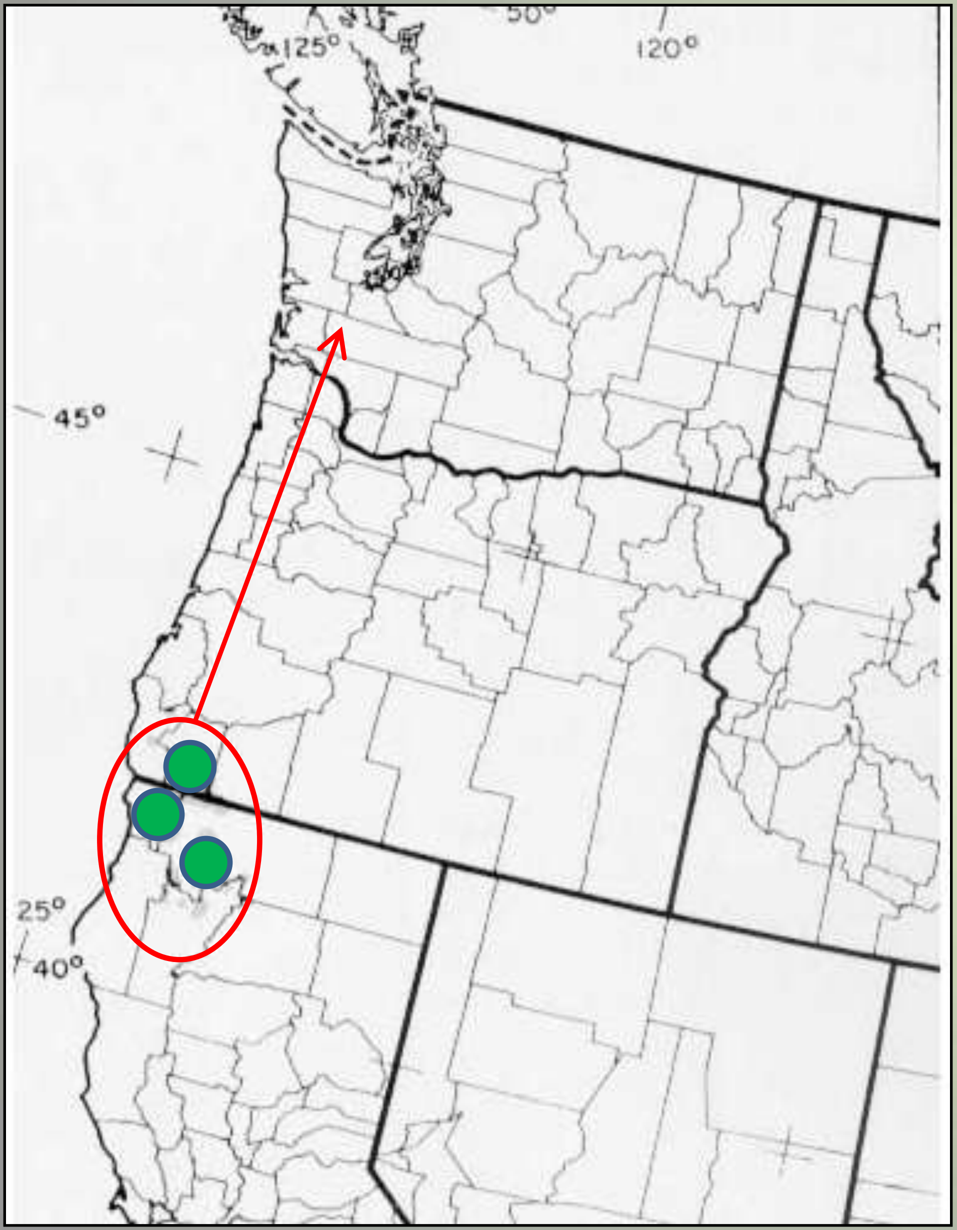
Variable frost damage in different sources of Douglas-fir seedlings

- Not just diversity for diversity's sake
- Adapted variation (ID'd via CGSs)
- Maladapted variation can reduce fitness

Principle 3: Large Risks over Small Areas Small Risks over Large Areas

- Estimates of past migration rates vary
  - Davis and Shaw 2001: 200-400 m per yr
  - Aitken et al 2007: 100- 200 m per yr
- But current rates of climate change might require 3000-5000 m per yr
  - Seed migration may not be sufficient
  - Pollen flow may be ineffective due to non-synchronous flowering phenology

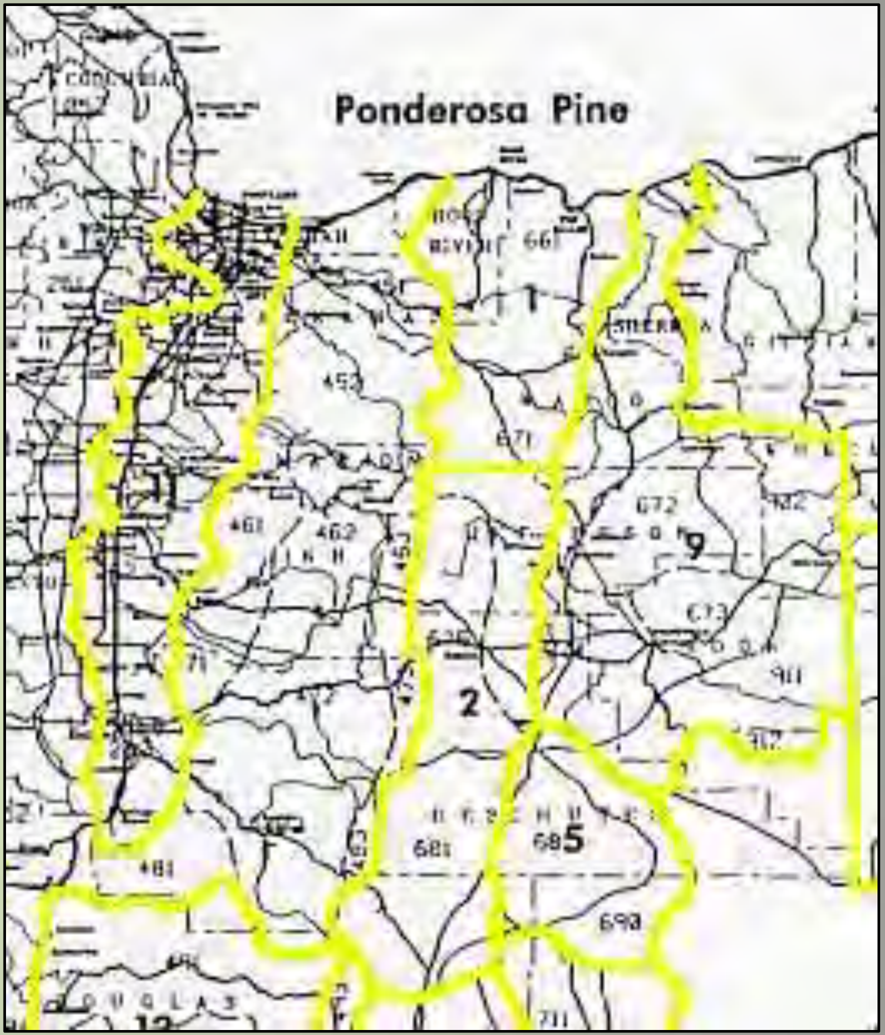
Example: Small risks over large areas



Brewer spruce

- Broad spatial emphasis
- Small amount of materials
- Experimental context

Example: Large risks over small areas



Perhaps…
•Move materials between adjacent zones

Better yet…
•Widen/adjust elevation bands within zones

- ↑ Diversity (bet –hedging)
- Small spatial scale
- Large quantities of materials (Mixing, not replacing)
- Operational/Experimental context

Decision Tools and Resources

Seedlot Selection Tool (SST)

http://sst.forestry.oregonstate.edu/PNW/index.html

Seedlot Selection Tool (SST)

http://sst.forestry.oregonstate.edu/PNW/index.html

User inputs and actions

Choose analysis approach…………….. → ***Find seedlot or planting site / Use zone or seed transfer rule***

Select species and climate variables… → ***Choose from a list of species / Uni- or multivariate climate variables***

Select location…………………………… → ***Location of seedlot or planting site***

Select future climate model (GCM)…… → ***GCM1, GCM2, GCM3***

Select year of interest…………………… → ***Present, 2030, 2060, 2090***

Climate space of the selected zone or transfer rule in the chosen year

Optional return to parameters and scenarios

Review output map, change parameters if desired, download map………………… ← ***Map***

Web browser

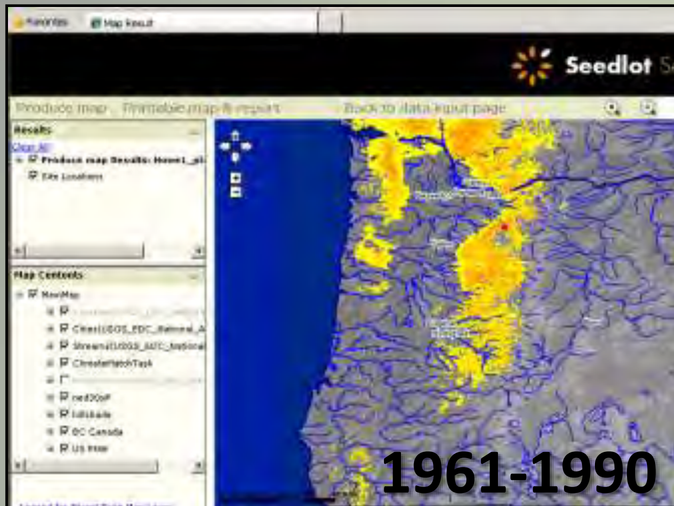
Web server tool

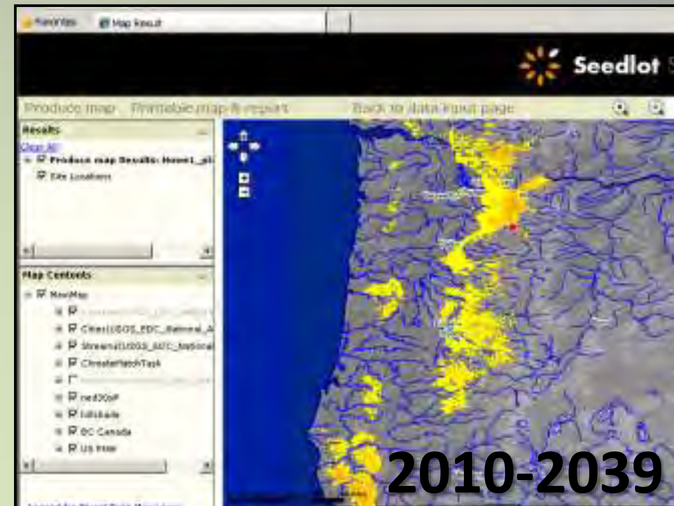
Ron Beloin, Glenn Howe, Brad St.Clair, Lauren Magalska, USFS Climate Change Research Program

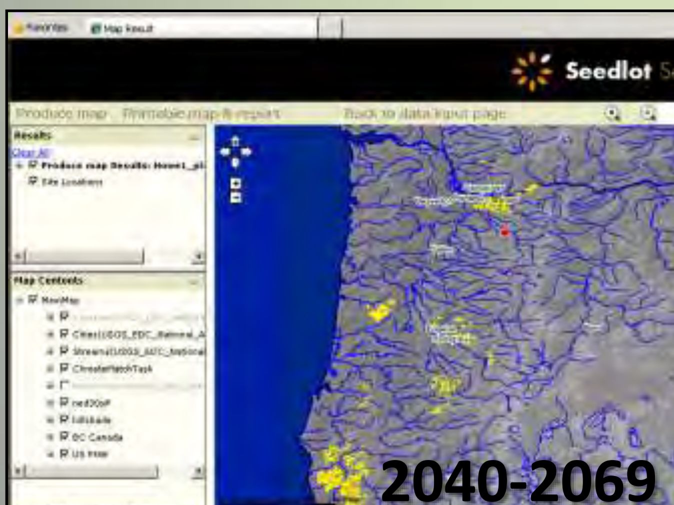
PNW

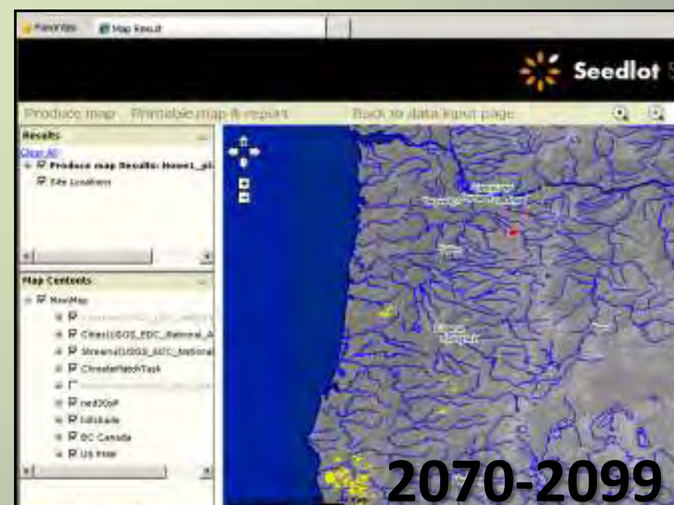
OSU

Output used for planning and education





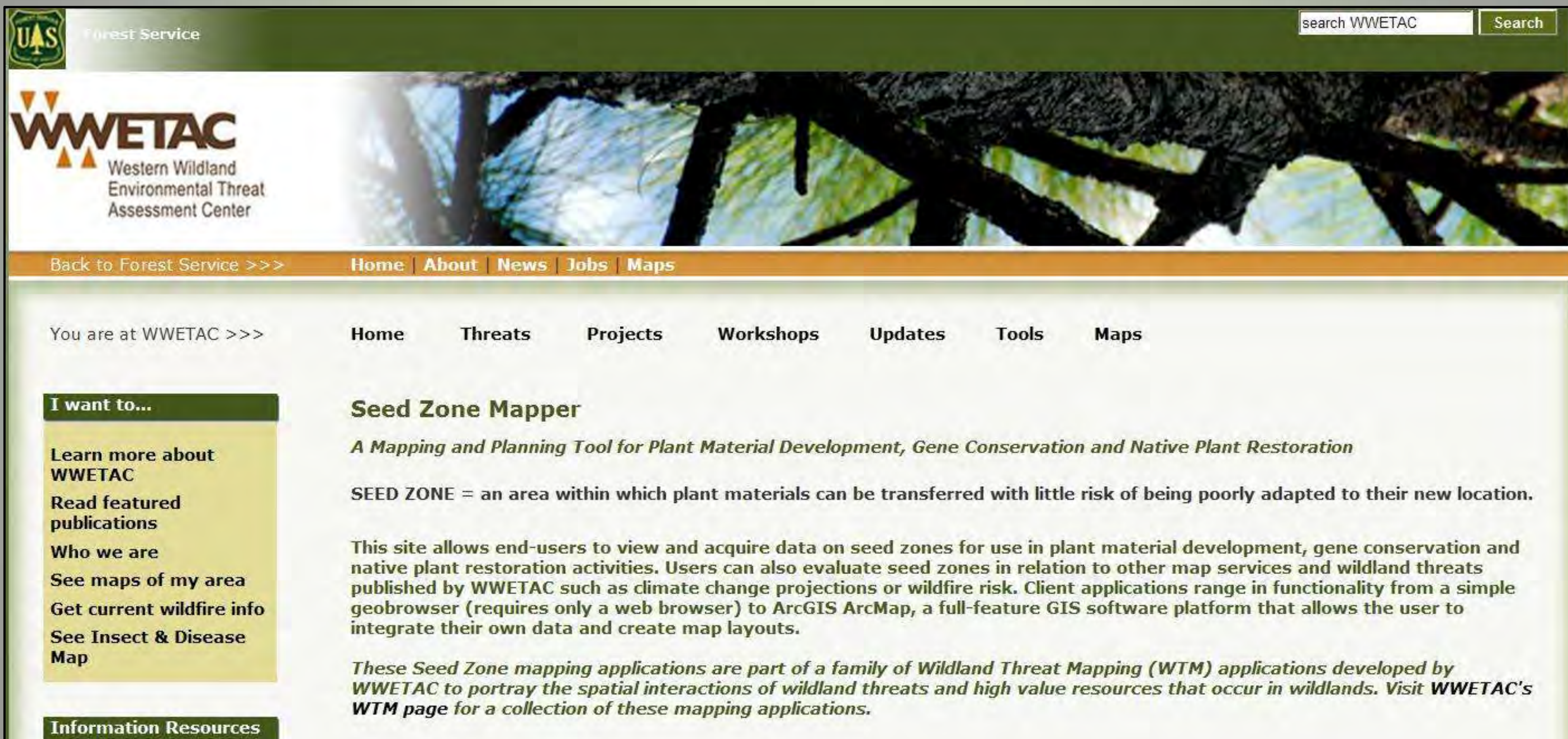




http://sst.forestry.oregonstate.edu/PNW/index.html

Seed Zone Mapper

V Erickson, A Bower, C Schrader-Patton, A Ager



http://www.fs.fed.us/wwetac/threat_map/SeedZones_Intro.html

Spatial data available for download

Download Edited Provisional Seed Zone GIS data:

Dataset	Extent	Download	Map	More Info
Edited Provisional Seed Zones	Northern Great Basin	SHP Shapefile	PDF	PDF
Edited Provisional Seed Zones	Central Great Basin	SHP Shapefile	PDF	PDF

Download Empirical (Common Garden Studies) Seed Zone GIS data:

Dataset	Extent	Download	Map	More Info
Blue wildrye (*Elymus glaucus*)	Blue Mountains Ecoregion (Oregon, WA)	SHP Shapefile	PDF	PDF
Mountain Brome (*Bromus carinatus*)	Blue Mountains Ecoregion (Oregon, WA)	SHP Shapefile	PDF	PDF
Prairie junegrass (*Koelaria macrantha*)	Columbia Basin and Great Basin	SHP Shapefile	PDF	PDF

http://www.fs.fed.us/wwetac/threat_map/SeedZones_Intro.html

Choose your interface

WTM Seed Zone GeoBrowser

The SeedZone GeoBrowser is an interactive 2D map that displays in your internet web browser - no software installation is required. To navigate around the map, Left-click and drag your mouse to pan, use your mouse wheel or the slider control in the upper left to zoom, and Shift-Left click to drag to define a new map extent.

WTM Seed Zone GeoBrowser - Google Earth

Like the SeedZone GeoBrowser, the Google Earth application functions inside your web browser, except it is in 3D and uses the Google Earth globe. A small software plug-in is required; you will be prompted for this the first time the application attempts to load. (Note: USFS users will need administrative privileges to load the plug-in).

WTM Seed Zone KML file (Google Earth)

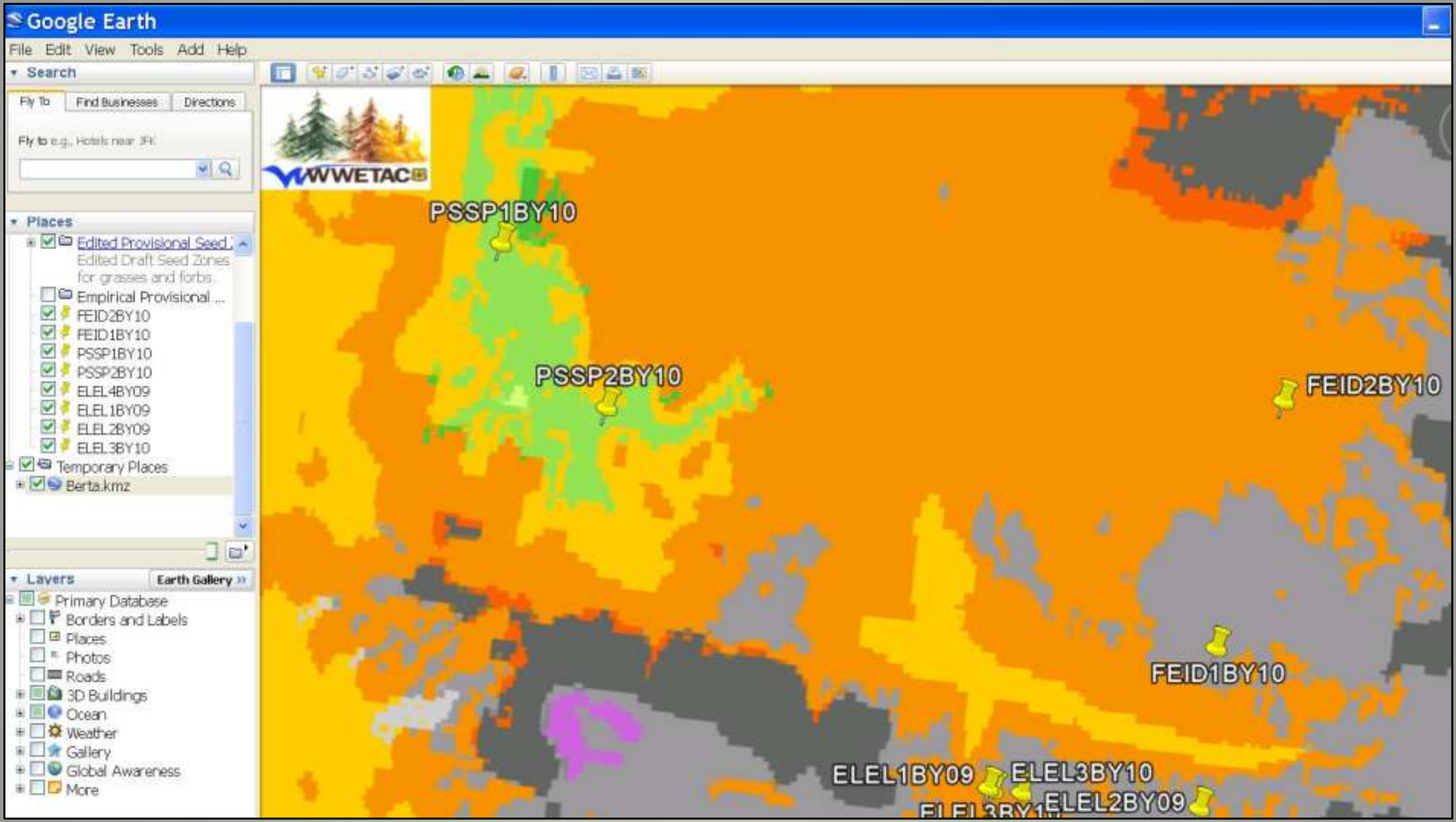
If you have desktop **Google Earth** installed, you can view seed zone layers by loading a KML file. The KML file may load and initialize Google Earth when the link is clicked, or you may have to Right- click and use 'Save As' to download the file to your PC then open the file in Google Earth.

WTM Seed Zone MXD file (ArcMap)

ArcMap is GIS software from **ESRI**; if you have ArcMap installed on your PC, this map document (.mxd) contains links to the served WTM and Seed Zone layers and can be opened in ArcMap. Using ArcMap you can load and view your own local or enterprise GIS data with the SeedZone layers. To download the seedzone.mxd file, Right-click on the above hot-link title text and select 'Save As'.

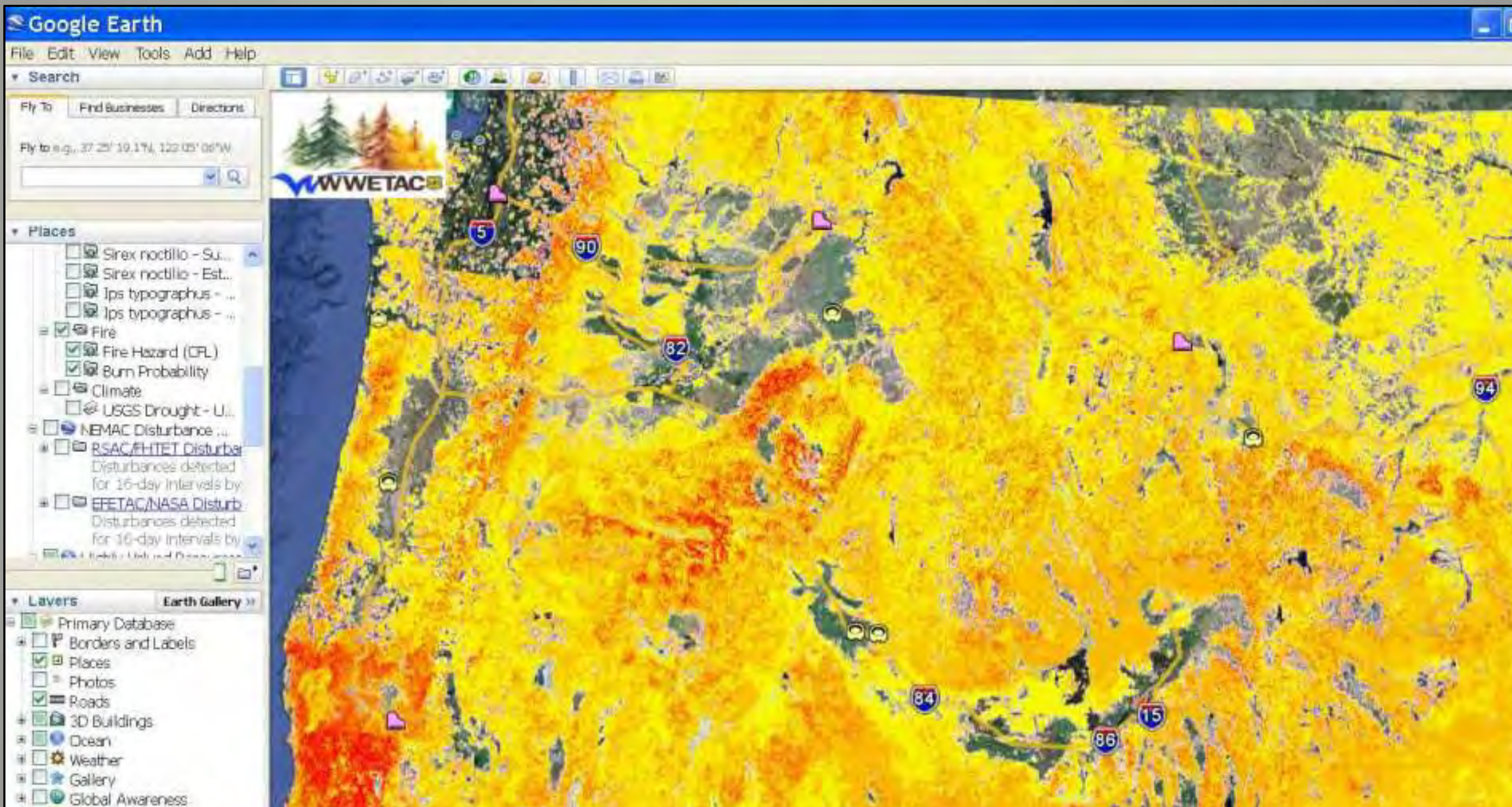
http://www.fs.fed.us/wwetac/threat_map/SeedZones_Intro.html

Example: VGE interface



http://www.fs.fed.us/wwetac/threat_map/SeedZones_Intro.html

Value-added products: Fire Risk



http://www.fs.fed.us/wwetac/threat_map/index.html

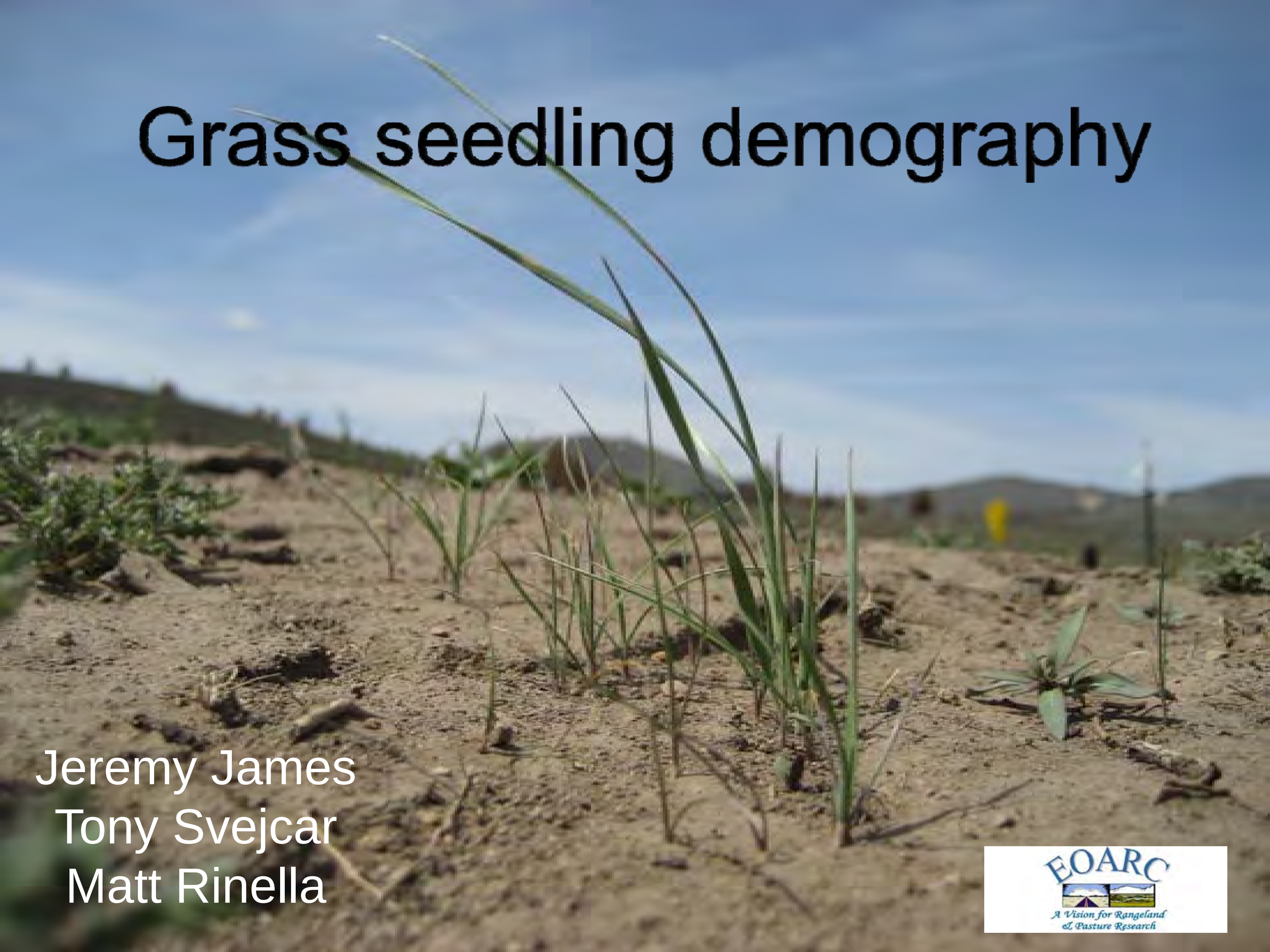
Caveats

- Any type of seed zone etc is only a *starting point*
- Decision support tools are just that
- Local knowledge is essential for assessing rec's

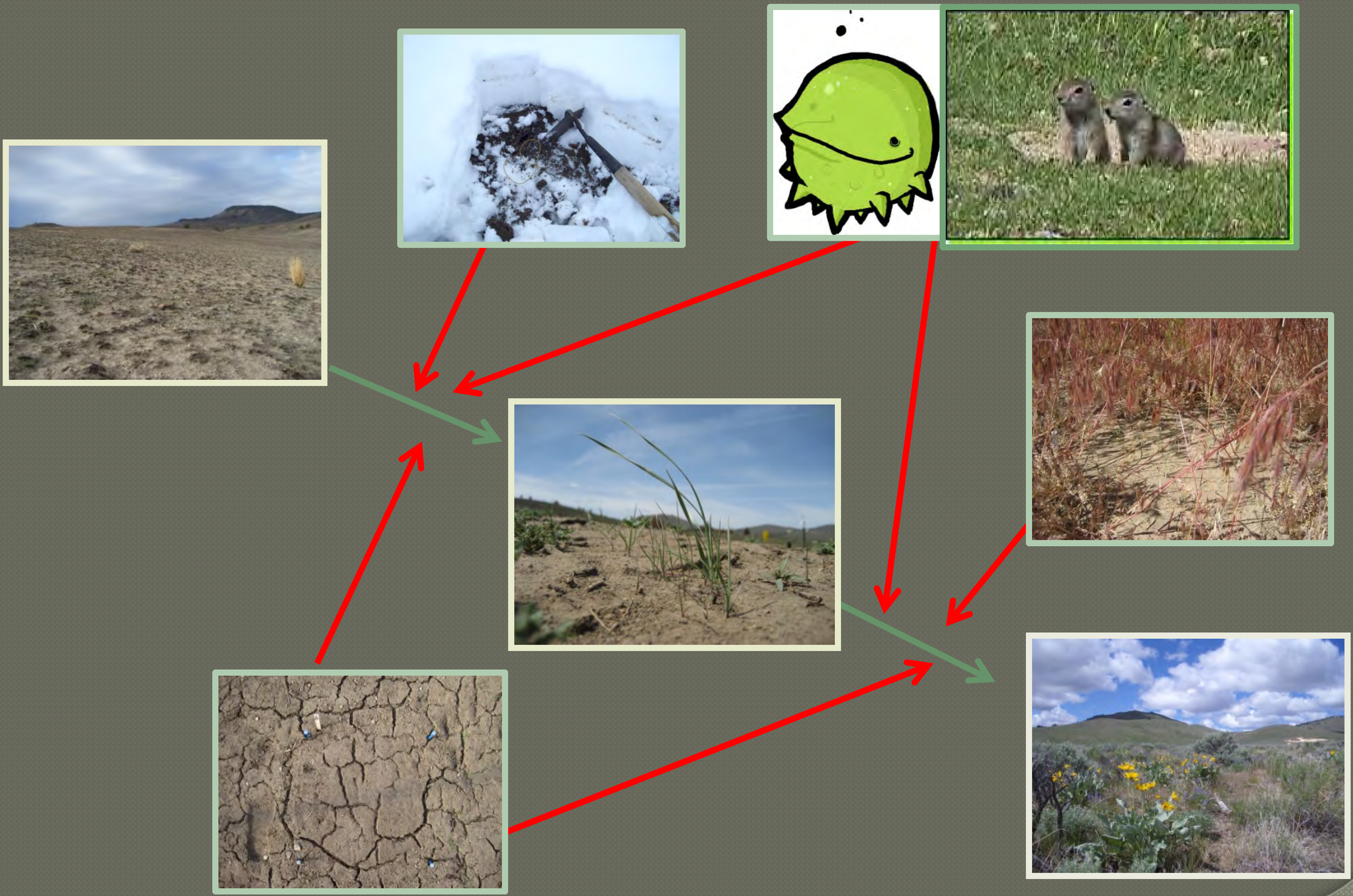
Additional complicating factors Influencing Species Presence:
- Soils
- Competition
- Disease and insects
- Fragmentation

Questions?

Matt Horning
mhorning@fs.fed.us
(office) 541-383-5519
(cell) 541-408-1711


Grass seedling demography
Jeremy James
Tony Svejcar
Matt Rinella
EOARC
A Vision for Rangeland
& Pasture Research

Drivers of restoration outcomes



Seedling demography

Sowing

Germination

Emergence

Establishment

Juvenile Survival

Adult Survival

Quantifying demography

3 years at NGBER

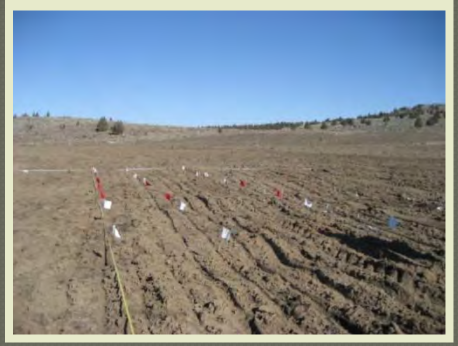
- Crested
- Bluebunch
- Squirreltail

Egley

Butte

Bartlett

Roundtop



Seedling demography

Sowing

Germination

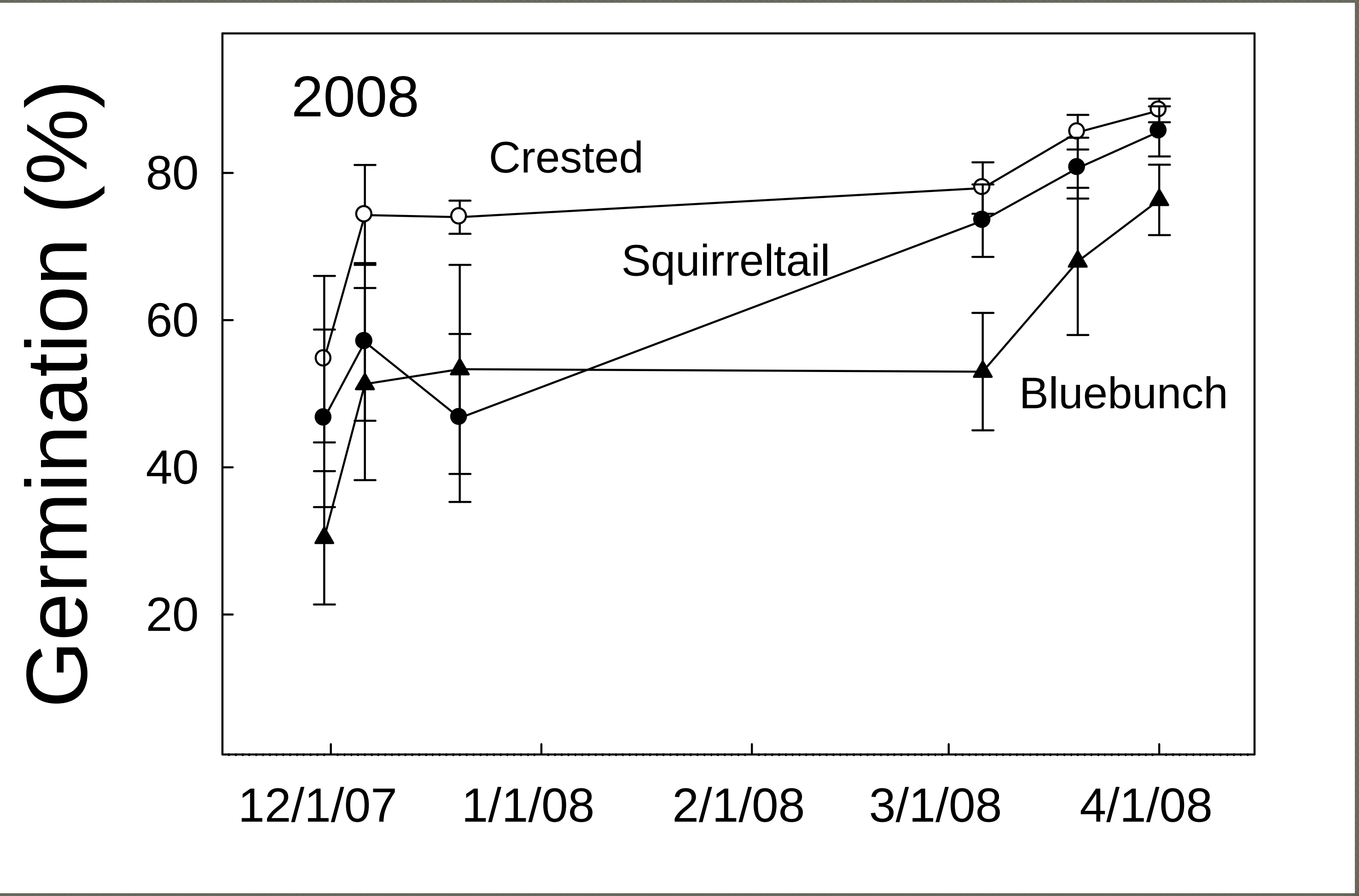
Emergence

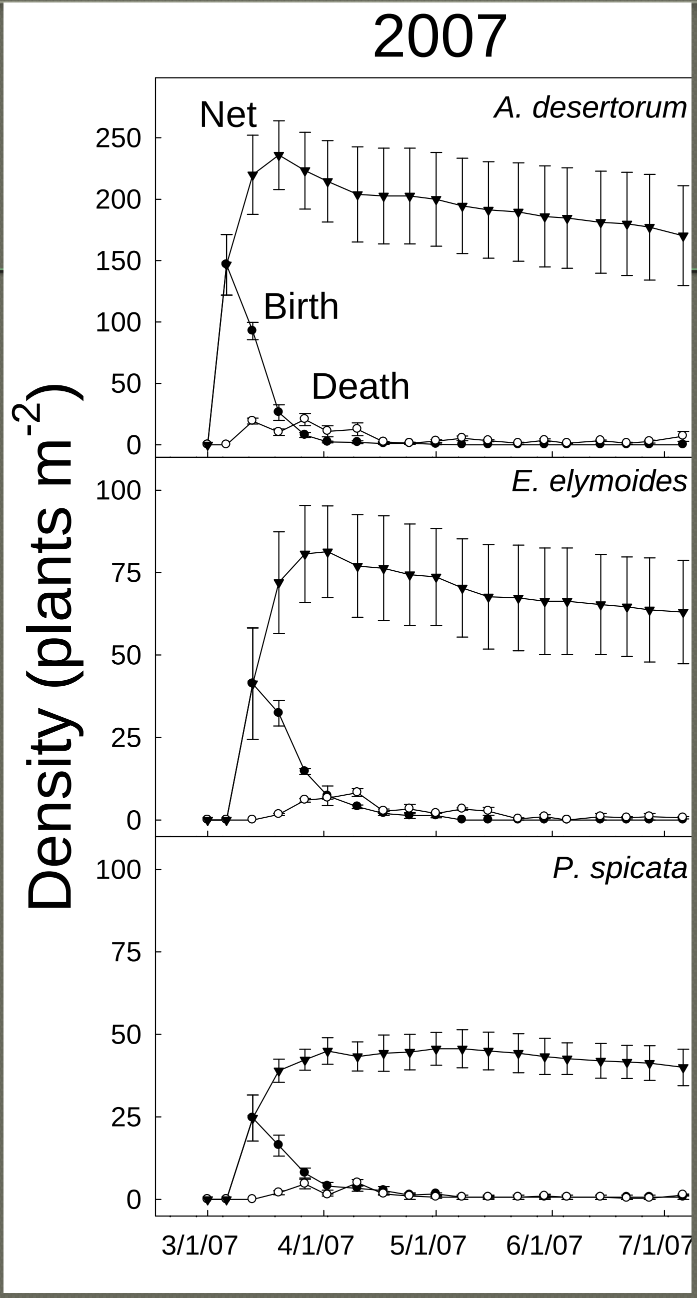
Establishment

Juvenile Survival

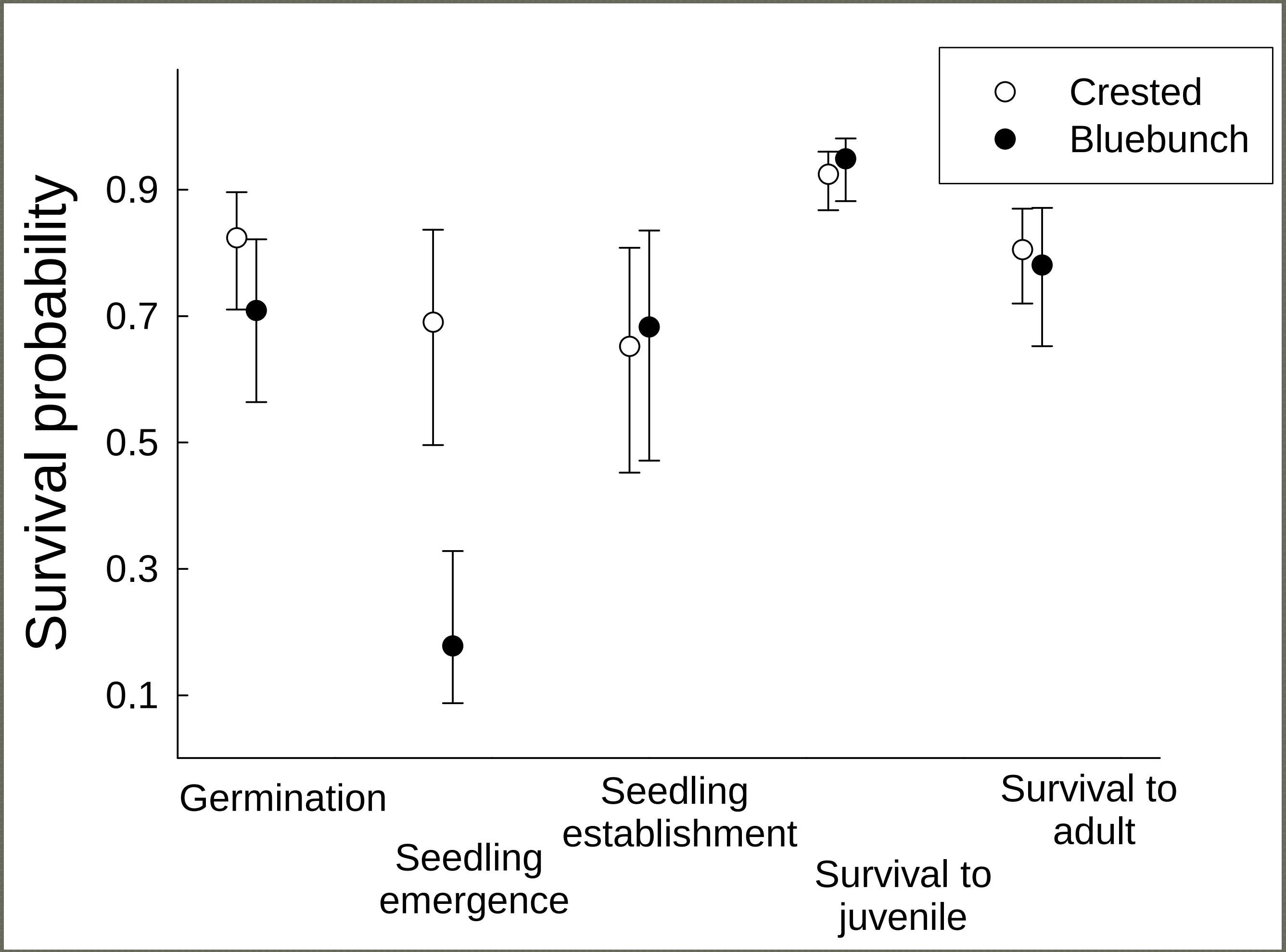
Adult Survival

Germination timing

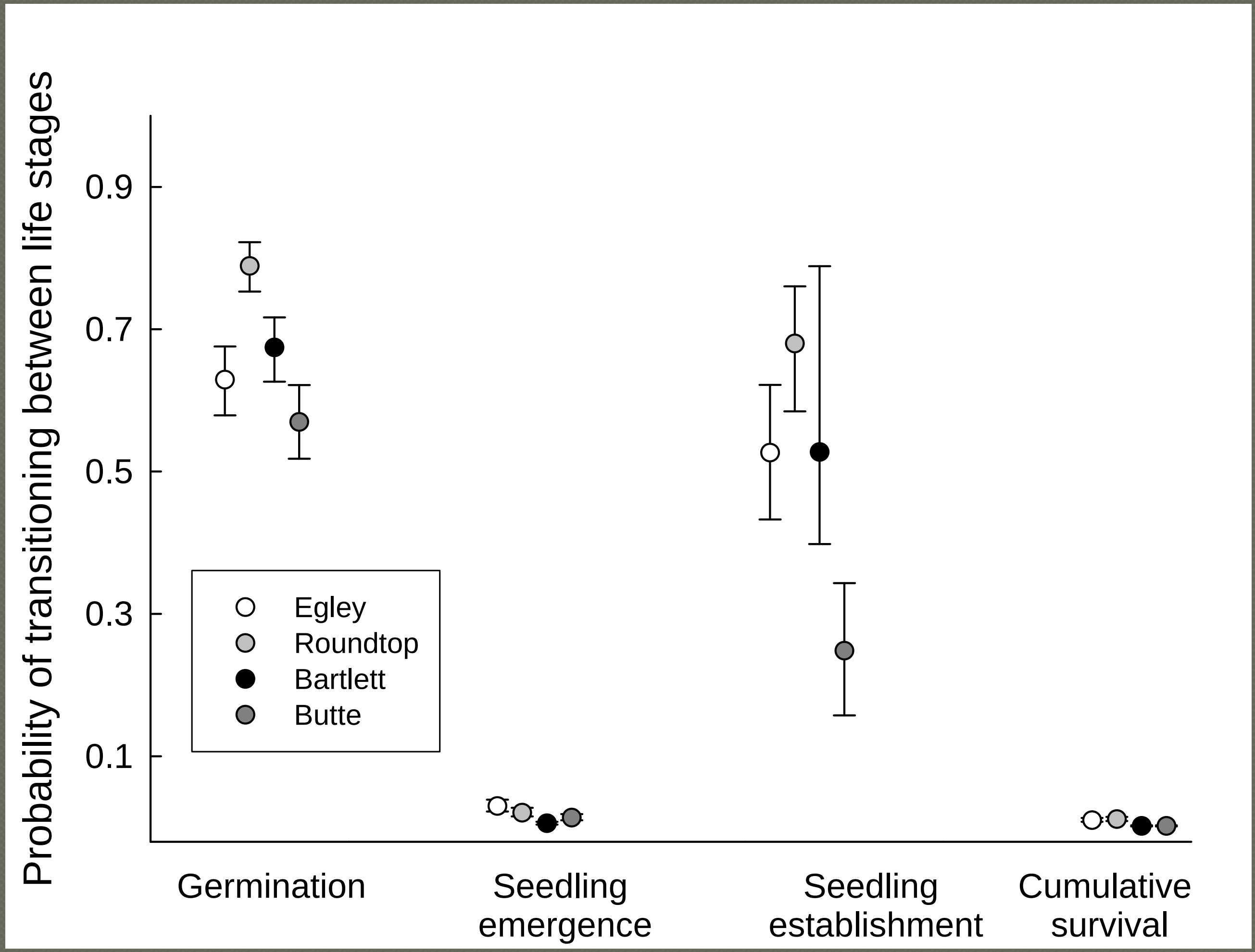



2007
Net
Birth
Death
A. desertorum
E. elymoides
P. spicata
Density (plants m-2)
250
200
150
100
50
0
100
75
50
25
0
100
75
50
25
0
3/1/07
4/1/07
5/1/07
6/1/07
7/1/07

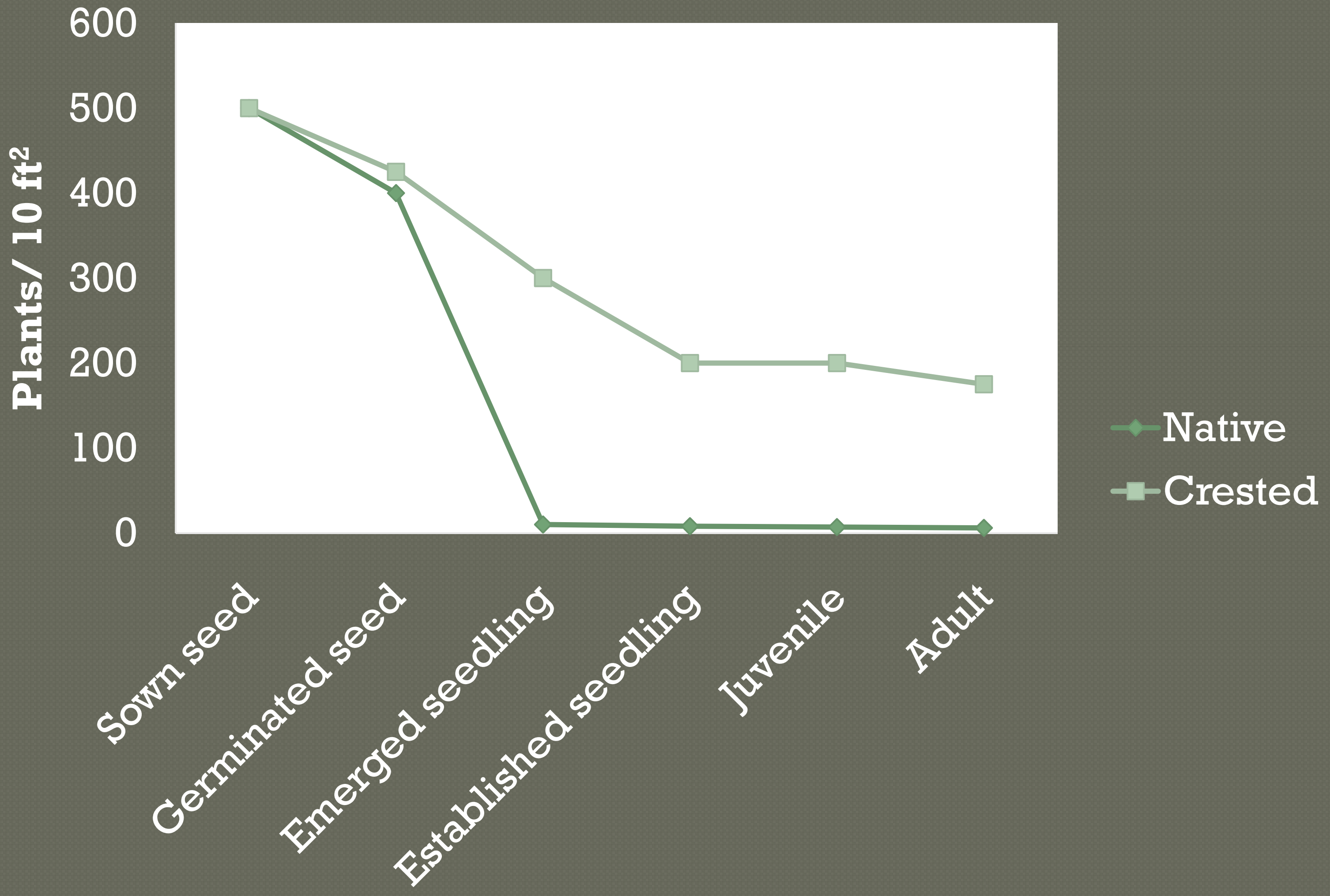
Seedling survival



Transition probabilities at fires

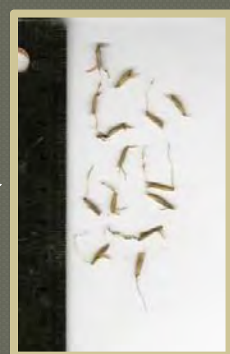


Seedling survival

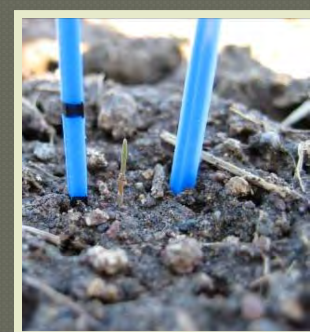


When do plants die?

20%



88%



5-10%

90%

Summary

- Germination is high across years and sites (60-80%)
- Emergence is the bottleneck to native plant recruitment
  - 90% of germinated native seeds do not emerge
  - 50% of germinated crested seeds do not emerge
- Over >90% of seeds sown are lost before they emerge from soil surface


Questions

U.S. Department of Agriculture
Agricultural Research Service

Forage and Range Research Laboratory

Three North American Legumes for the Great Basin: Basalt Milkvetch, Western Prairie Clover, and Searls Prairie Clover

Doug Johnson
Shaun Bushman
Kishor Bhattarai
Kevin Connors

FRRL
PLANTS FOR THE WEST

FRRL
PLANTS FOR THE WEST

USDA-ARS Forage and Range Research Lab (FRRL)
Logan, Utah

Our Mission:

Provide an array of improved <u>plant materials</u> and <u>management alternatives</u> for sustainable stewardship of rangelands and pastures in the western U.S.

Scientists:

Genetics/Plant Breeding (6)
Molecular Biology (4)
Physiology/Ecology (2)

Background

- Thousands of acres burn each year in the Great Basin.
- Many land managers prefer a mix of diverse plant species for rangeland revegetation.
- Very few North American legumes are available for rangeland revegetation in the Great Basin.
- Identifying regional seed sources is beneficial for commercial seed production.

Need for Native Legume Species

Important for:

- **Nitrogen fixation**
- **Seeding diversification**
- **Wildlife habitat and grazing**
- **Native pollinators**
- **Highways and roads**
- **Home xeriscaping**

→ **Targeted three legume species native to western North America.**

Basalt Milkvetch - *Astragalus filipes*

- Wide spread
- Upright habit

- Creamy, showy flower
- Good seed production
- No reports of toxicity

PLANTS FOR THE WEST

Western Prairie Clover (*Dalea ornata*)

- Northern GB
- Upright habit

- Purple, showy flower
- Good seed production
- No reports of toxicity

FRRL
PLANTS FOR THE WEST

Searls Prairie Clover (*Dalea searlsiae)*

- Southern GB
- Upright habit

- Purple, showy flower
- Good seed production
- No reports of toxicity

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PLANTS FOR THE WEST

Objectives

- Make diverse seed collections of three North American legume species
- Conduct common-garden and molecular genetics studies to identify populations for release to the commercial seed trade

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PLANTS FOR THE WEST

For Each Legume Species

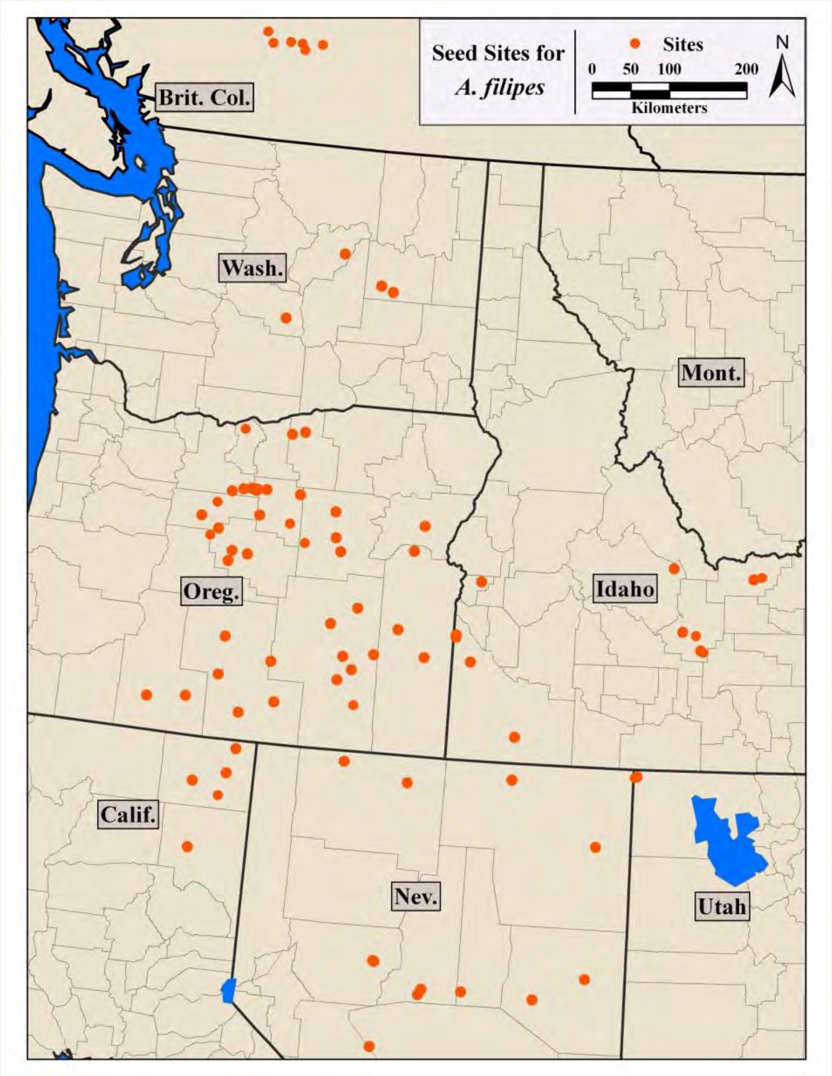
- Collected seed, soil, and plant samples for the three legume species
- Recorded site and plant information for each collection
- Analyzed plant samples for animal toxicity (swainsonine, nitrotoxins, selenium)

→ No detectable levels or extremely low levels of toxic compounds in all three species.

PLANTS FOR THE WEST

Basalt Milkvetch Collections

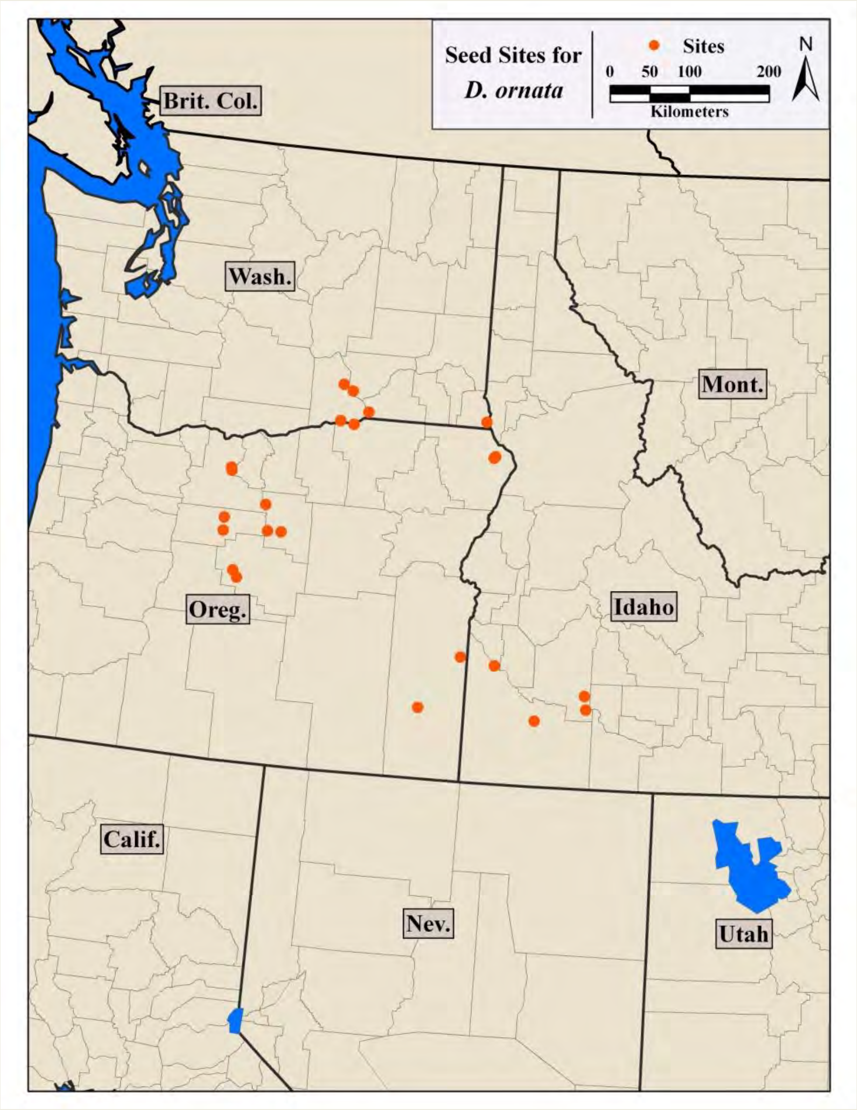
85 sites



PLANTS FOR THE WEST

Western Prairie Clover Collections

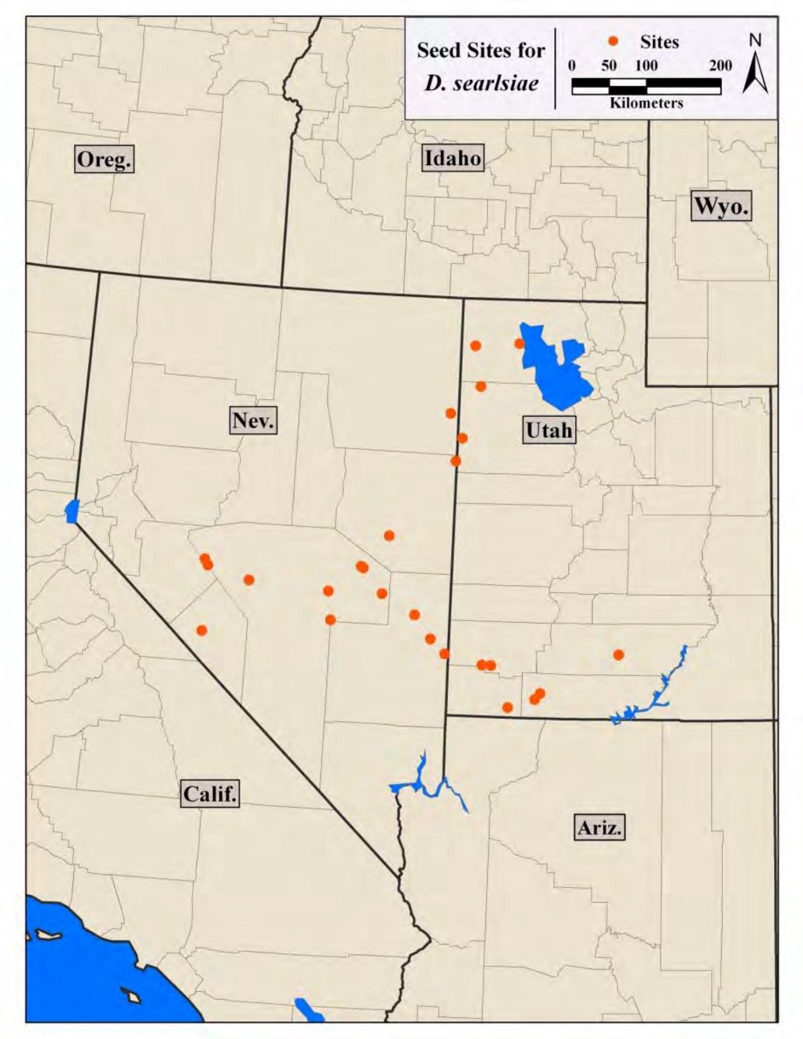
25 sites



PLANTS FOR THE WEST

Searls Prairie Clover Collections

25 sites



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PLANTS FOR THE WEST

Common-Garden Field Data

Two Common Gardens for Plant Evaluations

Two years of data collection

- Flowering date
- June biomass
- Plant height
- Plant vigor score
- Seed yield
- Fall regrowth
- Forage quality

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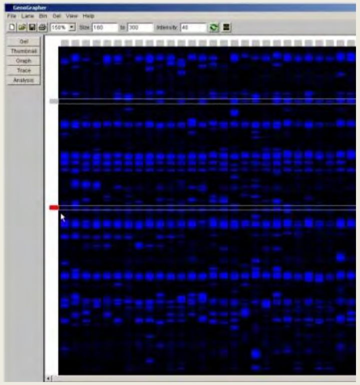
Genetic Diversity Structure Determined For The Three Legume Species

- DNA procedures (AFLP) were used to determine the genetic diversity structure for each of the three legume species.



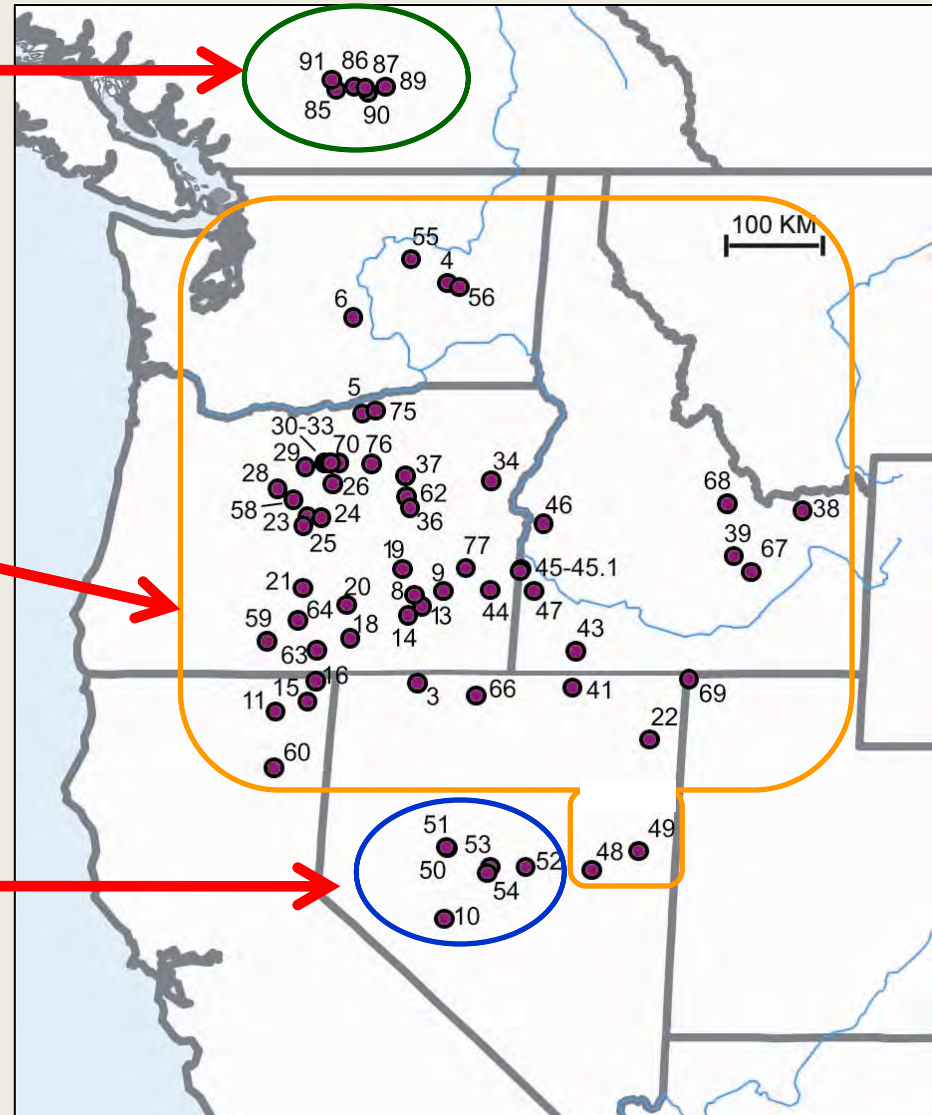
- Results from DNA analysis allowed grouping of collections with similar genetic background.

Release Strategy for Basalt Milkvetch

British Columbia

NBR-1 Germplasm

Southern Nevada

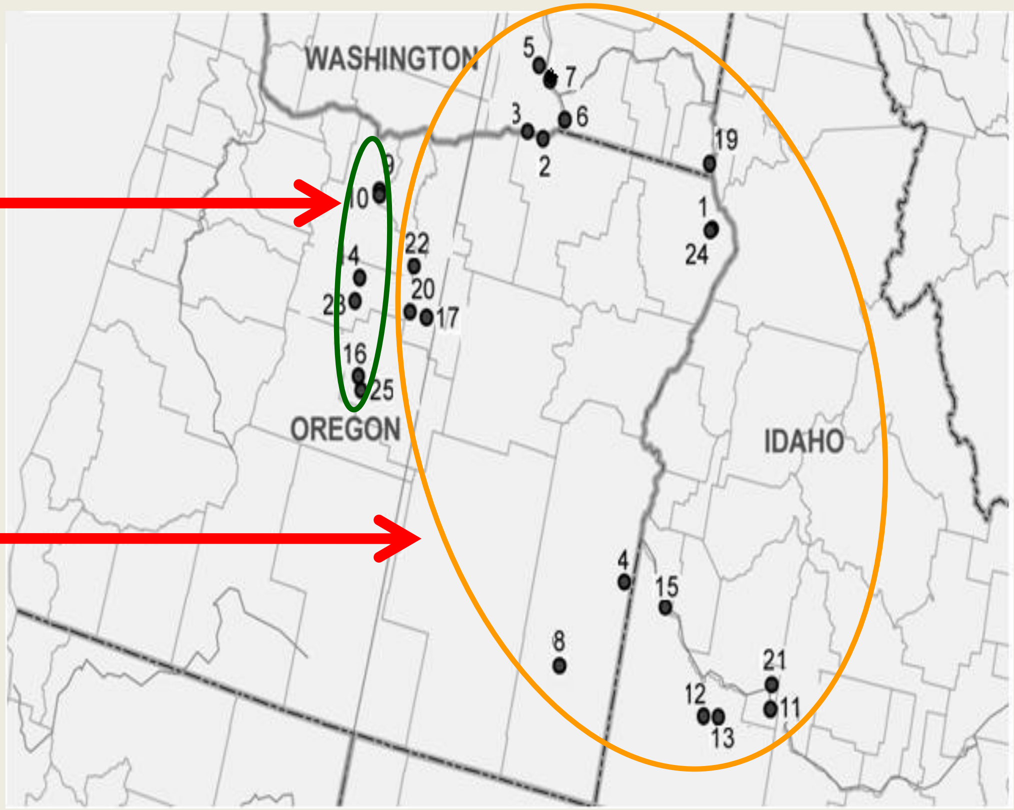


PLANTS FOR THE WEST

Release Strategy for Western Prairie Clover

Majestic Germplasm

Spectrum Germplasm



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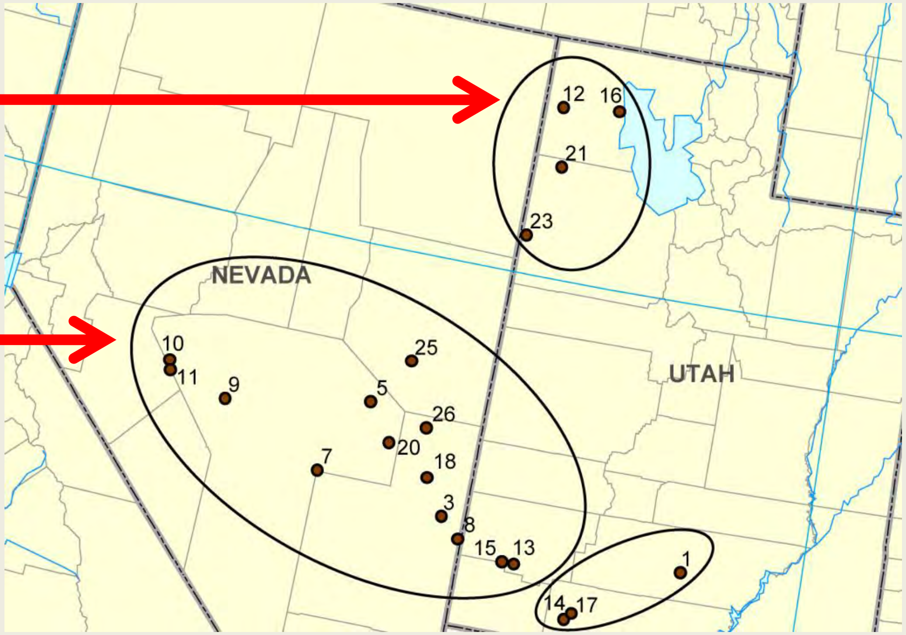
Release Strategy for Searls Prairie Clover

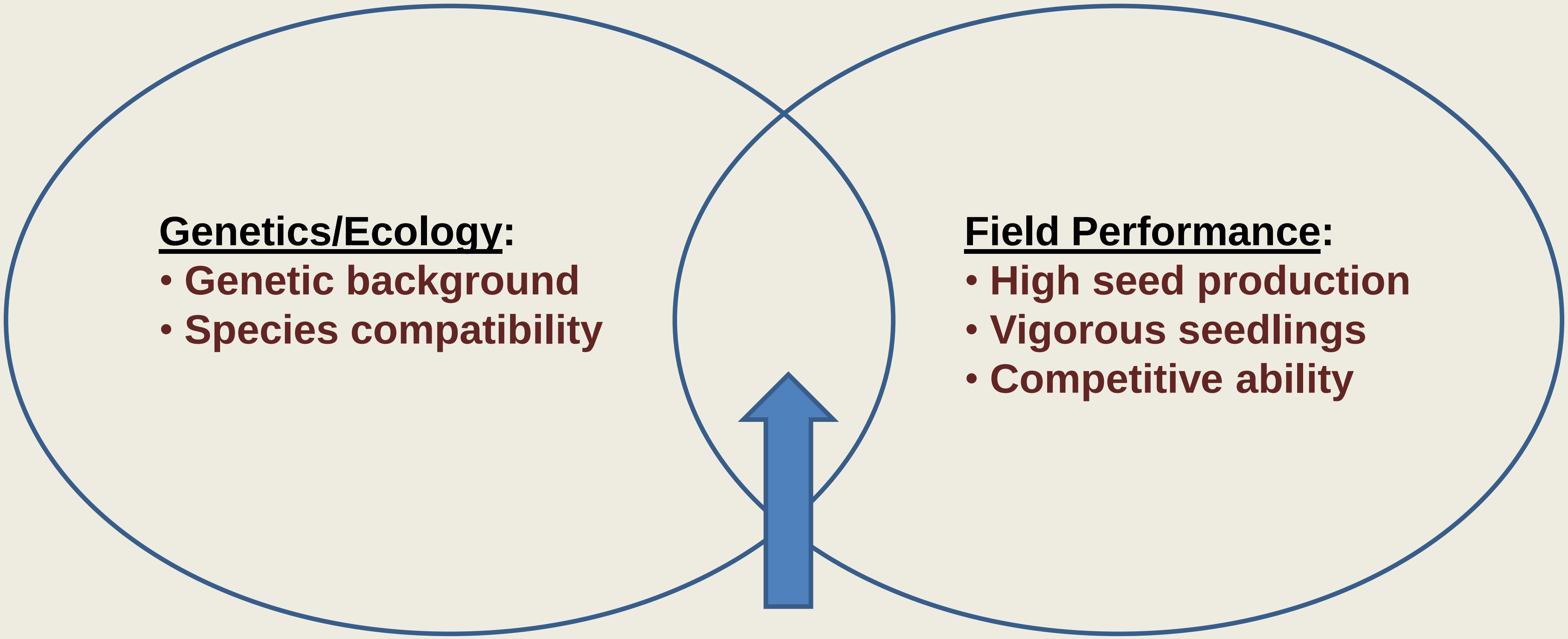
Northwestern Utah

Southern Great Basin



Colorado Plateau

Combining Genetic/Ecological and Performance Considerations



Plants that:
- Establish, compete, and persist
- Stabilize the site
- Have affordable, available seed

FRRL PLANTS FOR THE WEST

Partnering with Growers to Make Seed Available of Three Legume Species

1. Basalt Milkvetch (*Astragalus filipes*)


2. Western Prairie Clover (*Dalea ornata*)


3. Searls Prairie Clover (*Dalea searlsiae*)


→ **<u>Grower partners</u>: BFI Native Seeds, L&H Seed, Southwest Seed, Allied Seed, NRCS-Aberdeen & Meeker, Ron Bitner/Paul Beckman, Jerry Erstrom**

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PLANTS FOR THE WEST

Greenhouse Seedling Emergence Study

Problem: Hard seed (physical and/or physiological)

- Limits initial, uniform germination
- Germination during long time period

Species: Basalt milkvetch, western prairie clover, Searls prairie clover, Utah sweetvetch (check)

Seed Treatments: None, acid-scarified, sandpaper-scarified

Seeding Depth: 0.6 cm (¼ inch), 1.9 cm (¾ inch)

Seed Age: Current-year seed, two-year-old seed

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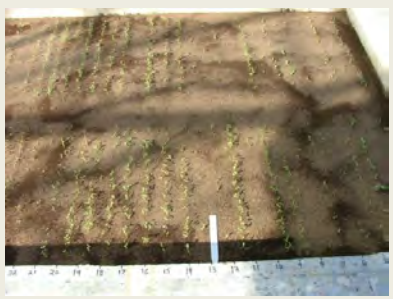
Preliminary Results

Day 10



NT NT NT

AS SS SS

Day 27

- **Scarification greatly improved germination in *Dalea,* less so for *A. filipes*.**

- **Seedlings of *Dalea* emerged well at ¾-inch depth.**

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PLANTS FOR THE WEST

Other Studies With These Species

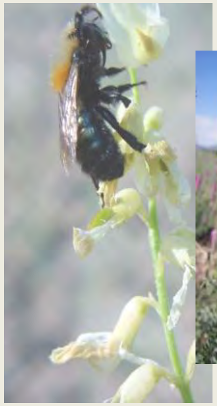
Field Seedling Establishment

Shaun Bushman

Doug Johnson

Pollination

Jim Cane



Seed Predation

Herbicide Effects

Corey Ransom

Clint Shock

Acknowledgements

Great Basin Native Plant Selection and Increase Project

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

GREAT BASIN
Native Plant
Selection & Increase
PROJECT

GREAT BASIN
Restoration Initiative

USDA

ROCKY MOUNTAIN
Research Station

U.S. Department of Agriculture
Agricultural Research Service

Forage and Range Research Laboratory

Doug Johnson

Phone: (435) 797-3067

Email: doug.johnson@ars.usda.gov

PLANTS FOR THE WEST

Rangeland Plant Ecology Research

Forage and Range Research Laboratory

'Continental' basin wildrye and the Tertiary Restoration Gene Pool

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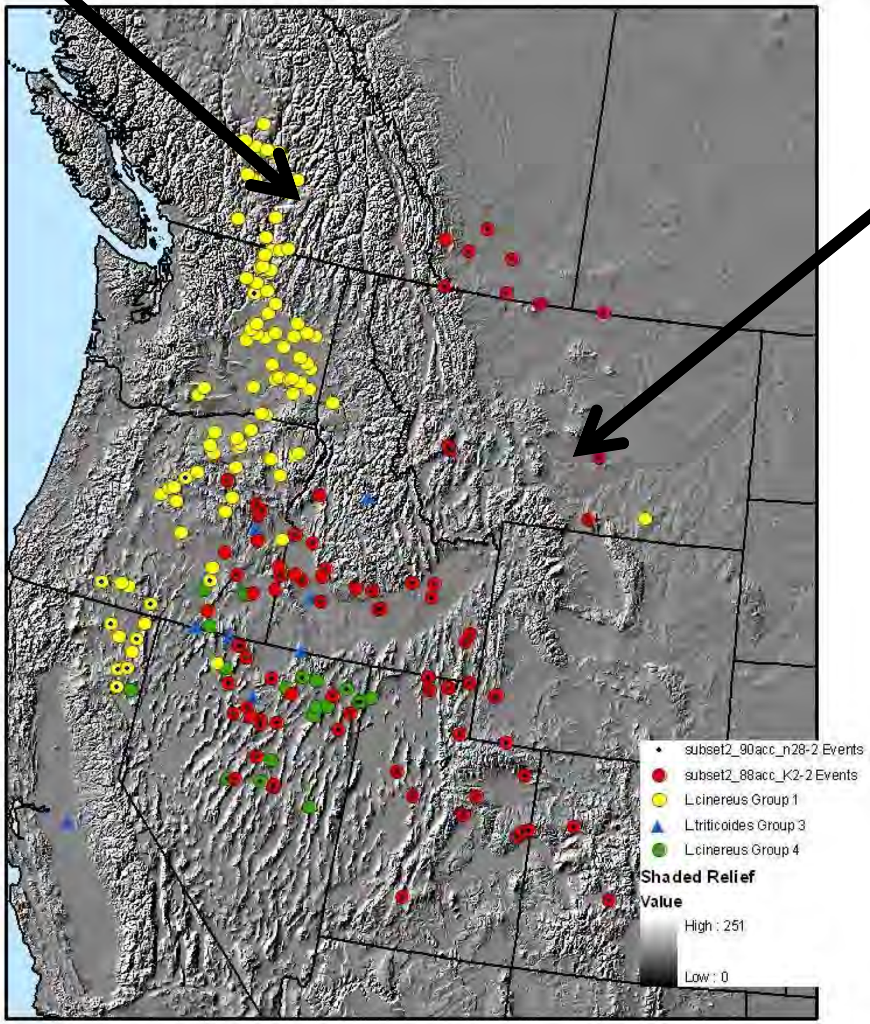
PLANTS FOR THE WEST

Three major genetic groupings of basin wildrye

Magnar

Trailhead



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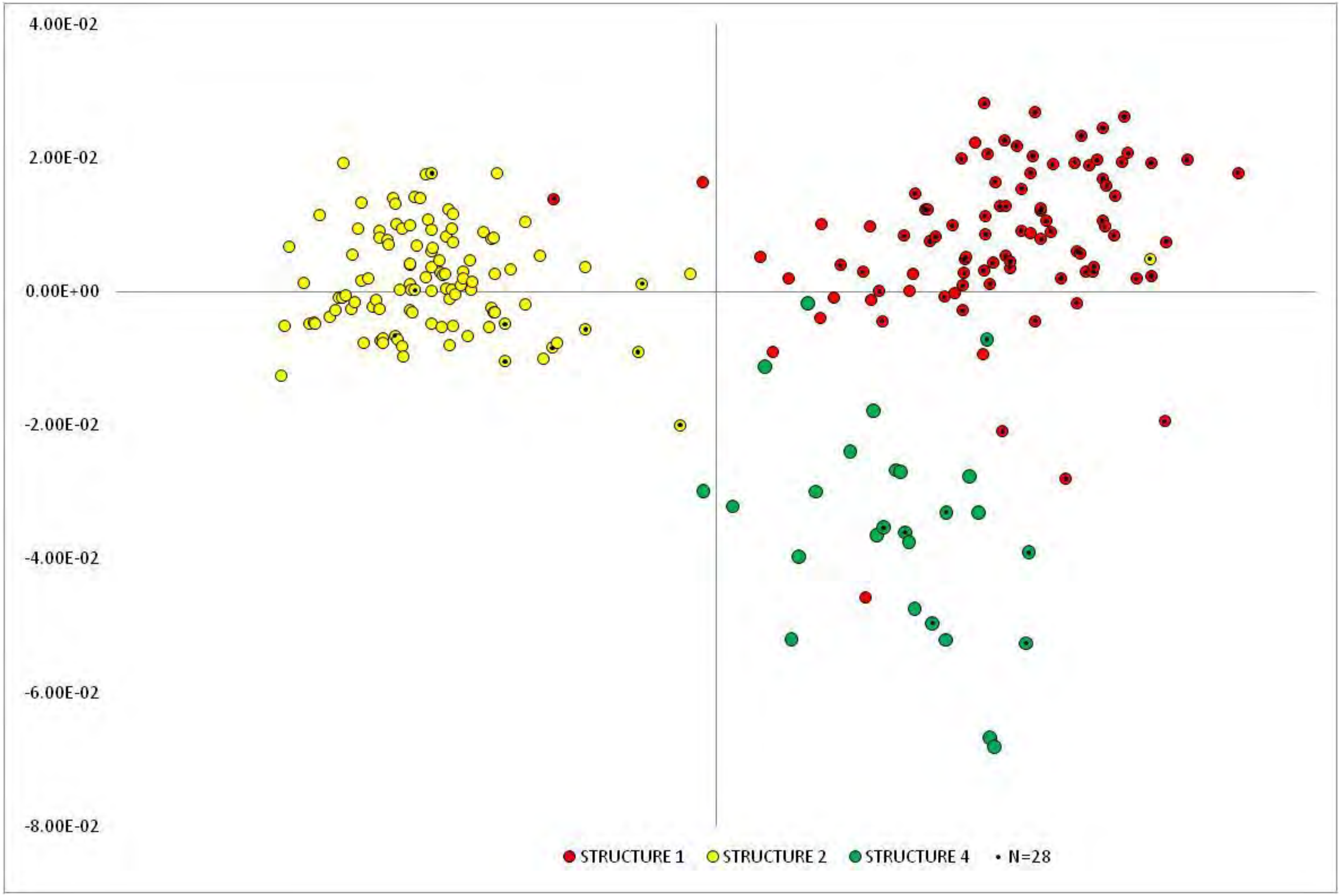
Three major genetic groupings of basin wildrye



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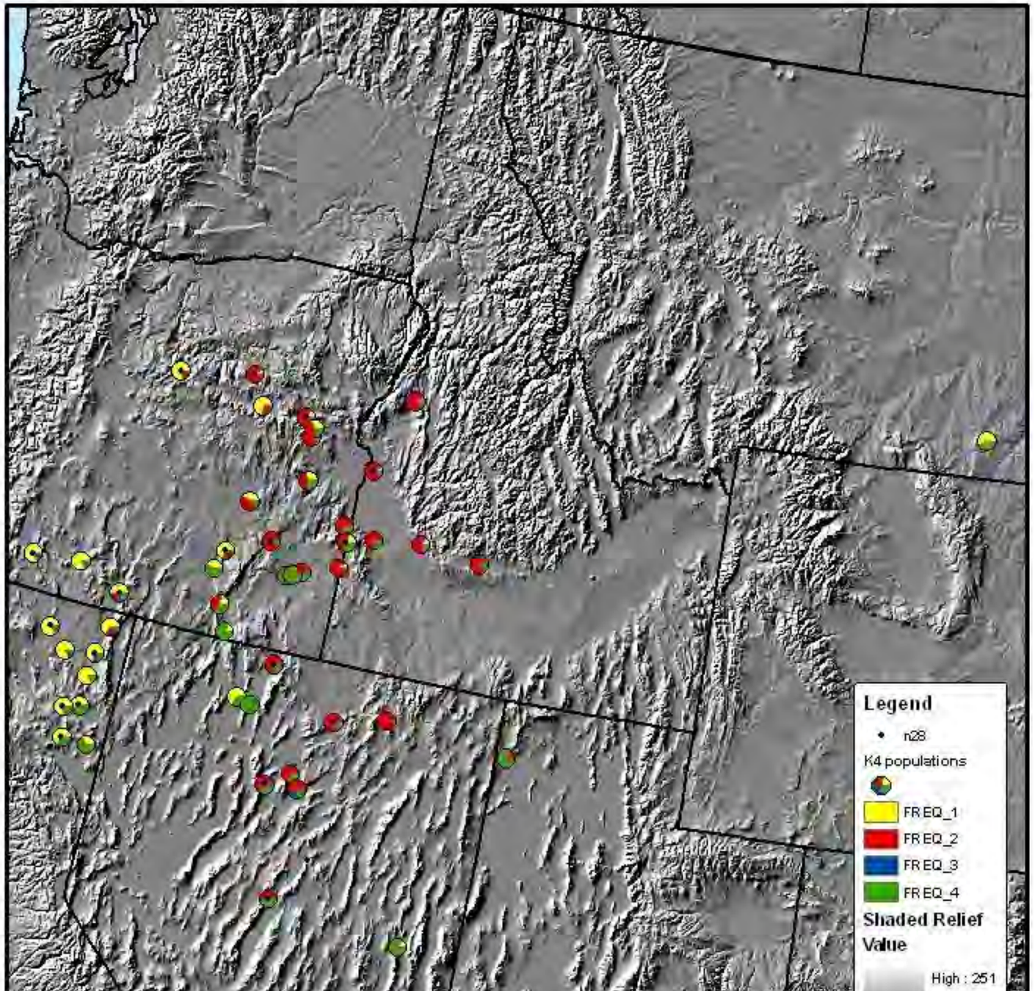
Admixed populations of basin wildrye



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Development of 'Continental' basin wildrye

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

↓ chromosome-doubling

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

↓

L-28

↓

↓

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

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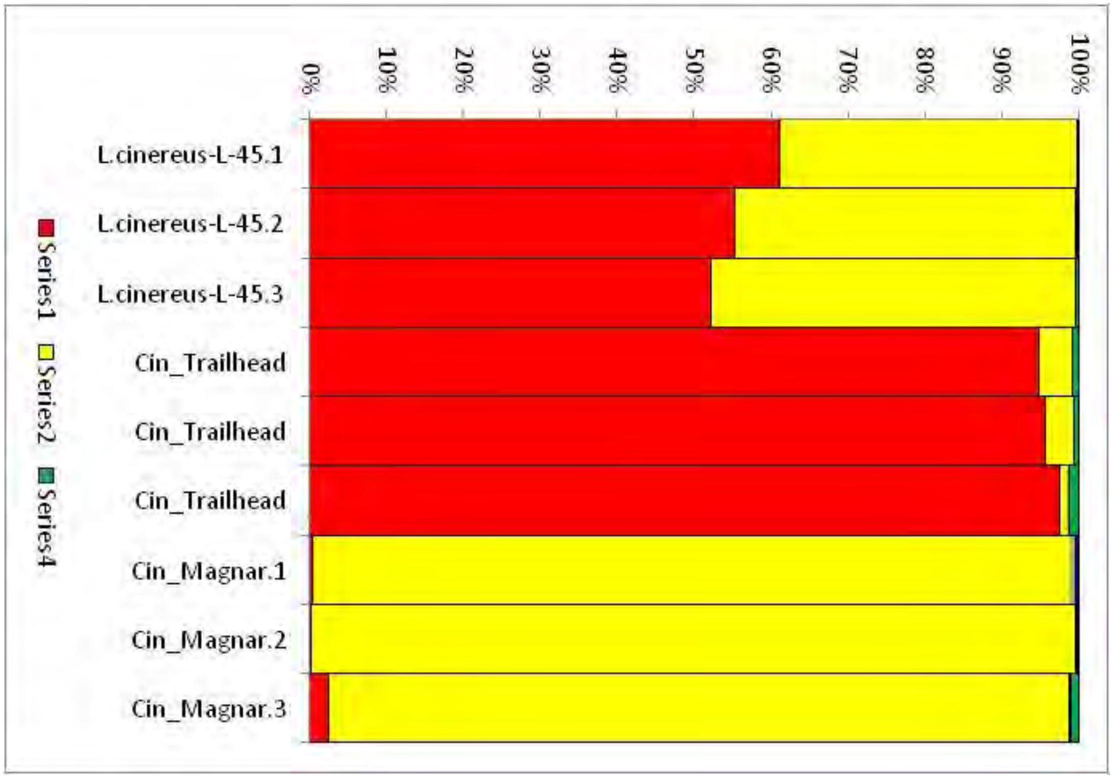

Continental

Trailhead

Magnar

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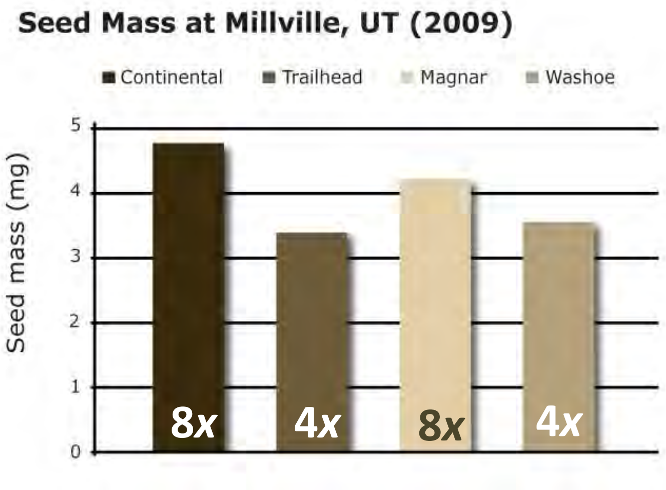
Continental basin wildrye seed mass



Seed mass of basin wildrye plant materials

Evans Farm (2009)

	mg/seed
Continental	4.60
Magnar	4.07
Washoe	3.42
Trailhead	3.25

North Park Farm (2010)

	mg/seed
Continental	4.59
L-61	4.44
Magnar	3.82

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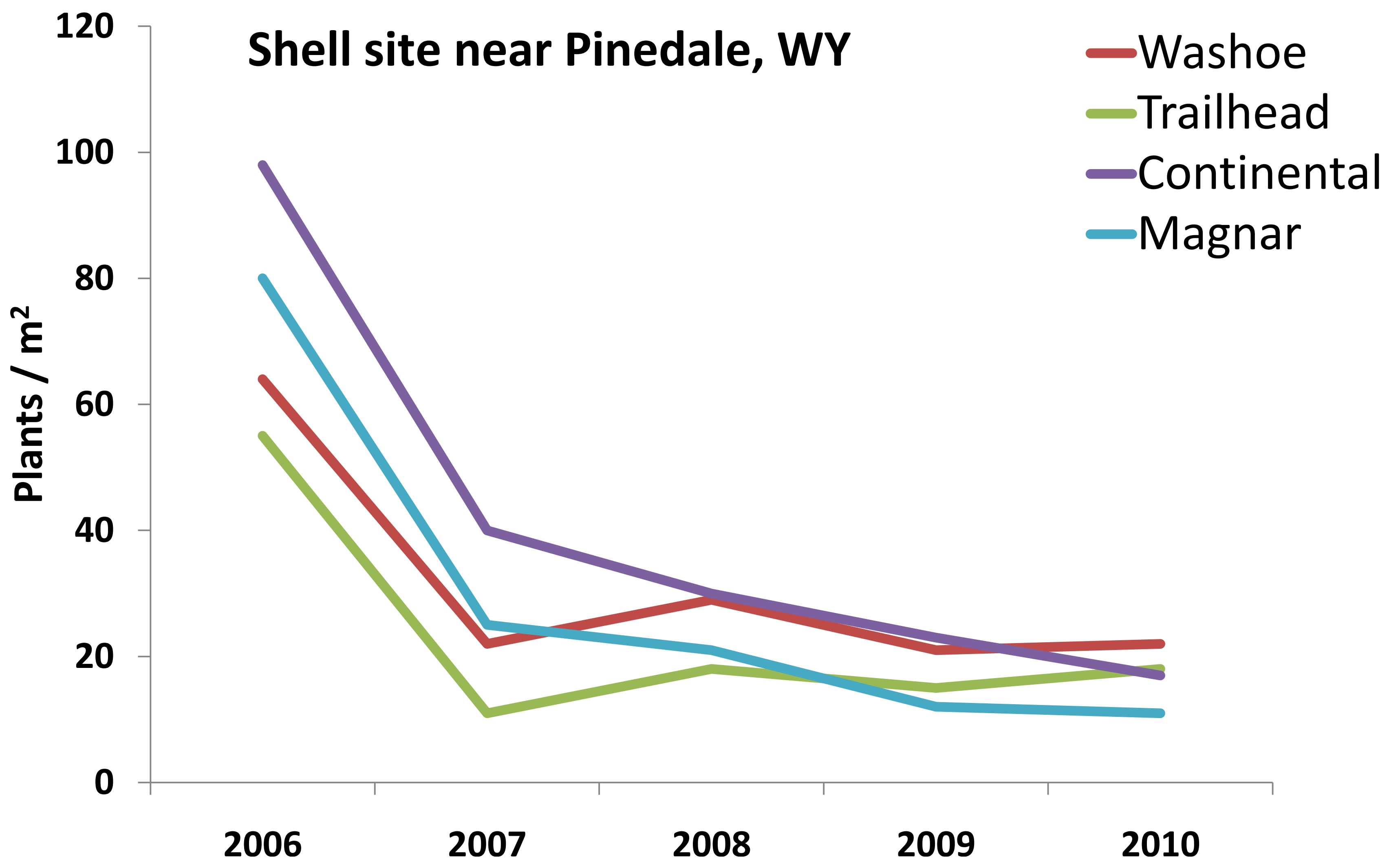
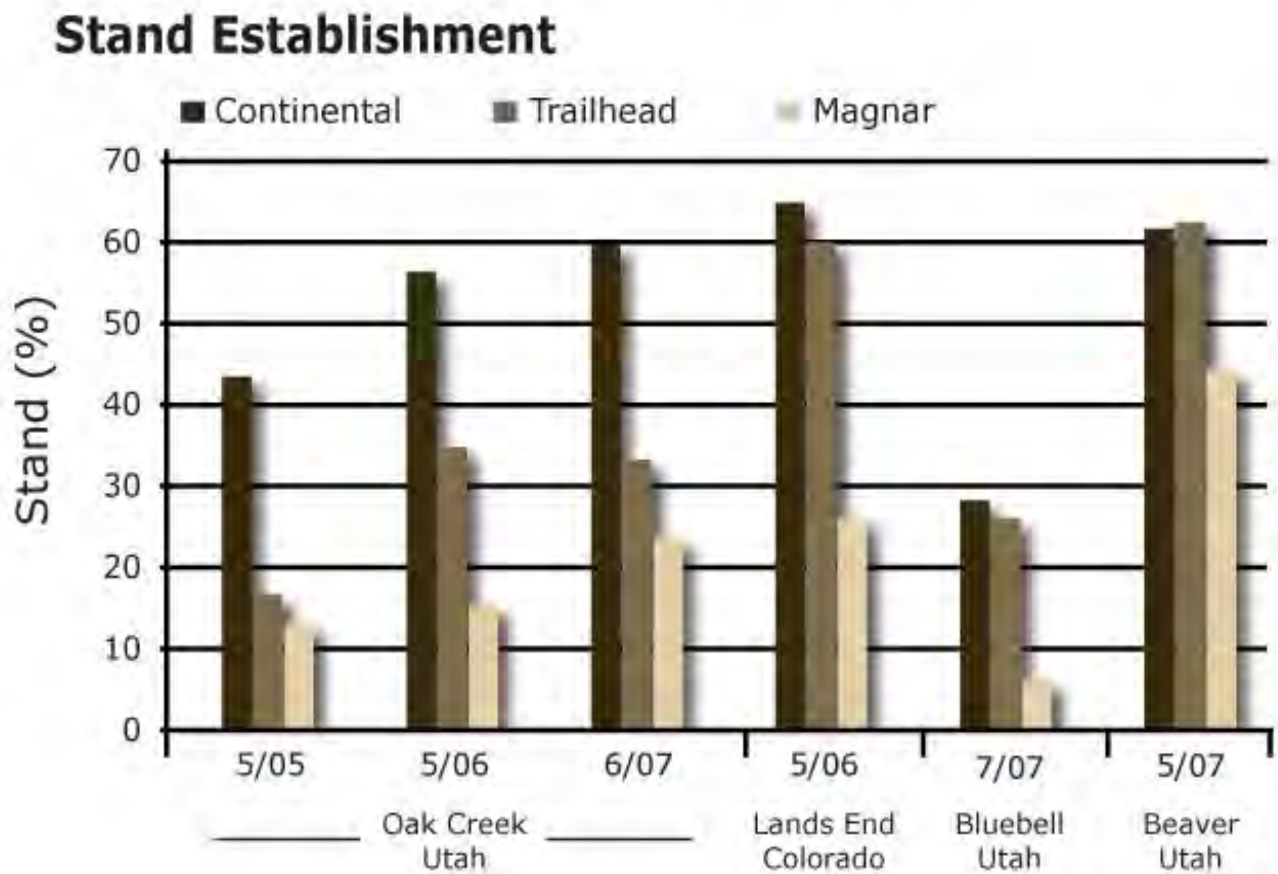
Stand establishment and persistence



FRRL PLANTS FOR THE WEST

Continental basin stand establishment



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PLANTS FOR THE WEST

Continental basin wildrye

THE WHY

GENETIC SHIFT


GENETIC DRIFT

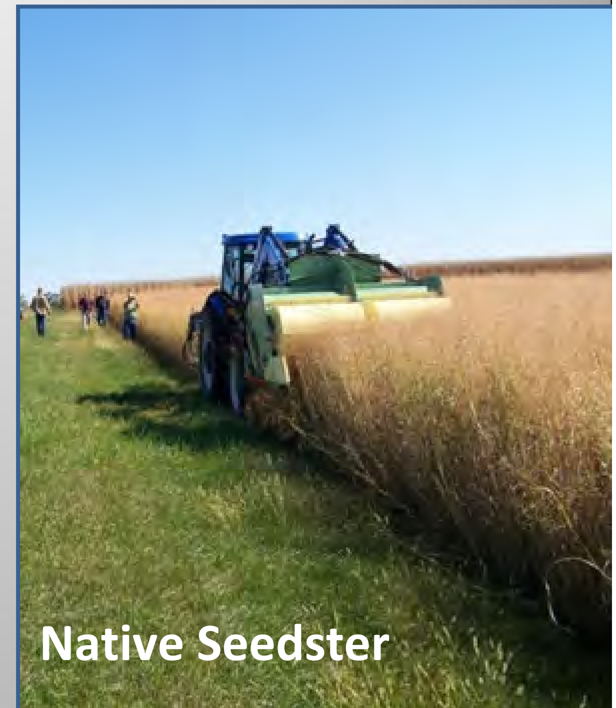
Harvestability Indexes for Native Wildflowers and Grasses

Mark Majerus and Lee Arbuckle

Native Seedsters, Inc.

Billings, Montana

Seed Harvesting of Native Plants



Developing Harvestability Indexes

♦388 native wildflower species
195 native grass species
(commercially produced or wildland collected) US and Canada

♦ Funded by: Montana Board of Research & Commercialization Technology

♦ Wildflowers 13- Grasses 9 morphological & physiological characteristics

♦ Consulted w/ professional seed producers & collectors

♦ Ranking of whether characteristics have a
(+) favorable impact
(-) limiting impact

♦ Index for Standard Combine harvest
♦ Index for Native Seedster harvest

Wildflower Harvestability Index

Plant Growth Form

	Combine	Seedster
upright	+30	+30
decumbent	-10	-10
creeping/vine	-20	-20

Plant Height

	Combine	Seedster
tall--> 3’	+10	+20
mid--1.5’ to 3’	+20	+20
short-- 1’ to 1.5’	-20	-20
very short-- 1’	-40	-40




Foliage Density

	Combine	Seedster
sparse	+10	+10
medium	+5	+5
thick	-10	-10

Type of Inflorescence

	Combine	Seedster
spike	+10	+10
raceme	+10	+10
panicle	+10	+10
umbel/corymb/cyme	+10	+10
solitary head	+10	+10
recessed in receptacle	+20	-10

Inflorescence Position in Relation to Forage

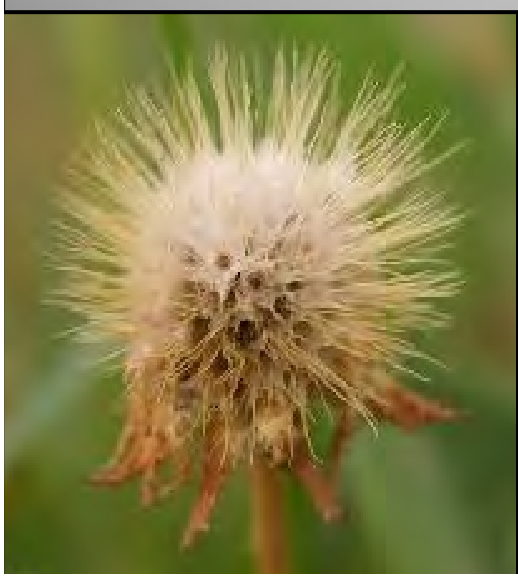
	Combine	Seedster
well above	+20	+20
terminal	+10	+10
in foliage	-10	-10
axillary	-20	-20

Flowering & Ripening Uniformity

	Combine	Seedster
very uniform	+30	+30
3-7 days	+10	+10
7-14 days	-10	+10
14+ days	-20	+10

Tendency to Shatter

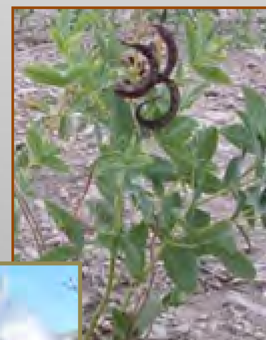
	Combine	Seedster
none	+30	+10
slight	+10	+10
moderate	-10	-10
severe	-30	-30

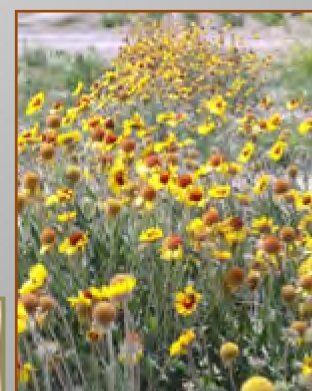
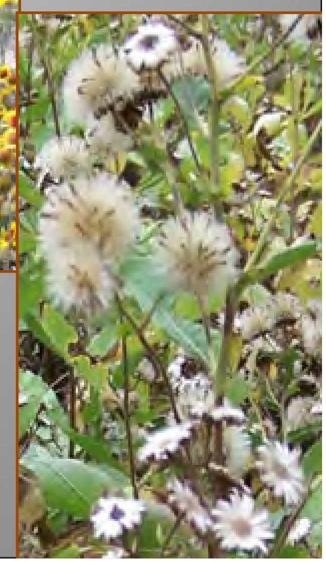



Container Type

	Combine	Seedster
capsule/loment	+20	+20
pod/silique/follicle/nutlet	+10	+10
recessed in receptacle	+20	-10
not contained	0	+10



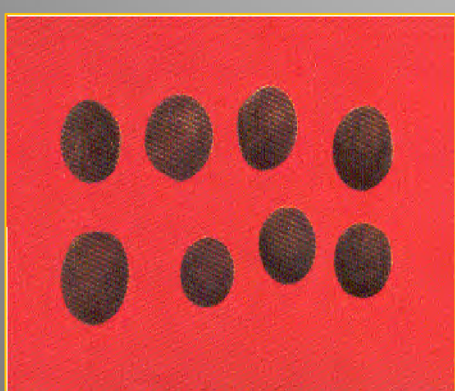



Container Integrity

	Combine	Seedster
strong	+20	-10
moderate	+10	+10
fragile	-10	-5
explosive	-20	-20

Seed Type

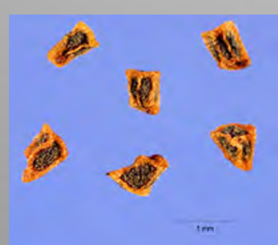
	Combine	Seedster
seed	+10	+10
achene	+10	+10
mericarp	+5	+5



Seed Size

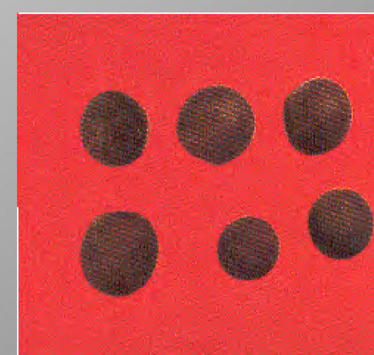
	Combine	Seedster
very small >1,000,000/lb.	-10	+5
small 200,000 to 1,000,000	0	+5
medium 80,000 to 200,000	+5	+5
large <80,000	+10	+5

Epilobium
3,000,000



Penstemon
400,000

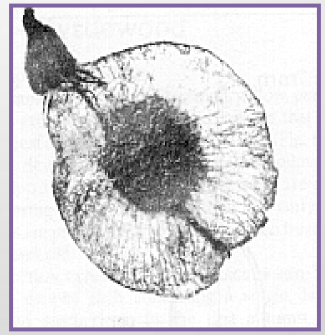
Asclepias
120,000



Vicia
33,000

Seed & Container Appendages

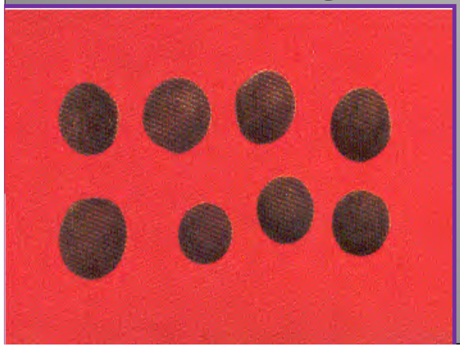


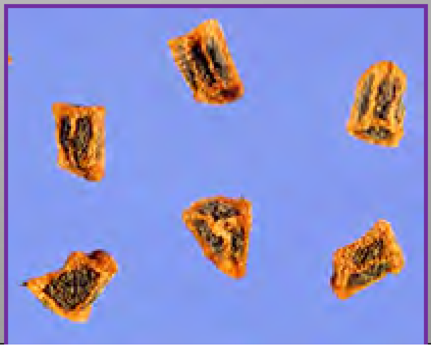


		Combine	Seedster
hair/bristle pappus			
scales/awns/wings	minute	-5	+5
	0.5-1 X	-5	+5
	2-3 X	-10	+10
	>3 X	-15	+10
hooks/barbs		-5	+5
hairs		-5	+5
none		+20	+5

Seed Surface/Flowability

	Combine	Seedster
smooth	+10	+10
hairy	-10	-10
ridged/deep nerved	-10	-10
angular	-5	-5
nerved/striate/wrinkled	-5	-5
wooly	-20	-20





Harvestability Indexes

Indexes ranged from -65 to +195

Groupings:

< +40 considered difficult to harvest

45 to 100 moderate harvestability

105 to 140 easy to harvest

> 145 considered very easy to harvest

Index Comparisons

Combine:

difficult--17%

moderate--46%

easy--26%

very easy--11%

Seedster:

difficult--10%

moderate--41%

easy--46%

very easy--3%

Index Examples

Apiaceae family	combine	Seedster
snow parsley	75	105
Nuttall desert parsley	35	60
cow parsnip	60	105
Fabaceae family		
leadplant	175	110
groundplum	15	-10
Illinois bundleflower	110	105
riverbank lupine	95	95

Index Examples

Asteraceae family	combine	Seedster
western yarrow	85	125
Maximilian sunflower	145	70
prairie coneflower	105	90
northern goldenrod	65	120
New England aster	55	130
Onograceae family		
willow herb	40	110
evening primrose	100	140

Index Examples

Ranunculaceae family	combine	Seedster
tall thimbleweed	45	85
monkshood	135	110
golden columbine	120	135
Scrophulariaceae family		
smooth penstemon	145	120
scarlet Indian paintbrush	95	115

Seedster w/ higher Index on 56% of species

Seedster Advantage-

♦ extended ripening period
  -opportunity for multiple harvest

♦ Seed appendages
  -difficult to glean through sieves of combine
  -more easily pulled into Seedster

Combine Advantage-

♦ strongly attached and tough seed containers
  -seed containers that require additional threshing action of cylinder/concave

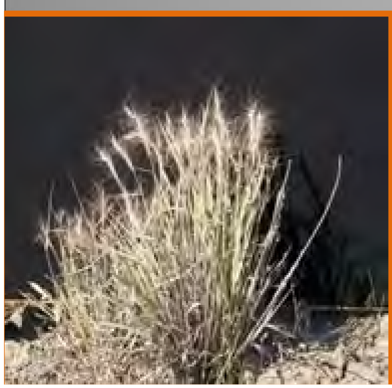
Difficult for both Combine and Seedster

♦ short stature and readily shatter

Grass Harvestability Index

Plant Height

	Combine	Seedster
tall--> 3’	+10	+20
mid--1.5’ to 3’	+20	+20
short-- 1’ to 1.5’	-10	-10
very short-- 1’	-20	-30




Type of Inflorescence

	Combine	Seedster
spike	+20	+10
raceme (open)	+10	+10
raceme (tight)	+20	-20
panicle (narrow)	+20	+10
panicle (open)	+20	+20
panicle (diffuse)	+20	+10



Inflorescence Position in Relation to Foliage

	Combine	Seedster
well above	+20	+20
terminal	+10	+10
in foliage	-10	-20

Foliage Density

	Combine	Seedster
sparse	+10	+10
medium	+5	+5
thick	-5	-10
basal	+20	+20

Tendency to Shatter

	Combine	Seedster
none	+30	-10
slight	+20	+10
moderate	0	+10
severe	-10	-10
extreme	-30	-20

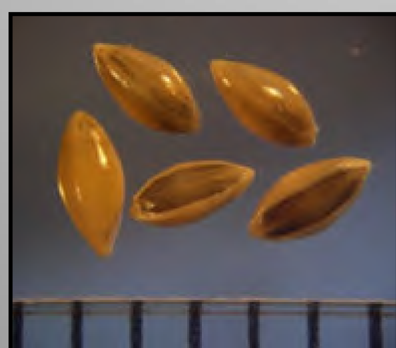
Flowering & Ripening Uniformity

	Combine	Seedster
3-7 days	+10	+10
7-10 days	0	+10
10+ days	-10	+10

Seed Size

	Combine	Seedster
very small >1,000,000/lb.	0	+10
small 200,000 to 1,000,000	+5	+10
medium 80,000 to 200,000	+10	+10
large <80,000	+10	0

Sporobolus
5,000,000



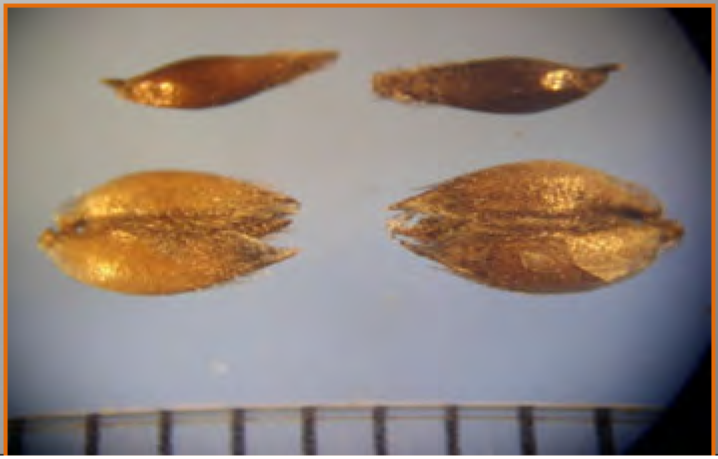
Panicum
389,000

Nassella
186,000

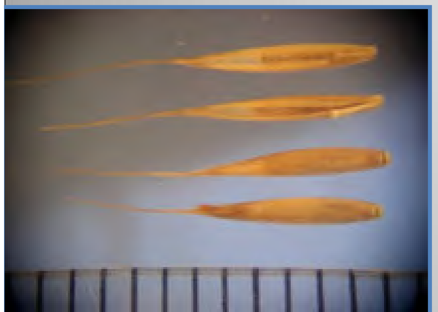
Bouteloua
48,000

Seed Shape

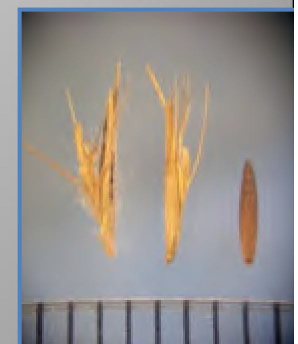
	Combine	Seedster
elongate	+10	+10
ellipsoid	+10	+10
ovoid	+5	+5
Irregular	+5	+10

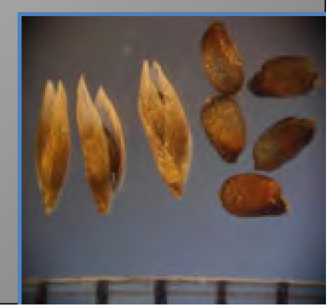


Seed Appendages



	Combine	Seedster
awns – tipped	+10	+5
0.5-1 X	-5	+5
2-3 X	-10	+10
>3 X	-15	+10
pubescence	0	+5
callus hairs	-10	+10
sterile florets	-5	+10
multiples (awns, hairs, florets)	-20	+30
none	+20	0





Harvestability Indexes

Indexes ranged from 5 to 140

Groupings:

< 55 considered difficult to harvest

60 to 100 moderate harvestability

> 105 considered easy to harvest

Index Comparisons

Combine:

difficult--16%

moderate--51%

easy--33%

Seedster:

difficult--7%

moderate--58%

easy--35%

Index Examples

Aveneae tribe	Combine	Seedster
rough bentgrass	75	95
alpine timothy	95	65
spike trisetum	90	110
Poeae tribe		
Idaho fescue	90	105
tufted hairgrass	105	115
Sandberg bluegrass	100	90

Index Examples

	Combine	Seedster
Stipeae tribe		
needle & thread	55	110
green needlegrass	35	90
red threeawn	70	110
Triticeae tribe		
blue wildrye	55	100
bluebunch wheatgrass	70	80
bottlebrush squirreltail	5	50

Index Examples

Paniceae tribe	Combine	Seedster
switchgrass	65	65
seashore paspalum	100	70
Andropodeae tribe		
big bluestem	45	80
little bluestem	75	100
Indiangrass	100	120

Seedster w/ higher Index on 55% of species

Seedster Advantage-

♦ extended ripening period
  -opportunity for multiple harvest
♦ Seed appendages (awns, hairs, sterile florets)
  -difficult to glean through sieves of combine
  -more easily pulled into Seedster

Combine Advantage-

♦ strongly attached and tough inflorescence
  -inflorescences that require additional threshing action of cylinder/concave

Difficult for both Combine and Seedster

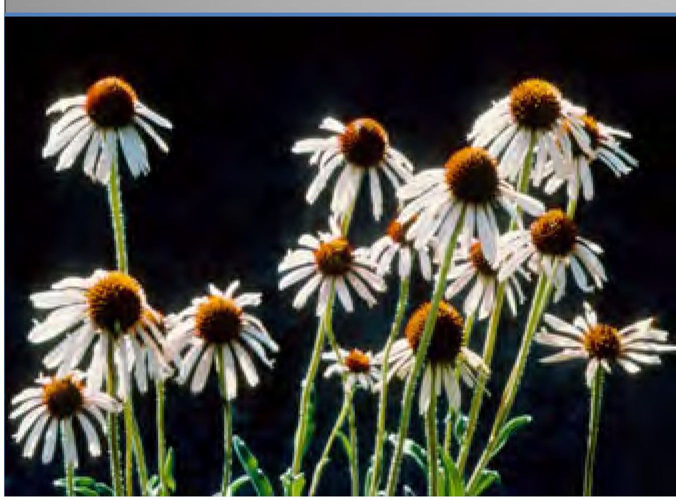
♦ short stature and readily shatter

Wildflower Harvestability Indexes-388 species

Native Grass Harvestability Indexes-195 species

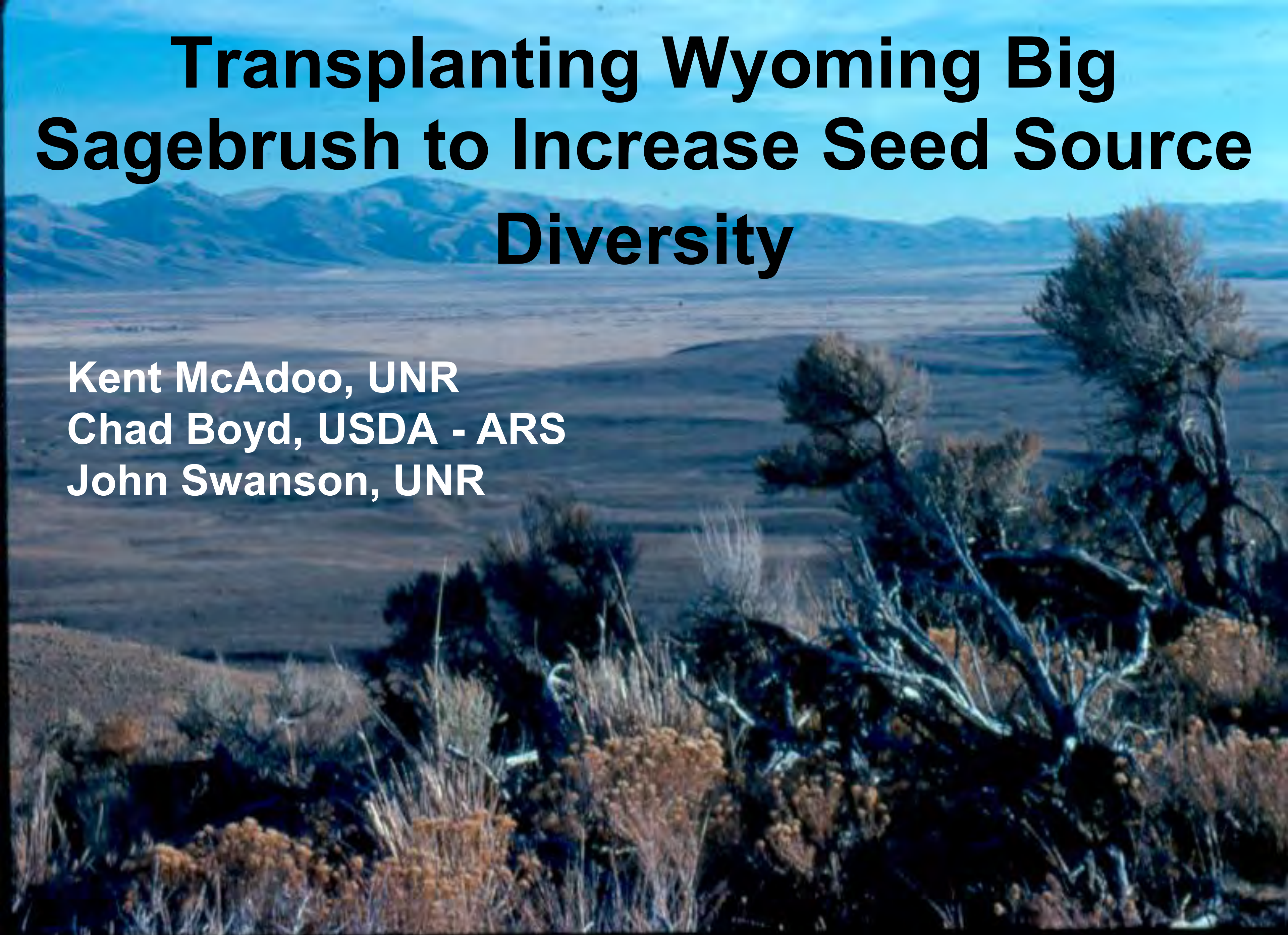
Are now accessible at:

www.NativeSeedsters.com



Transplanting Wyoming Big Sagebrush to Increase Seed Source Diversity

Kent McAdoo, UNR
Chad Boyd, USDA - ARS
John Swanson, UNR




Crested Wheatgrass Seedings
With 10% Successional Sage Cover
(18 - 28 yr after shrub control & seeding)
48% Sage Obligate Birds
52% Grass-nesting Birds
(McAdoo et al. 1989 J. Wildlife Manage.)

Seeded Species Establishment

(grasses, forbs, no sagebrush)

Rationale for Planting “Island” Sagebrush Plants

- Recruitment from existing seedbanks unreliable/episodic (Perryman et al. 2001)
- Successfully planting seeds is unreliable (Shaw et al. 2005)
- But seedlings can be readily transplanted (McArthur et al. 2004)
- Shrub “islands” can serve as dispersed seed sources, accelerating site diversification (Longland & Bateman 2002)

Objectives - to determine the influence of:

- Site (3 plant communities)
- Reduction of herbaceous competition
- Plant source (wildings vs. nursery stock)

…on survival of sagebrush transplants

Collecting Wildings with a "Weed Wrench" ®

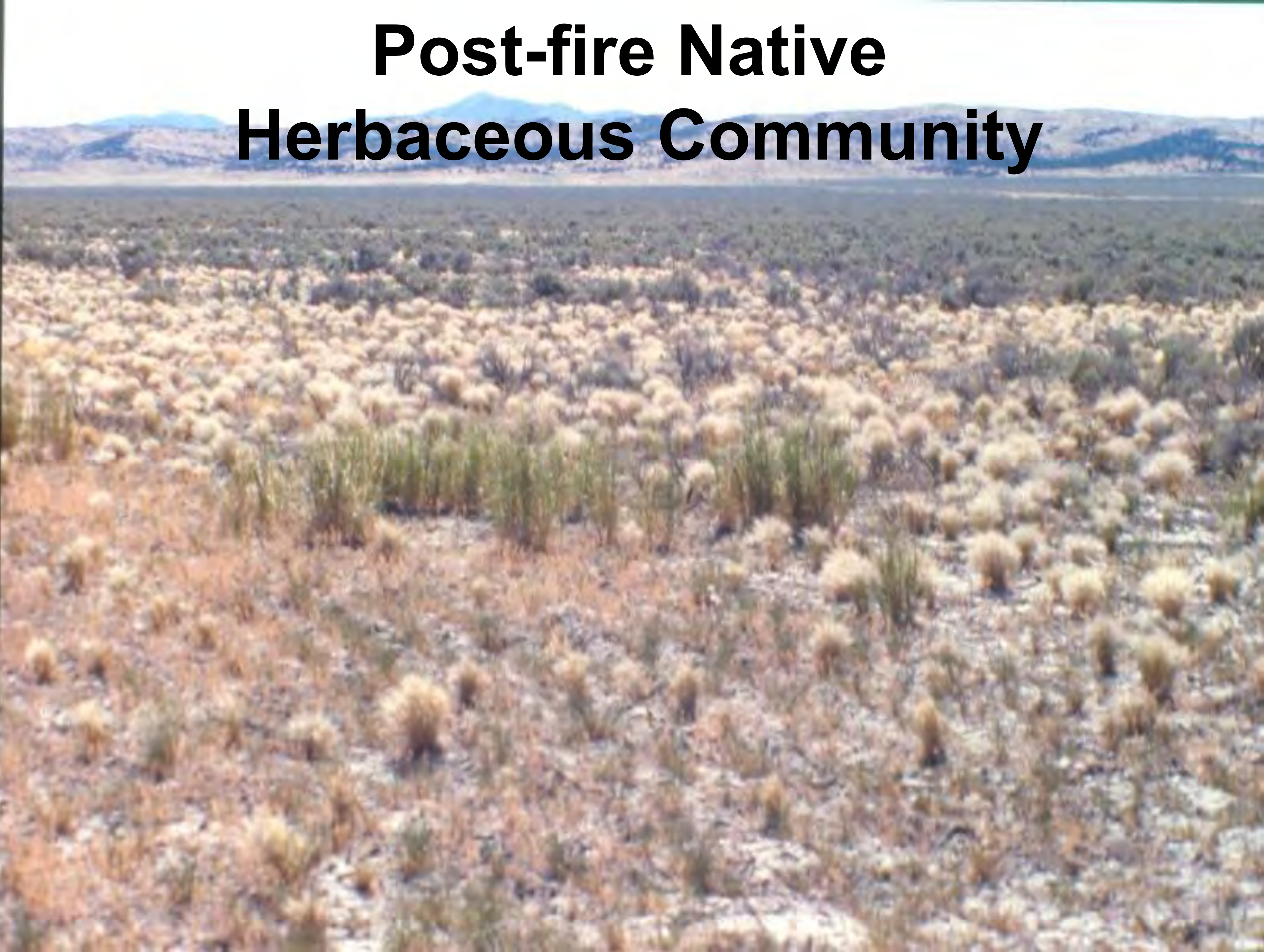
Study Sites

- Cheatgrass monoculture
- Crested wheatgrass monoculture
- Post-fire native herbaceous community

Cheatgrass Monoculture


Crested Wheatgrass Monoculture

Post-fire Native Herbaceous Community



Treatments

- Treatments in randomized block design with 5 replications
- Spring-applied treatment of glyphosate (64 oz/ac) to reduce herbaceous cover.
- Each block includes eight 5m^2 plots representing factorial combinations of herbicide treatment, no herbicide treatment, year of planting, and plant source (native or nursery stock).
- Ten sagebrush plants were planted in each plot.

Sampling & Analysis

- Sagebrush survival measured in Sept. by direct count
- Seedling height recorded for each surviving transplant
- Data analyzed for treatment effects using mixed model analysis of variance with block and treatment x block considered random and other effects fixed.

Timeline

- 2009, spring - establish plots, spray herbicide, pull and plant sagebrush wildings, plant sagebrush nursery stock
- 2009, fall – collect survival and height data
- 2010, spring & fall – repeat as described above
- 2011 – collect estab. data, complete data analysis, and prepare manuscript

Directing Successional Change (Applied EBIPM Principles)

- Disturbance/Site Availability – glyphosate
- Colonization/Dispersal – shrub transplants
- Species Performance –
  - * competition reduction
  - * plant source provision


87% Herbaceous Vegetation
Control with Glyphosate

Preliminary Results

Cheatgrass Monoculture Site - 2009

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	38[a]
Nursery	Glyphosate	50[a]
Wilding	Untreated	6[b]
Wilding	Glyphosate	18[c]

* Means followed by differing letters are significantly different @ $p<0.05$

Cheatgrass Monoculture Site - 2010

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	8[cd]
Nursery	Glyphosate	16[bd]
Wilding	Untreated	10[c]
Wilding	Glyphosate	34[a]

* Means followed by differing letters are significantly different @ $p<0.05$

Crested Wheatgrass Monoculture Site - 2009

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	40[a]
Nursery	Glyphosate	46[a]
Wilding	Untreated	4[b]
Wilding	Glyphosate	10[c]

* Means followed by differing letters are significantly different @ $p<0.05$

Crested Wheatgrass Monoculture Site - 2010

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	4[ab]
Nursery	Glyphosate	12[a]
Wilding	Untreated	2[b]
Wilding	Glyphosate	4[ab]

* Means followed by differing letters are significantly different @ $p<0.05$

Native Herbaceous (Post-fire) Site - 2009

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	68[a]
Nursery	Glyphosate	68[a]
Wilding	Untreated	6[b]
Wilding	Glyphosate	22[c]

---

* Means followed by differing letters are significantly different @ $p<0.05$

Native Herbaceous (Post-fire) Site - 2010

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	14^{b}
Nursery	Glyphosate	36^{a}
Wilding	Untreated	12^{ab}
Wilding	Glyphosate	20^{ab}

---

* Means followed by differing letters are significantly different @ p<0.05

All Sites Combined - 2009

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	49[a]
Nursery	Glyphosate	55[a]
Wilding	Untreated	5[b]
Wilding	Glyphosate	17[c]

* Means followed by differing letters are significantly different @ $p<0.05$

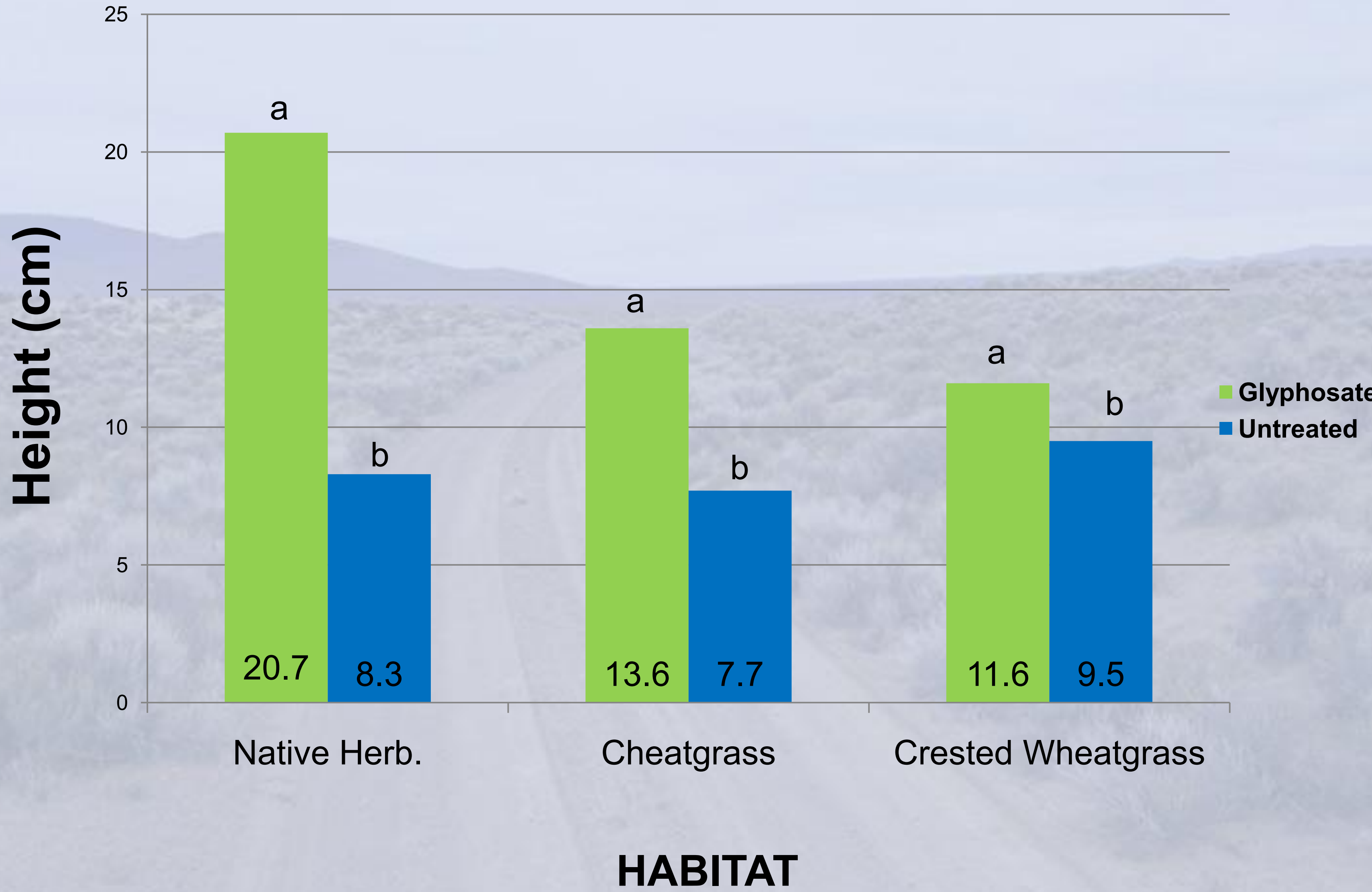
All Sites Combined - 2010

Sagebrush Transplant Survival

Source	Herb. Control	% Survival*
Nursery	Untreated	10.0[a]
Nursery	Glyphosate	21.3[b]
Wilding	Untreated	8.7[a]
Wilding	Glyphosate	19.3[b]

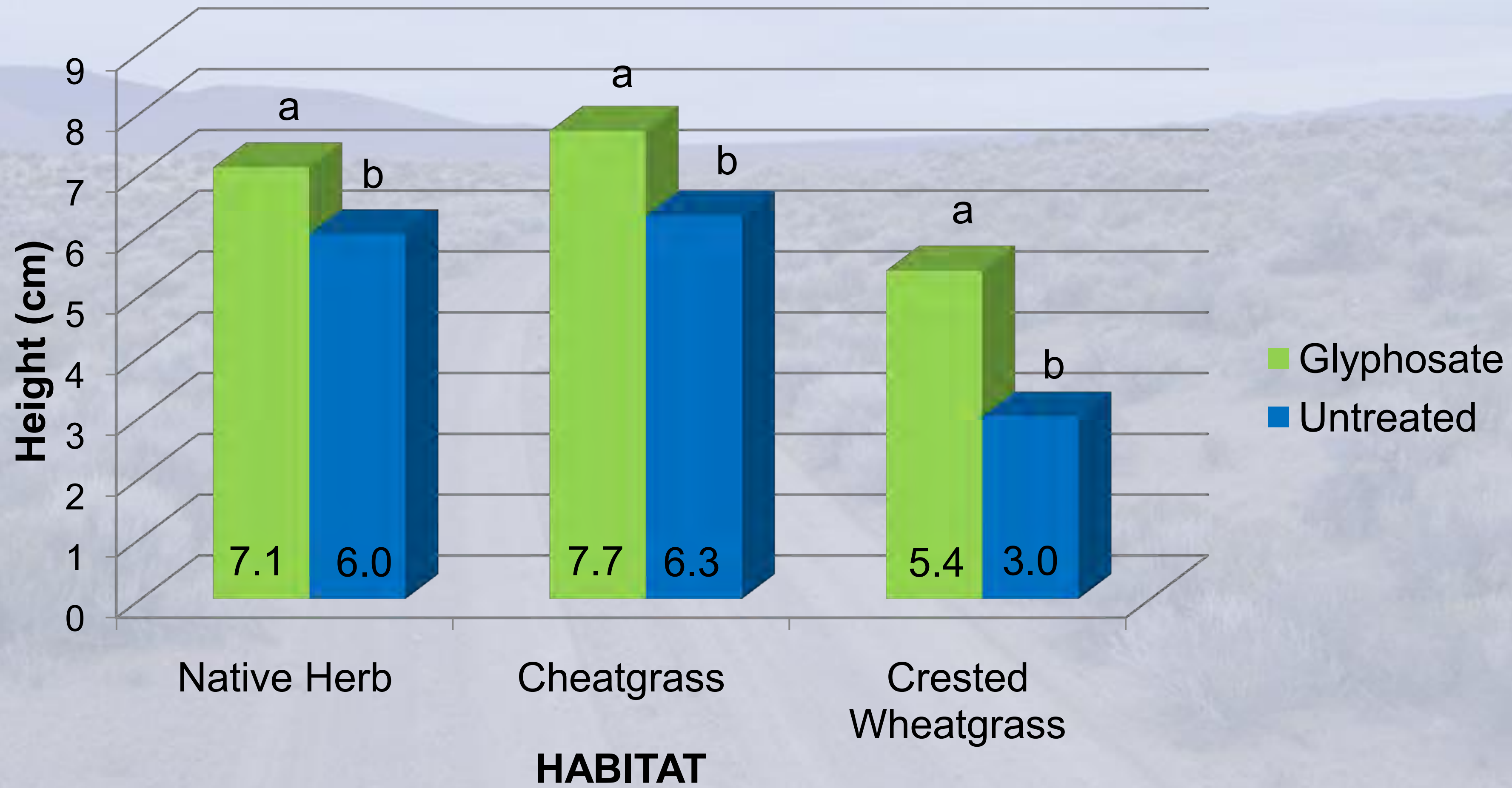
* Means followed by differing letters are significantly different @ $p<0.05$

Sagebrush Nursery Stock Robustness - 2009



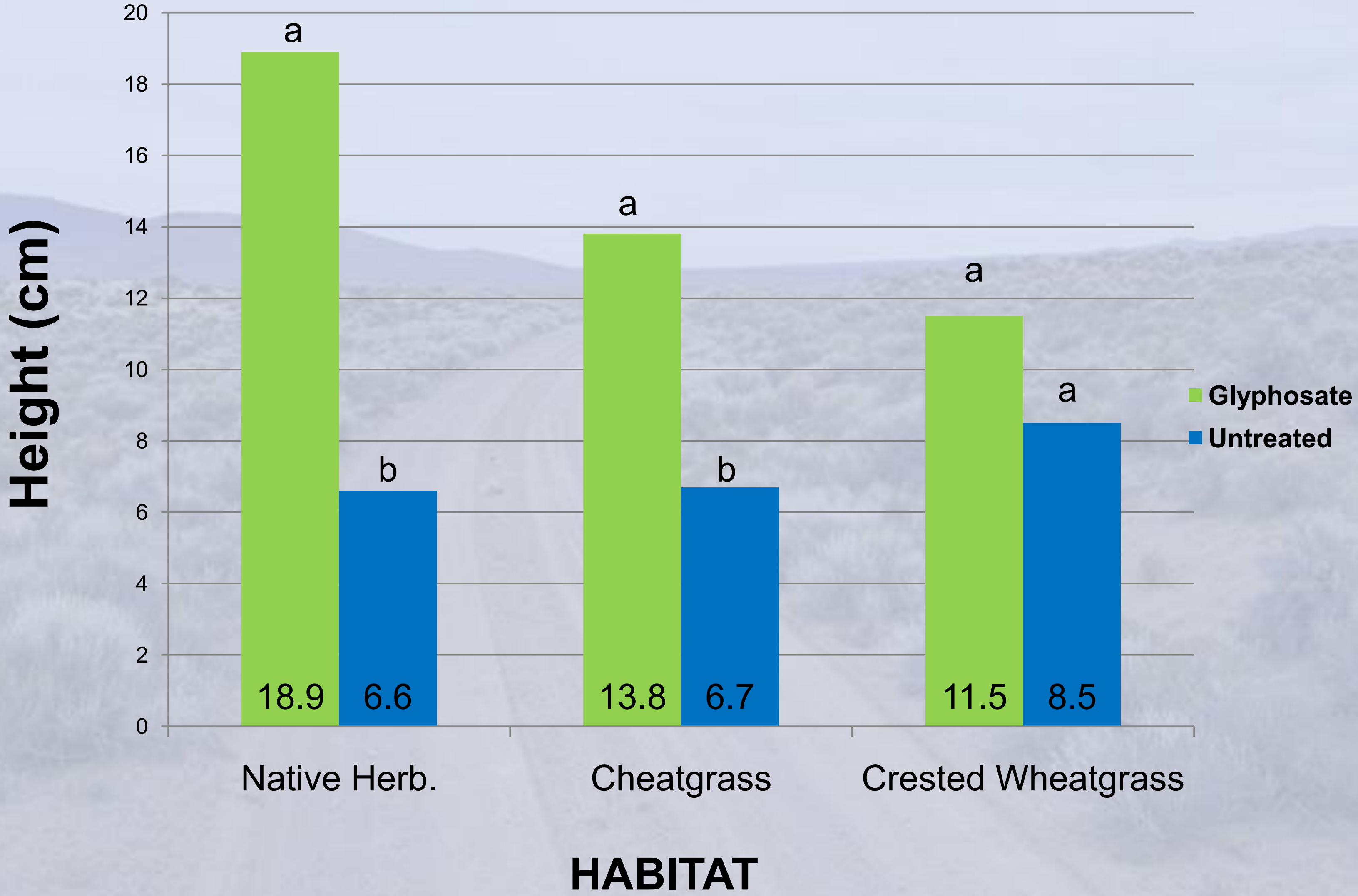
*Means within a habitat followed by differing letters are significant @ p<0.001

Sagebrush Nursery Stock Robustness - 2010



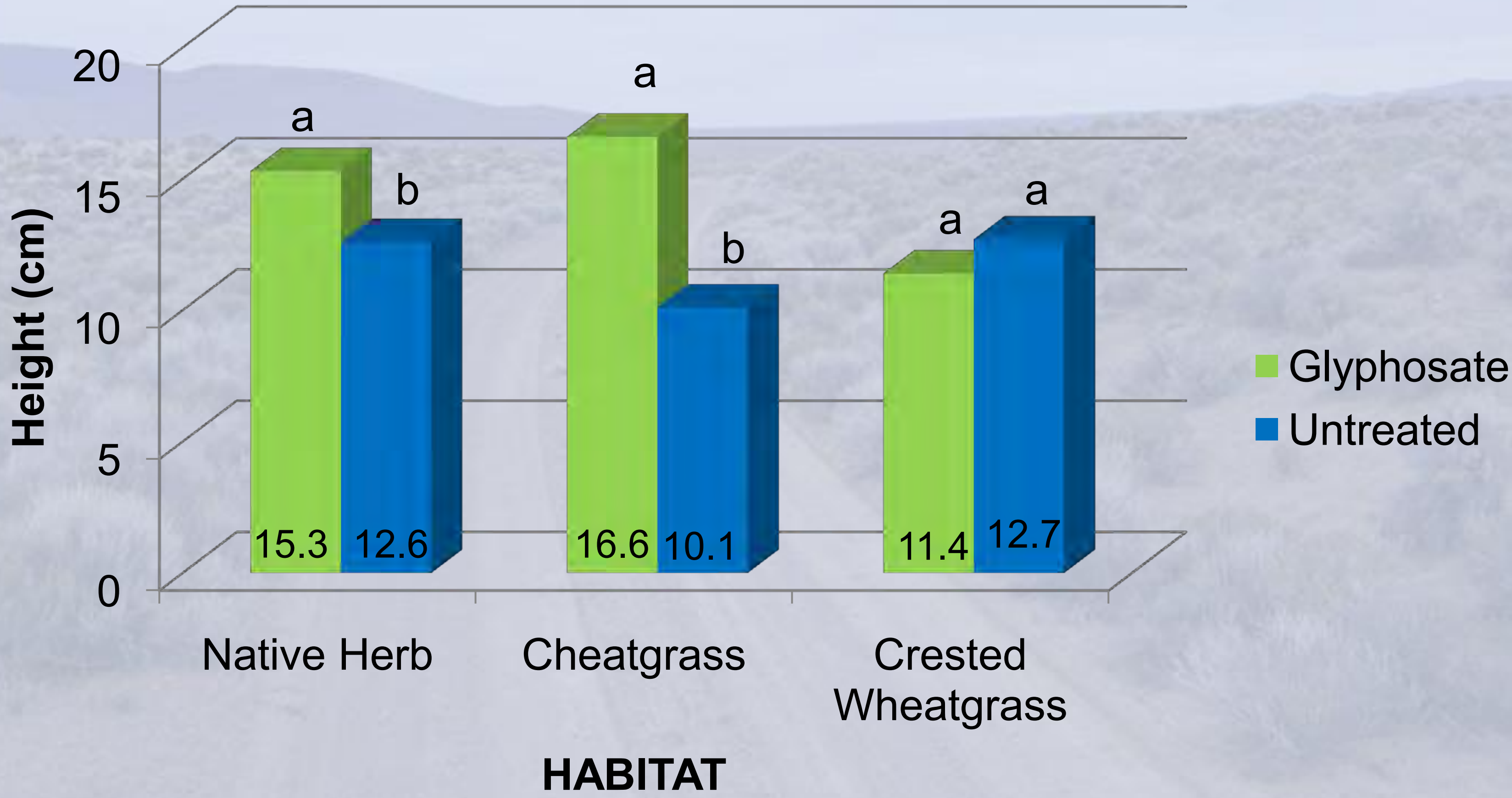
*Means within a habitat followed by differing letters are significant @ p<0.001

Sagebrush Wilding Transplant Robustness - 2009



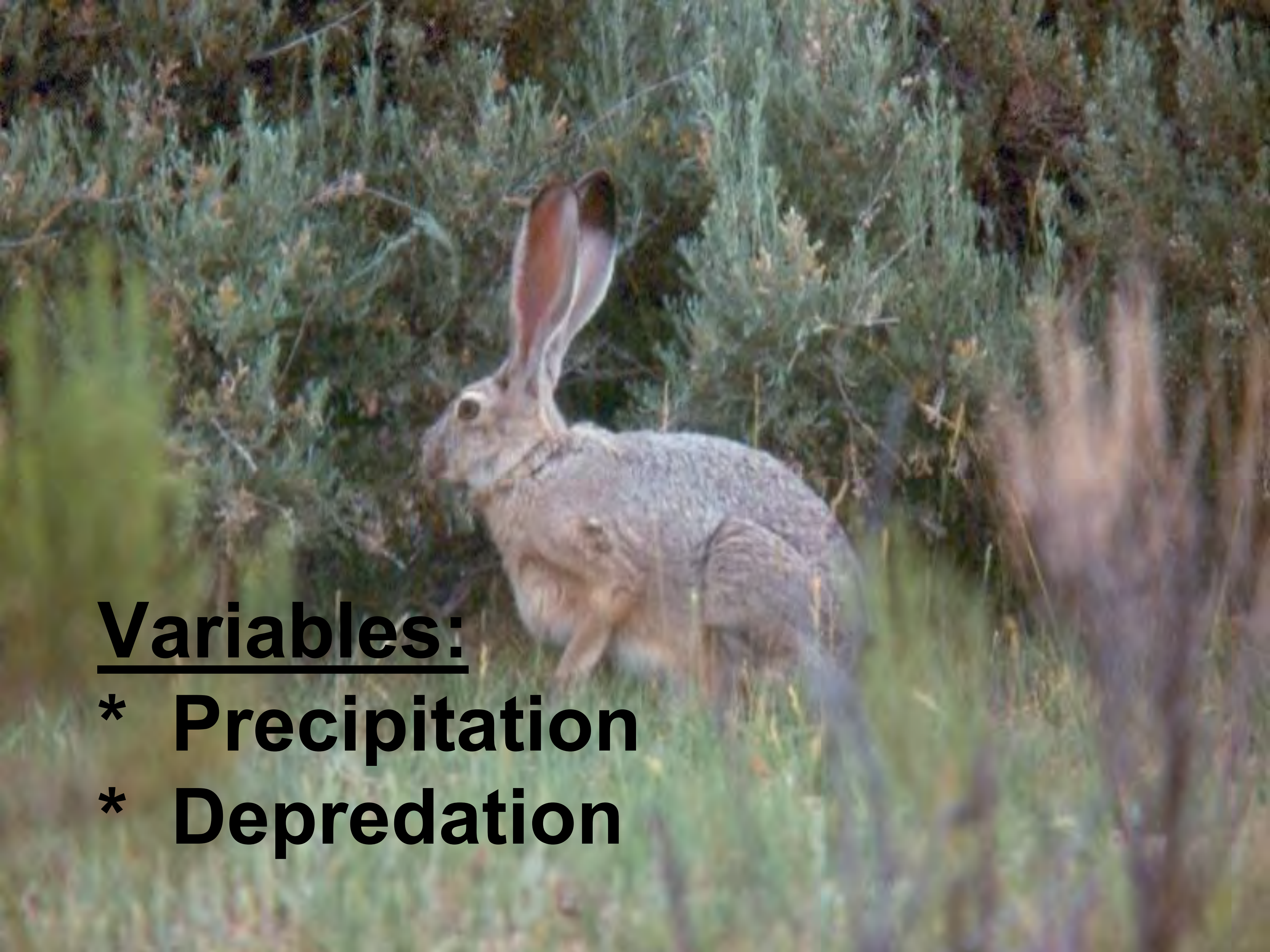
*Means within a habitat followed by differing letters are significant @ p<0.001

Sagebrush Wilding Transplant Robustness - 2010



*Means within a habitat followed by differing letters are significant @ p<0.001


Second Growing Season



Variables:

* Precipitation
* Depredation

Jackrabbit Impacts?

McAdoo et al. 1987. Use of new rangeland seedings by black-tailed jackrabbits. J. Range Manage. 40:520-524.

Jackrabbit Depredation

Summary

- Nursery stock out-performed wildings first yr
- Overall survival variable by year (precipitation-related?)
- Control of herbaceous cover benefitted wildings more than nursery stock
- Control of herbaceous cover produced more robust sagebrush plants

A special thanks to Steve Monsen, retired USFS range ecologist, for his advice & encouragement

University of Nevada
Cooperative Extension

AREA-WIDE
EBIPM
SCIENCE-BASED SOLUTIONS
FOR INVASIVE ANNUAL GRASSES

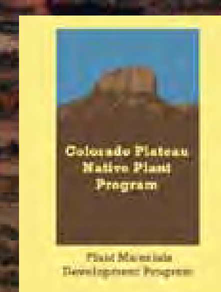
USDA

ars

Colorado Plateau Native Plant Program

Progress and Challenges

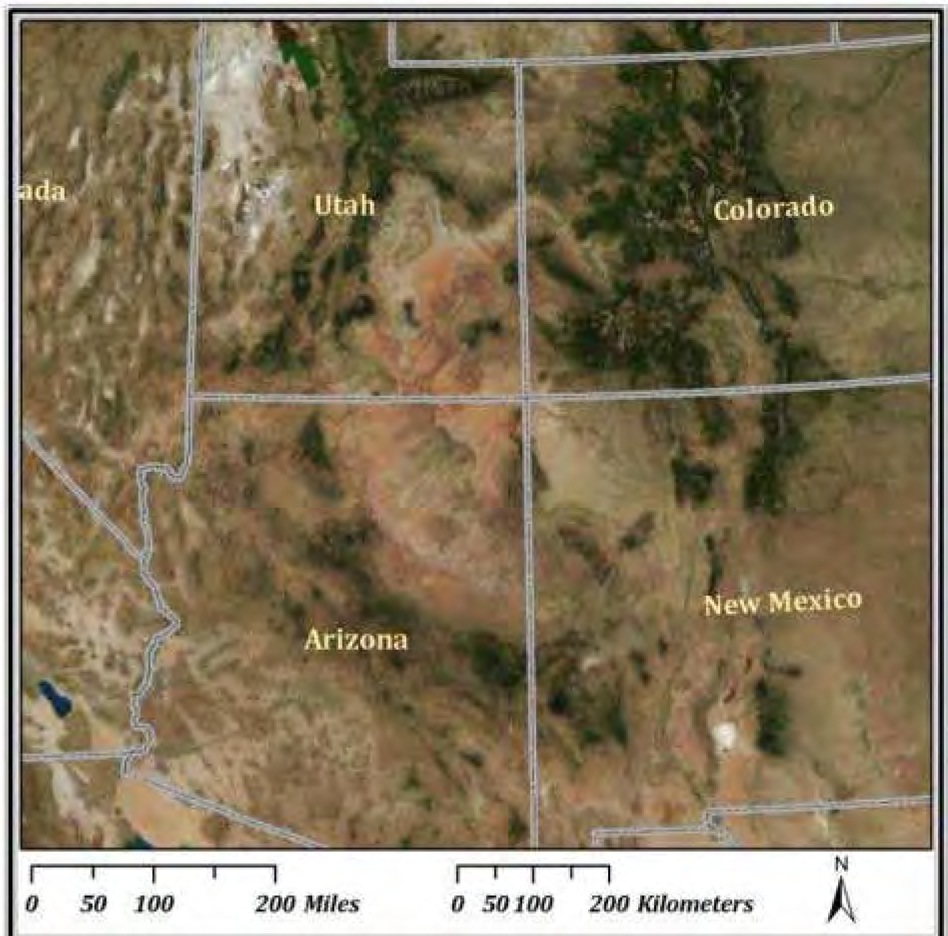
Wayne Padgett, Coordinator
Colorado Plateau Native Plant Program
Bureau of Land Management
Utah State Office

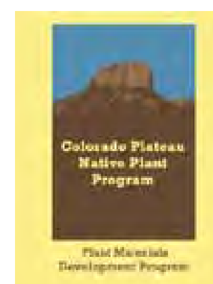


Colorado Plateau Native Plant Program

BLM

What is the Colorado Plateau?





Colorado Plateau Native Plant Program

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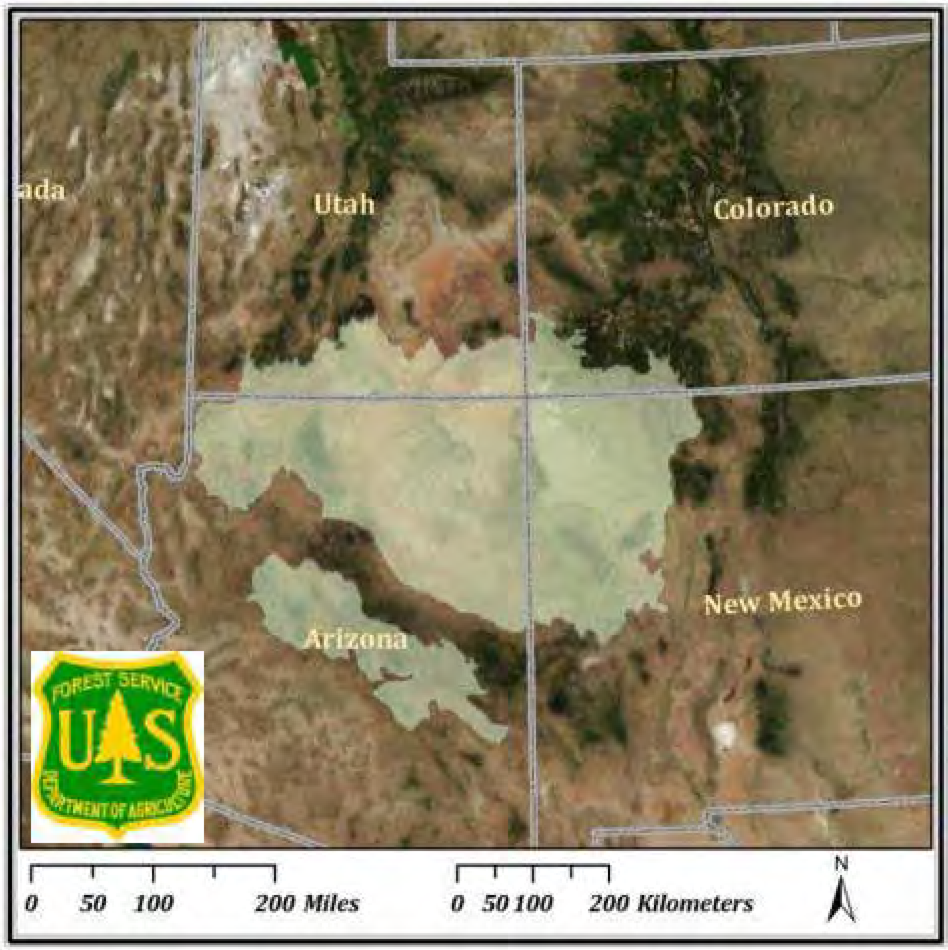
What is the Colorado Plateau?



Colorado Plateau Native Plant Program

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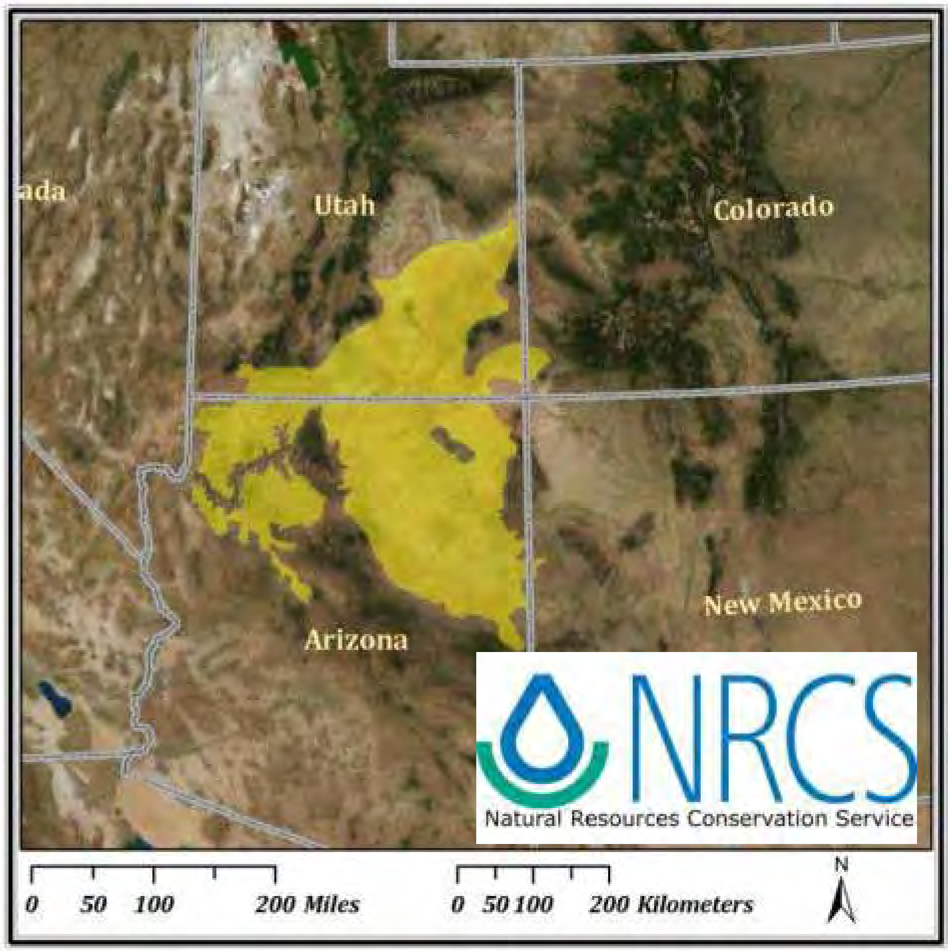

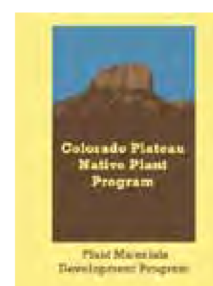

Colorado Plateau Native Plant Program

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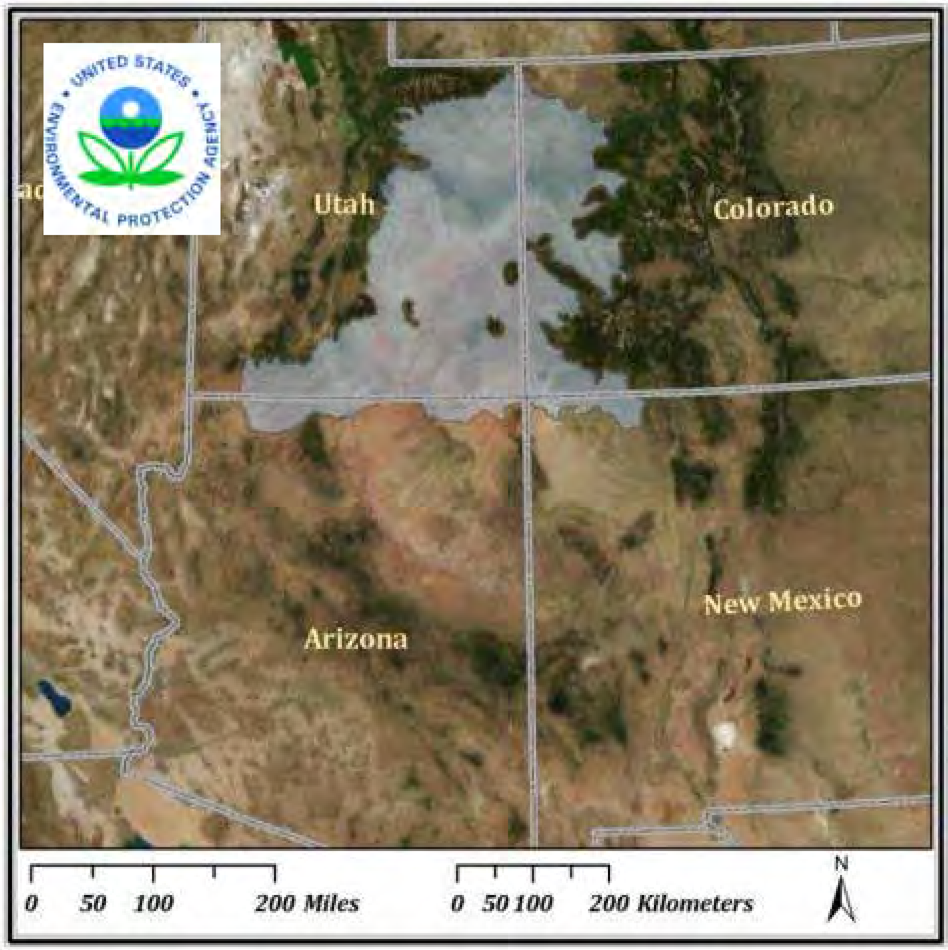

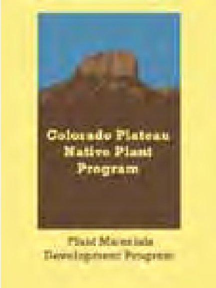

Colorado Plateau Native Plant Program

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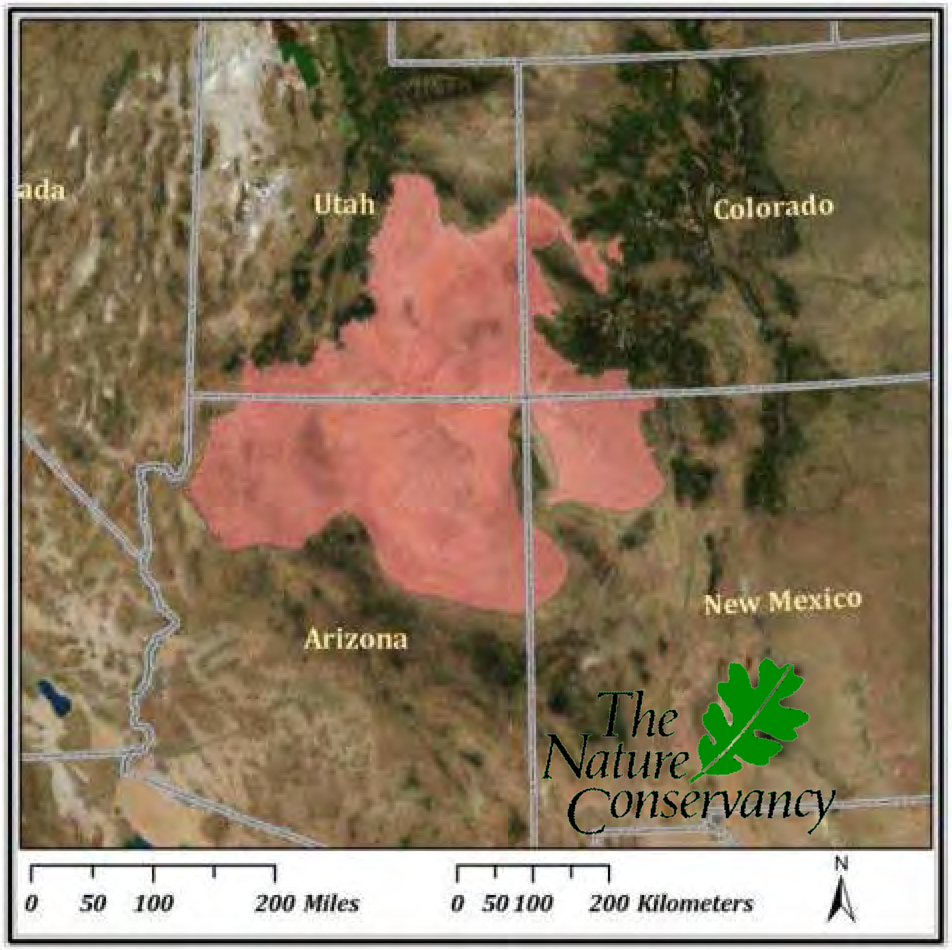
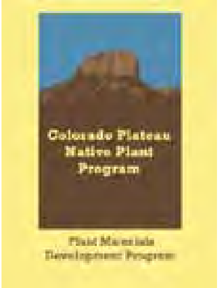
What is the Colorado Plateau?





Colorado Plateau Native Plant Program

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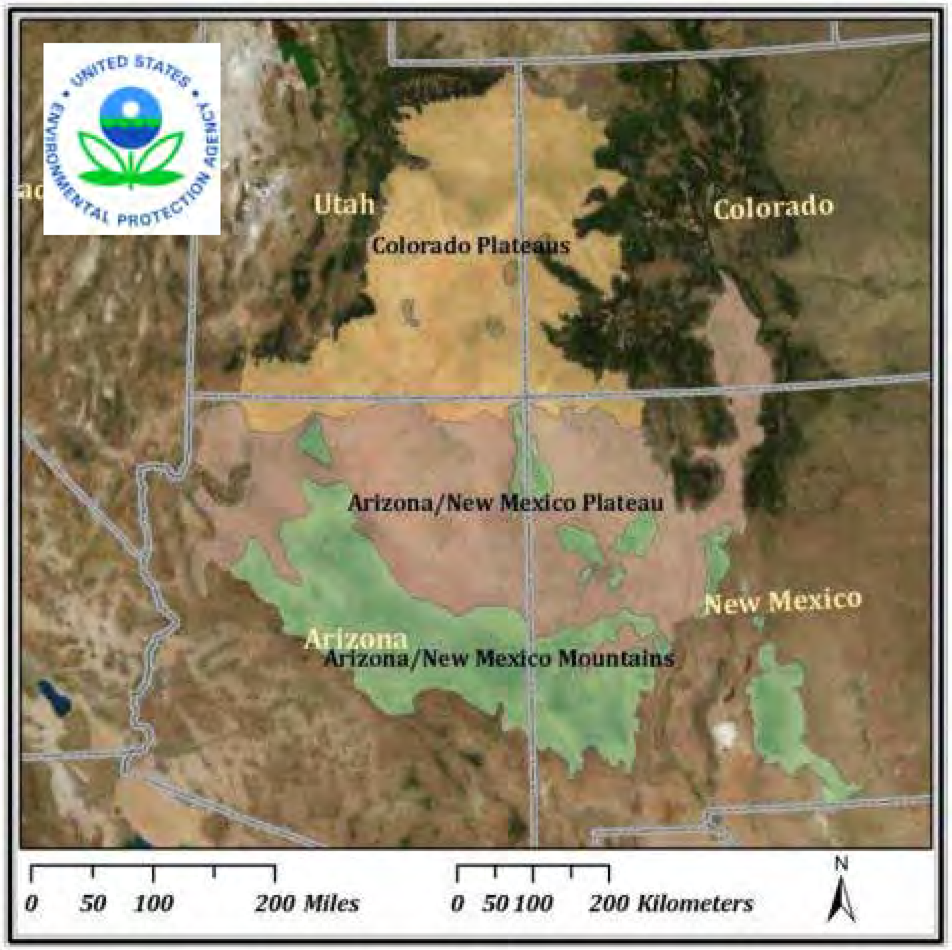
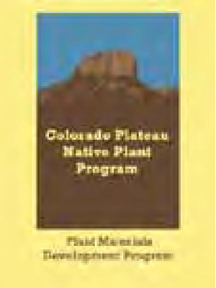
What is the Colorado Plateau?





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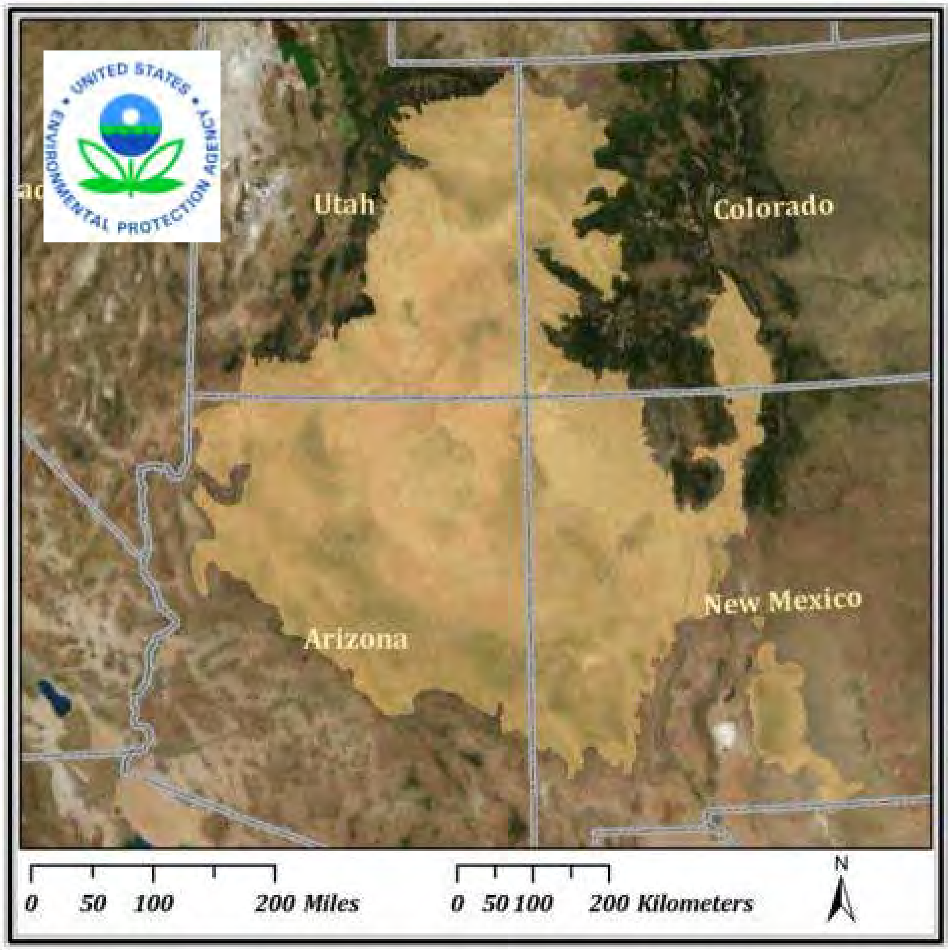
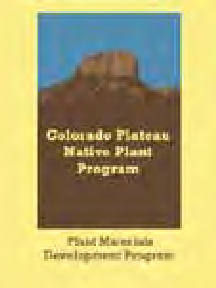
Colorado Plateau Native Plant Program

What is the Colorado Plateau?





Colorado Plateau Native Plant Program

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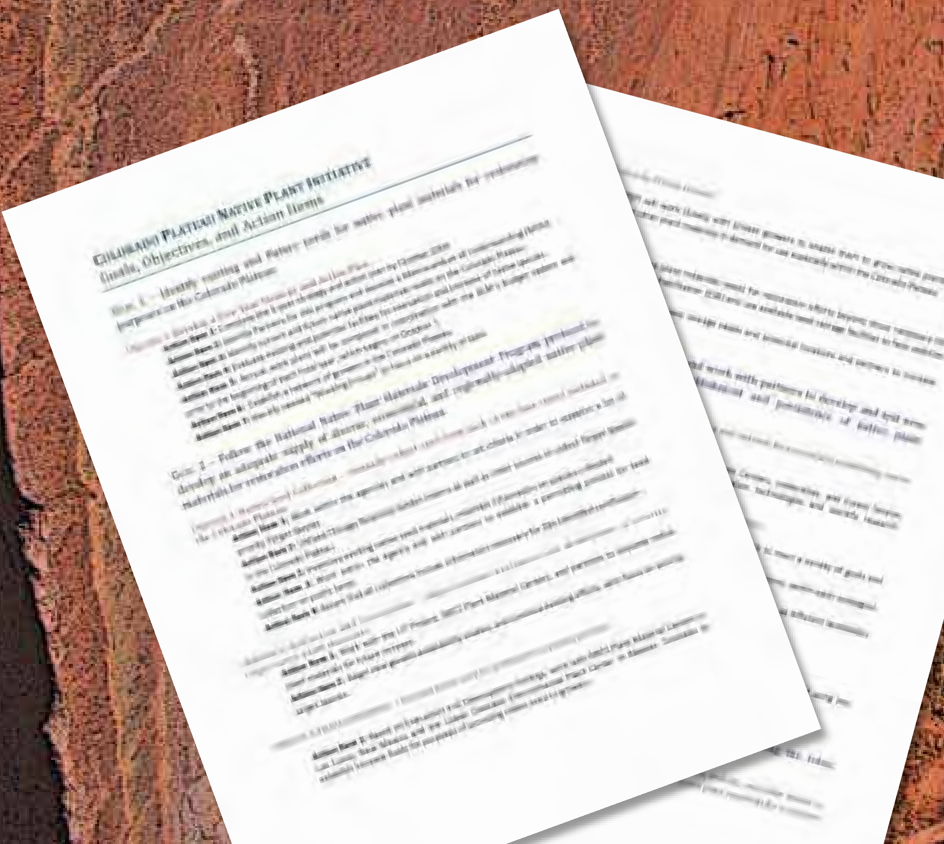
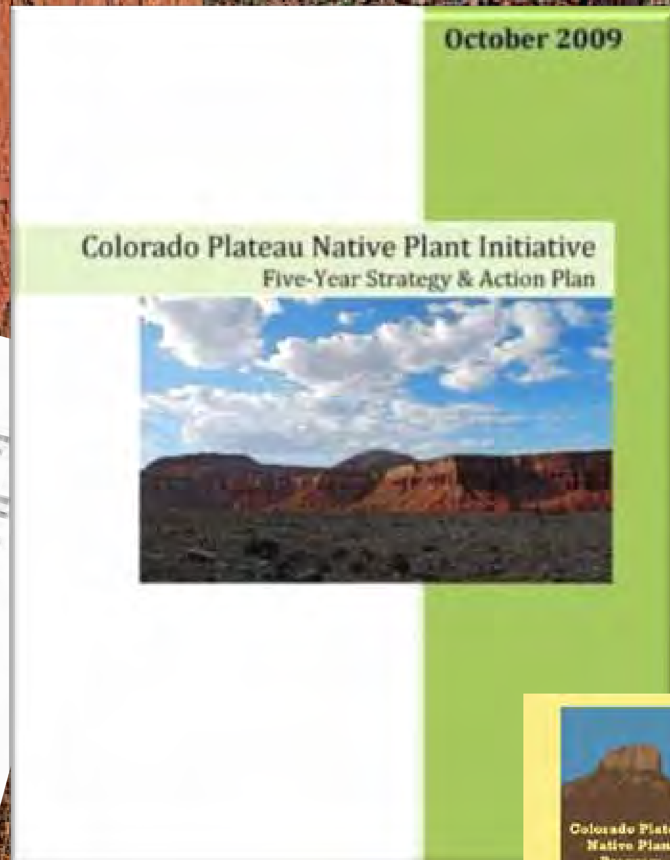
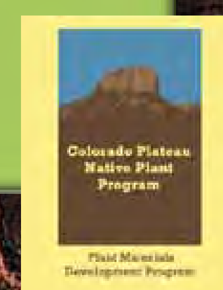
Colorado Plateau Native Plant Program

Five-Year Strategy and Action Plan







Colorado Plateau Native Plant Program

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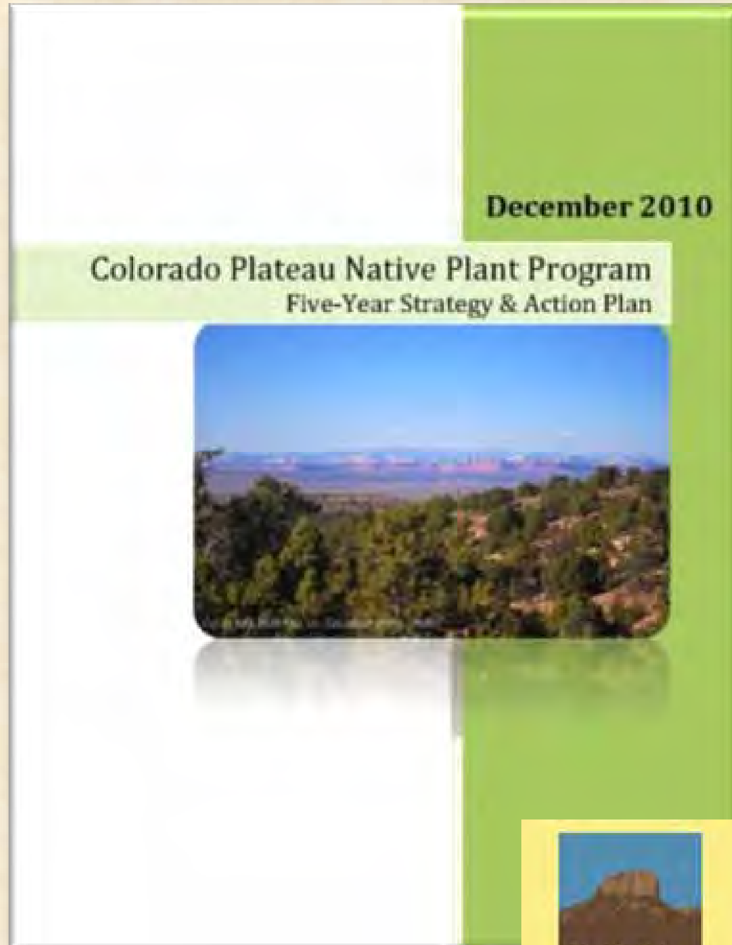
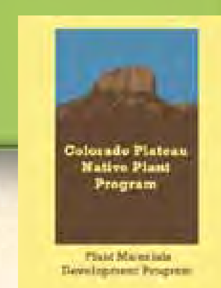
Colorado Plateau Native Plant Program

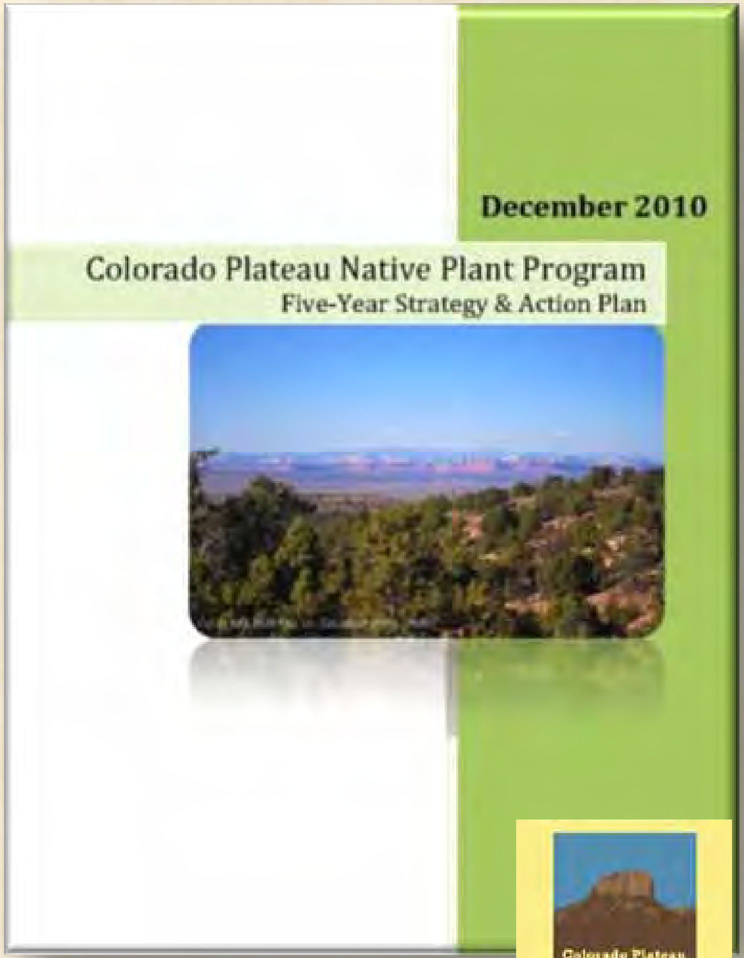


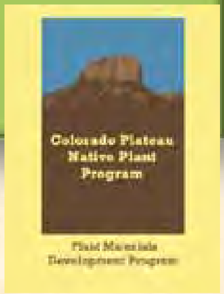
MISSION

Our mission is to facilitate the increased availability and use of native plant materials for use in restoring native plant communities and ecosystems of the Colorado Plateau.



Colorado Plateau Native Plant Program





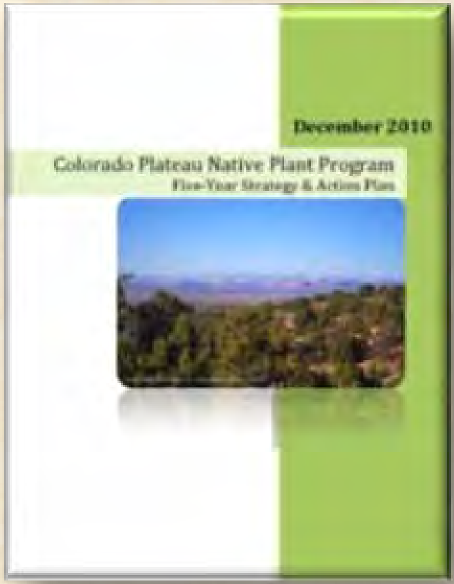
VISION

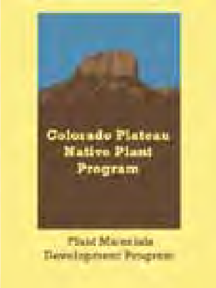
The vision of the Colorado Plateau Native Plant Program is a Colorado Plateau that supports healthy and resilient native plant communities now and for future generations

Colorado Plateau Native Plant Program

By implementing this strategic plan, the Colorado Plateau Native Plant Program will be better able to:

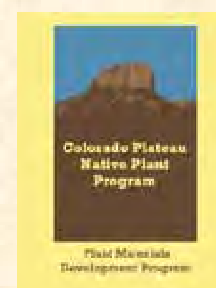
1. Increase the knowledge and understanding of the values and importance of using native plant materials for ecosystems restoration.
2. Contribute to the increased availability of regionally adapted native plant materials for use in restoration of native plant communities.
3. Identify and provide access to management practices that will result in the restoration of native plant communities.
4. Provide an economic benefit to businesses in the Colorado Plateau and facilitate a market for native plant materials and services.





Colorado Plateau Native Plant Program

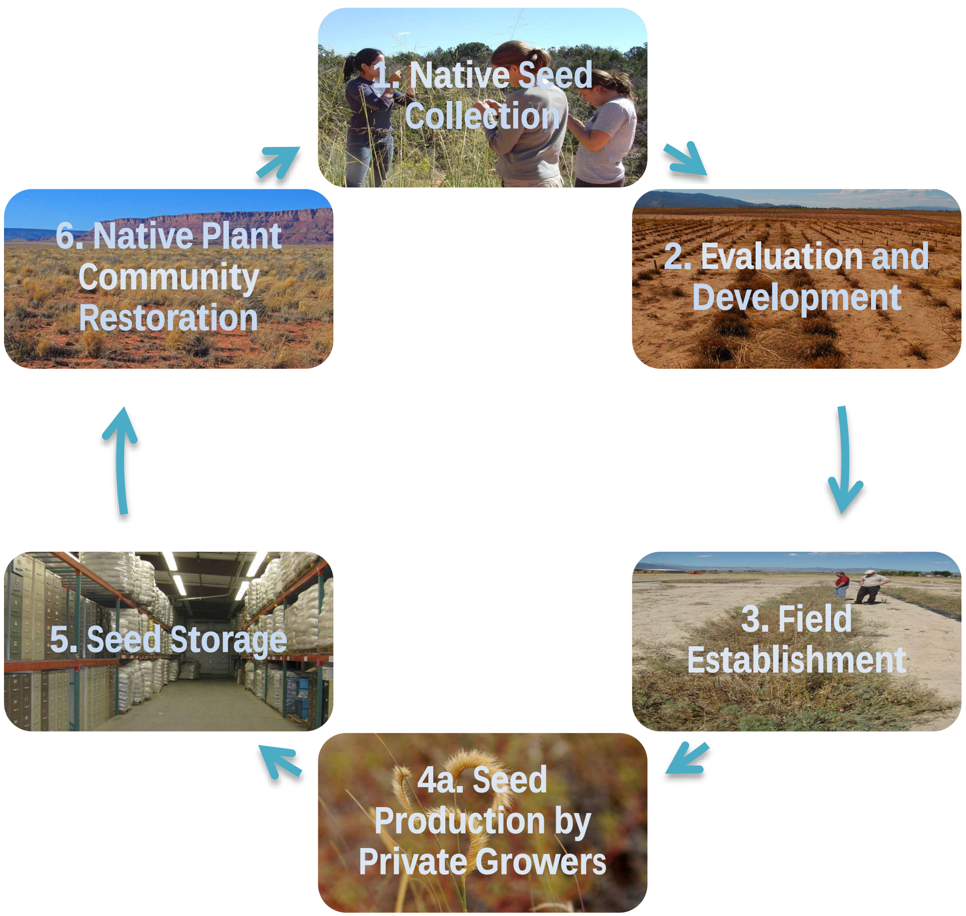
Goal – Follow the National Native Plant Materials Development Program to Develop an Adequate Supply of Diverse, Economical, and Regionally-Adapted Native Plant Materials for Restoration Efforts on the Colorado Plateau

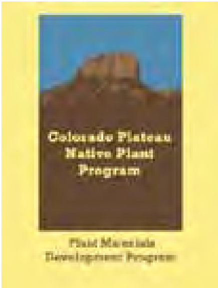


Colorado Plateau Native Plant Program

BLM

New Views of the Plant Materials Development Program





Colorado Plateau Native Plant Program

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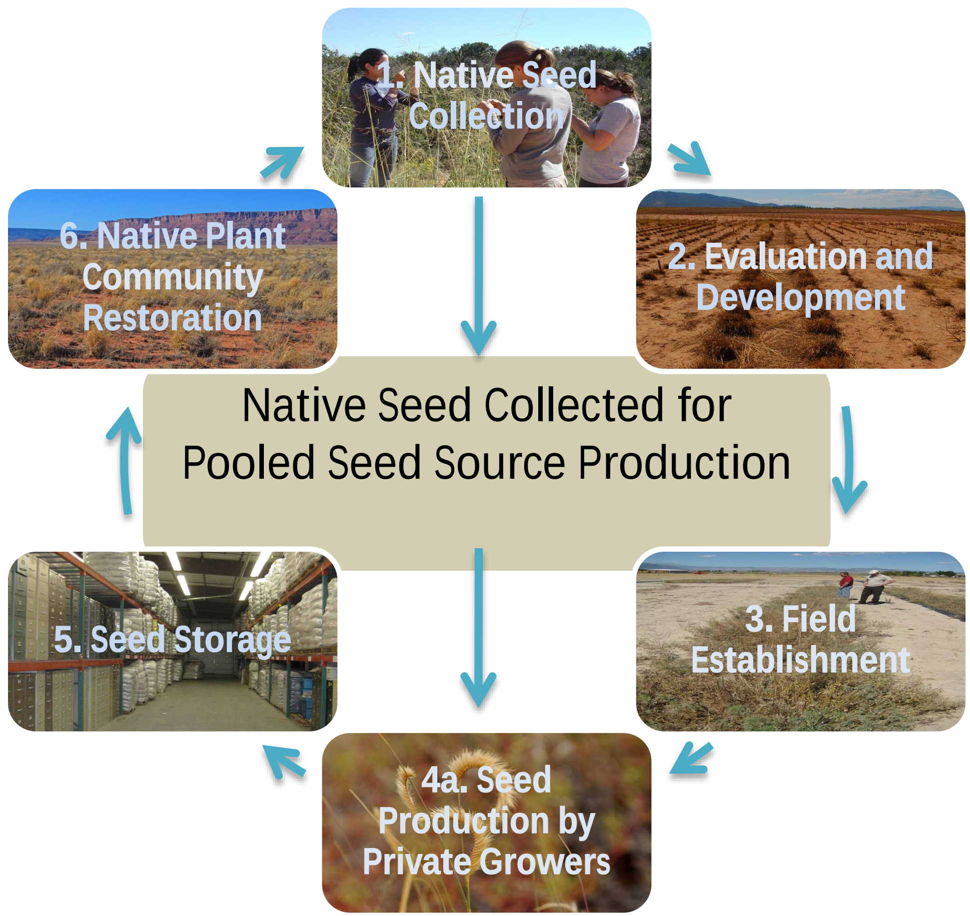

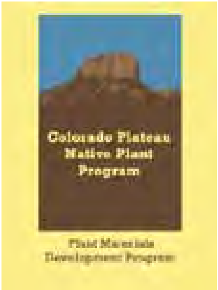

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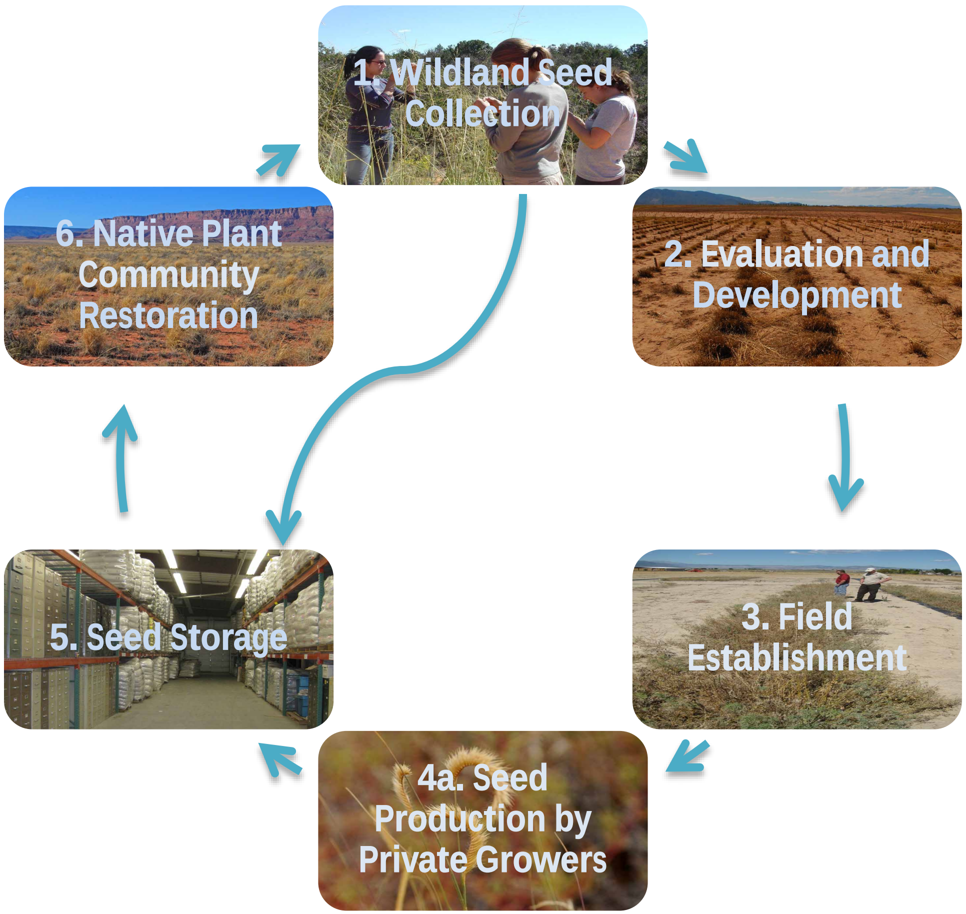
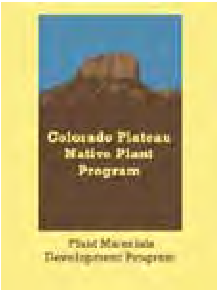
Colorado Plateau Native Plant Program

New Views of the Plant Materials Development Program





Colorado Plateau Native Plant Program

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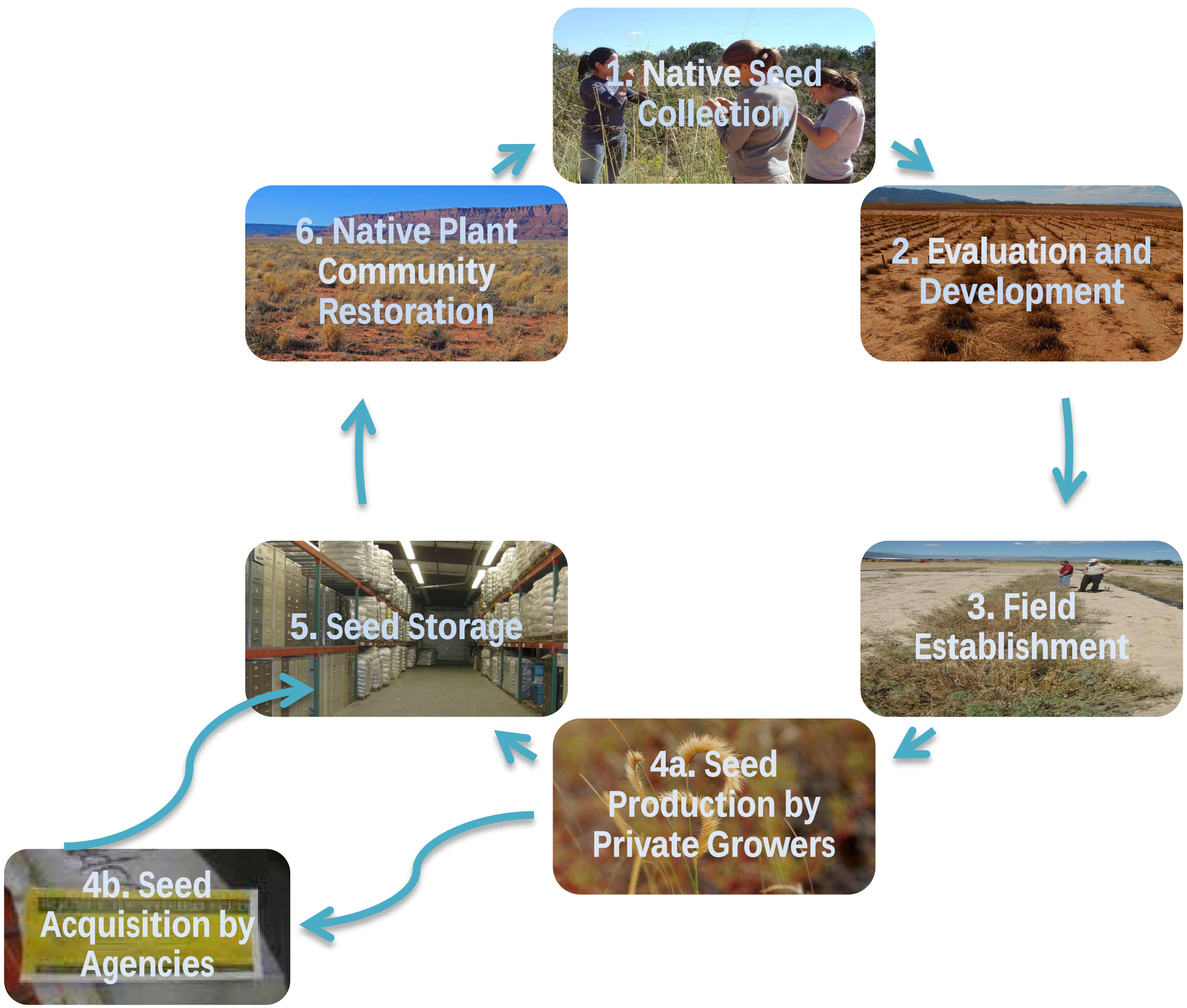

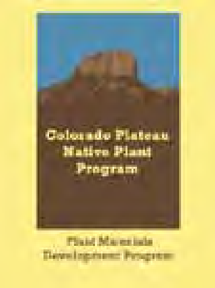

Colorado Plateau Native Plant Program

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Colorado Plateau Native Plant Program

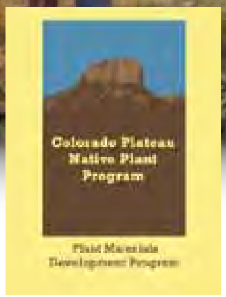
1. Native Seed Collection

Following Seeds of Success Protocol

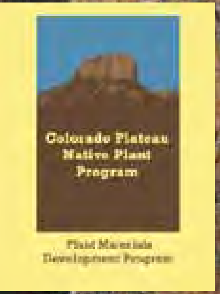
In 2010

Nearly 200 Collections of 140 Species

- Ø BLM – Richfield UT Field Office
- Ø BLM – Farmington NM Field Office
- Ø BLM – Colorado State Office
- Ø Red Butte Gardens
- Ø Northern Arizona Native Seed Alliance



2. Evaluation and Development



Colorado Plateau Native Plant Program

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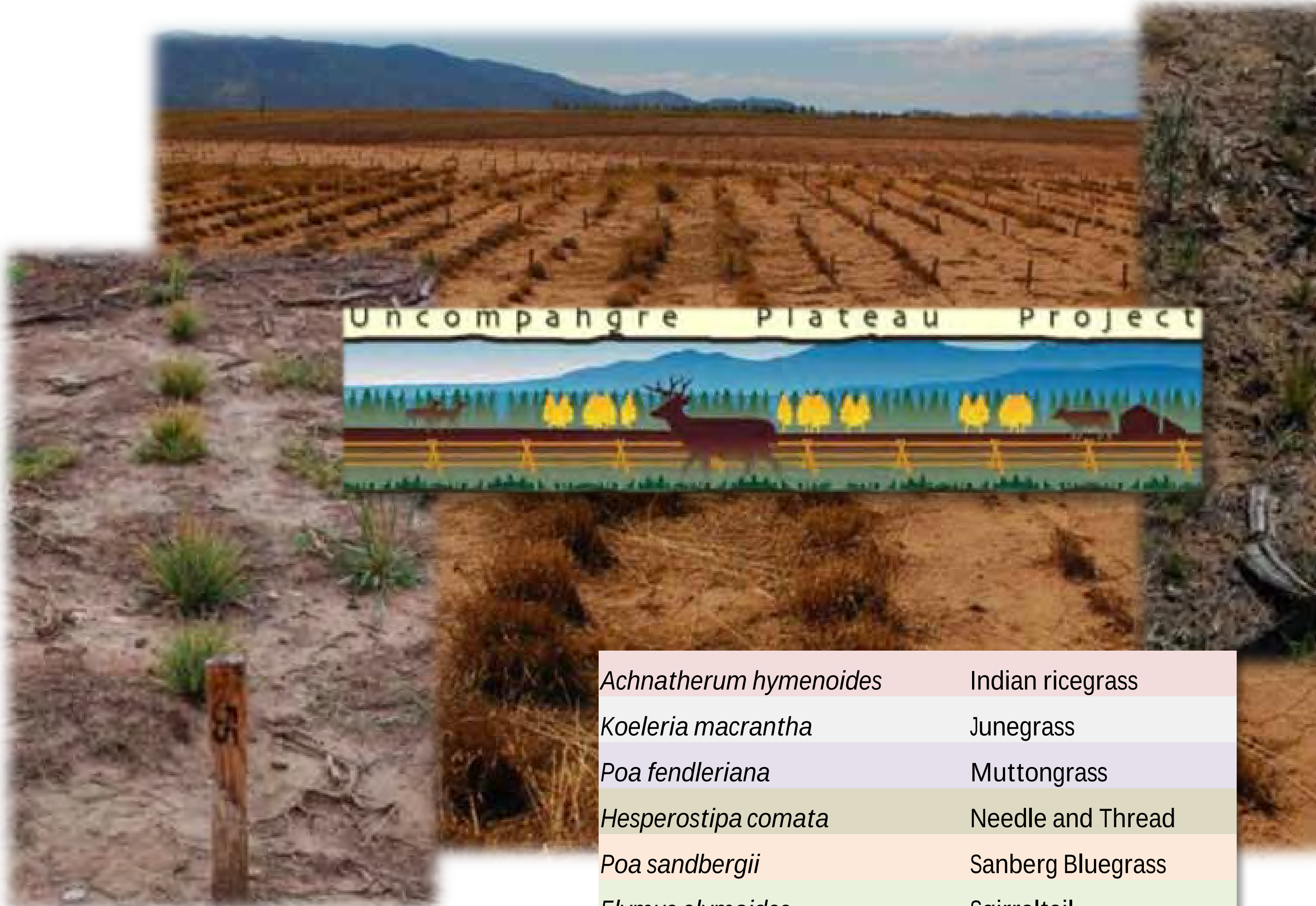
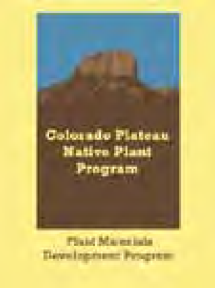


Achnatherum hymenoides	Indian ricegrass
Koeleria macrantha	Junegrass
Poa fendleriana	Muttongrass
Hesperostipa comata	Needle and Thread
Poa sandbergii	Sanberg Bluegrass
Elymus elymoides	Sqirreltail



Colorado Plateau Native Plant Program

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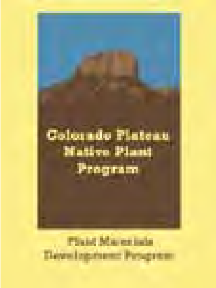
2. Evaluation and Development

RIO MESA CENTER
THE UNIVERSITY OF UTAH



Colorado Plateau Native Plant Program

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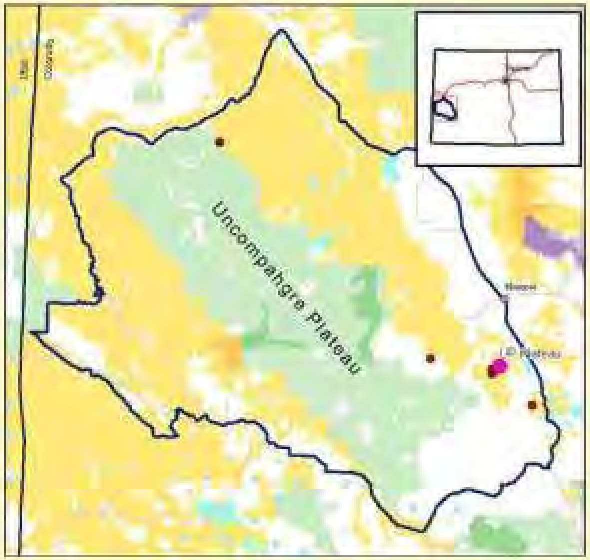
3. Field Establishment



The origin of the 'UP Colorado Plateau' Sandberg bluegrass

The UP delivers thirteen species to commercial growers

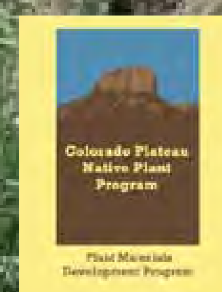
The UP has advanced thirteen species through our program, performing the necessary studies and seed increase process, and they are now in the hands of commercial growers. The UP has selected these species (six grasses and seven forbs) because they are considered key components of native ecosystems in the Colorado Plateau area.

Common Name	Scientific Name	Release name	Elevation (ft)
Grasses			
Basin wildrye	*Leymus cinereus*	UP Cochetopa	8,231
Prairie Junegrass	*Koeleria macrantha*	UP Sims Mesa	7,595
Muttongrass	*Poa fendleriana*	UP Colona	7,347
Bottlebrush squirreltail	*Elymus elymoides*	UP Paradox	5,712
Indian ricegrass	*Achnatherum hymenoides*	White River	5,413
Mountain brome	*Bromus marginatus*	UP Cold Springs	8,949
Forbs			
Western yarrow	*Achillea millefolium lanulosa*	UP Dry Fork	8,844
Oregon daisy	*Erigeron speciosus*	UP Dry Fork Hwy	8,844
Sulfur-flower buckwheat	*Eriogonum umbellatum*	UP Burn Canyon	7,849
Utah sweetvetch	*Hedysarum boreale gemmiale*	UP Uncompahgre	6,813
Dusty penstemon	*Penstemon comarrhenus*	UP Delta	7,721
Bluestem penstemon	*Penstemon cyanocaulis*	UP San Miguel	7,175
Scarlet globemallow	*Sphaeralcea coccinea*	UP Paradox Valley	4,996

Los Lunas PMC

Upper Colorado Environmental Plant Center

Uncompahgre Partnership



Colorado Plateau Native Plant Program

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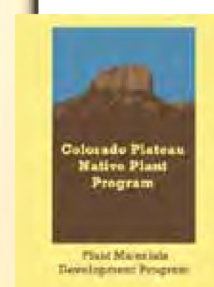
4. Seed Production by Private Growers

4. Seed Production by Private Growers



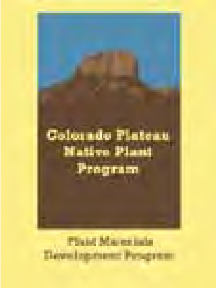
Colorado Plateau Native Plant Program

BLM

Colorado Plateau species provided to, and available for production through the Uncompahgre Partnership

Scientific Name	Rating	Source ID Name	Amount/Accession Given to Grower(s)
Poa secunda	9	CO Plateau	55 acres/C5-03
Leymus cinereus	8	UP Cochetopa	20 lbs/C2-03
Elymus elymoides	8		10 lbs (uncleaned)/C2-04
Achnatherum hymenoides	8	White River	100 lbs (uncleaned)/ White River
Bromus marginatus	8	UP Cold Springs	20 lbs/C3-04
Poa fendleriana	8	UP Colona	3.5 lbs/C1-03; 12.5 lbs/C1-03; 100 acres
Koeleria macrantha	8	UP Sims Mesa	15 lbs/C1-03 + 2.8 lbs blend of top 4; 16 lbs/C1-03
Penstemon cyanocaulis	8	UP San Miguel	1 lbs/C4-04; 1 lbs/C4-04
Penstemon comarrhenus	8	UP Delta	1 lbs/C1-04; 1 lbs/C1-04
Sphaeralcea coccinea	8	UP Paradox Valley	4 lbs/C1-04
Eriogonum umbellatum	8	UP Burn Canyon	2 lbs /C1-04; 2 lbs/C1-04
Hedysarum boreale	8	UP Uncompahgre	2 lbs/C2-03; 60 acres
Eurybia glauca	7	UP Cimarron	
Heterotheca villosa	7		
Erigeron pumilis	7	UP Log Hill	
Packera multilobatus	7	UP Montrose	
Erigeron speciosus	7	UP Dry Fork Hwy	1 lb (for 1/2 acre)/C1-03
Achillea millefolium	7	UP Dry Fork	3-4 lbs/C1-03
Eriogonum flavum	7		

[1] **Codes: 9 = Seed is available for purchase; 8 = Species in commercial production; 7 = Ready for commercial release**



Colorado Plateau Native Plant Program

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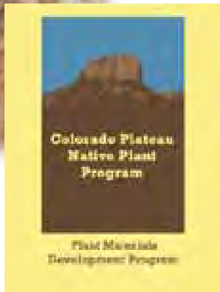
5. Seed Storage

6. Restoration of Native Plant Communities



Colorado Plateau Native Plant Program

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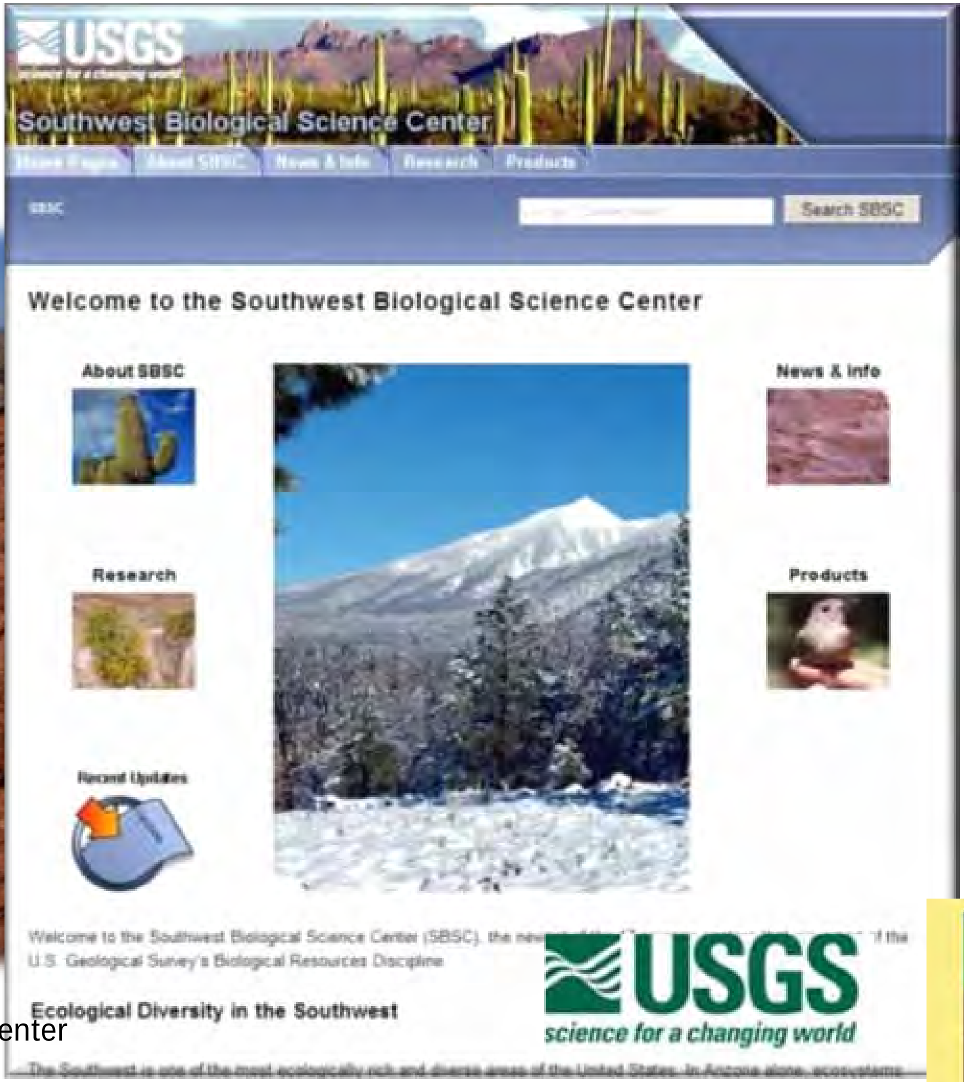
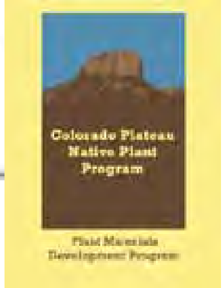
Research Program

Dr. Troy Wood, Plant Geneticist
USGS Southwest Biological Science Center





Colorado Plateau Native Plant Program

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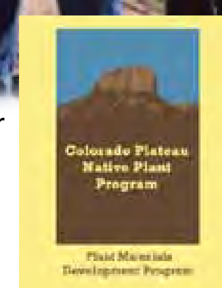
Additional Research Opportunities

Dr. Sylvia Torti, Director
University of Utah
Rio Mesa Center



Colorado Plateau Native Plant Program

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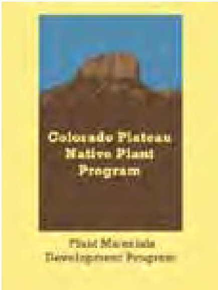
Colorado Plateau Native Plant Program

Partners

Who is involved with the Program?

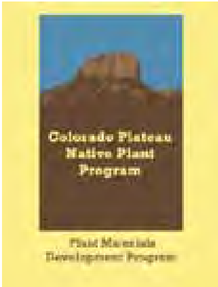
- Federal Agencies
  - Bureau of Land Management
  - U.S. Forest Service
  - U.S. Geological Survey
  - National Park Service
- State Agencies
  - Utah Division of Wildlife Resources
  - Colorado Division of Wildlife



Partners

Who is involved with the Program?

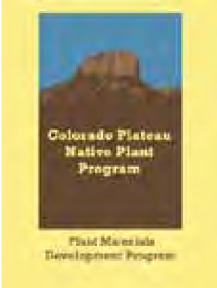
- Universities
  - University of Utah
  - Southern Utah University
  - Northern Arizona University
  - Fort Lewis College (Colorado)



Partners

Who is involved with the Program?

- Non-Government Organizations
  - Uncompahgre Partnership
  - The Nature Conservancy
  - The High Lonesome Ranch
  - Northern Arizona Native Seed Alliance
  - Museum of Northern Arizona
  - The Tamarisk Coalition
  - Rim to Rim Restoration



Colorado Plateau Native Plant Program

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Challenges

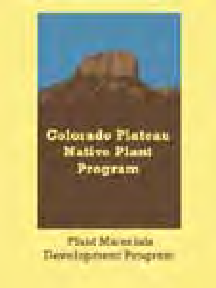
Challenges

Who is in Charge?

What are the Priorities?

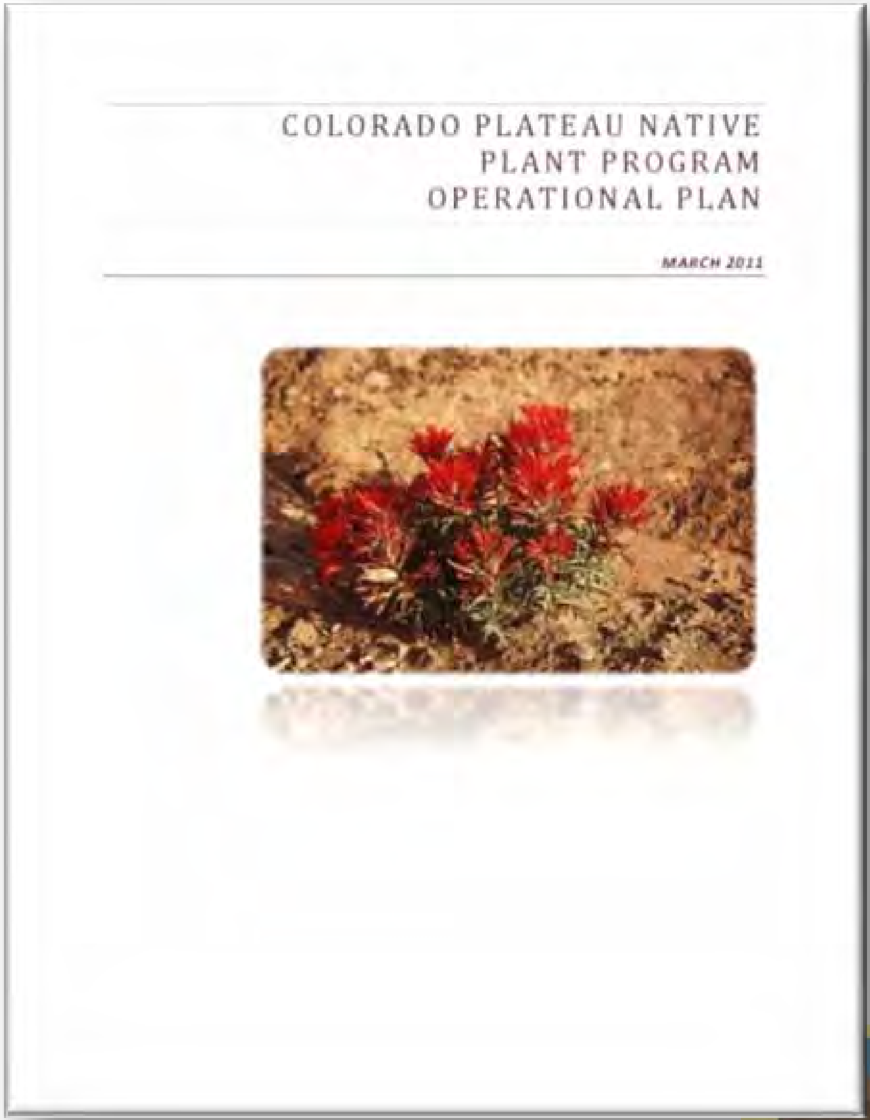
How Are Things Going to Get Done?

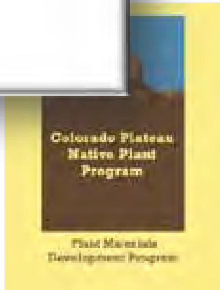
Who Is Going to Do What?



Operational Plan

Providing Direction and Guidance beyond the Five-Year Strategy and Action Plan.

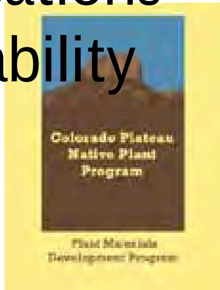




Operational Plan

Providing Direction and Guidance beyond the Five-Year Strategy and Action Plan.

- KEY FOCUS AREAS
  - Focus Area 1: Collection
  - Focus Area 2: Evaluation and Development
  - Focus Area 3: Field Establishment
  - Focus Area 4: Seed Production by Private Growers
  - Focus Area 5: Storage
  - Focus Area 6: Restoration of Native Plant Communities
  - Focus Area 7: Communications
  - Focus Area 8: Market Stability



Colorado Plateau Native Plant Program

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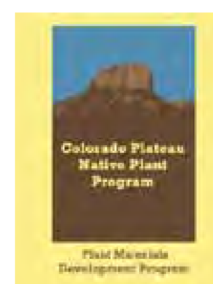
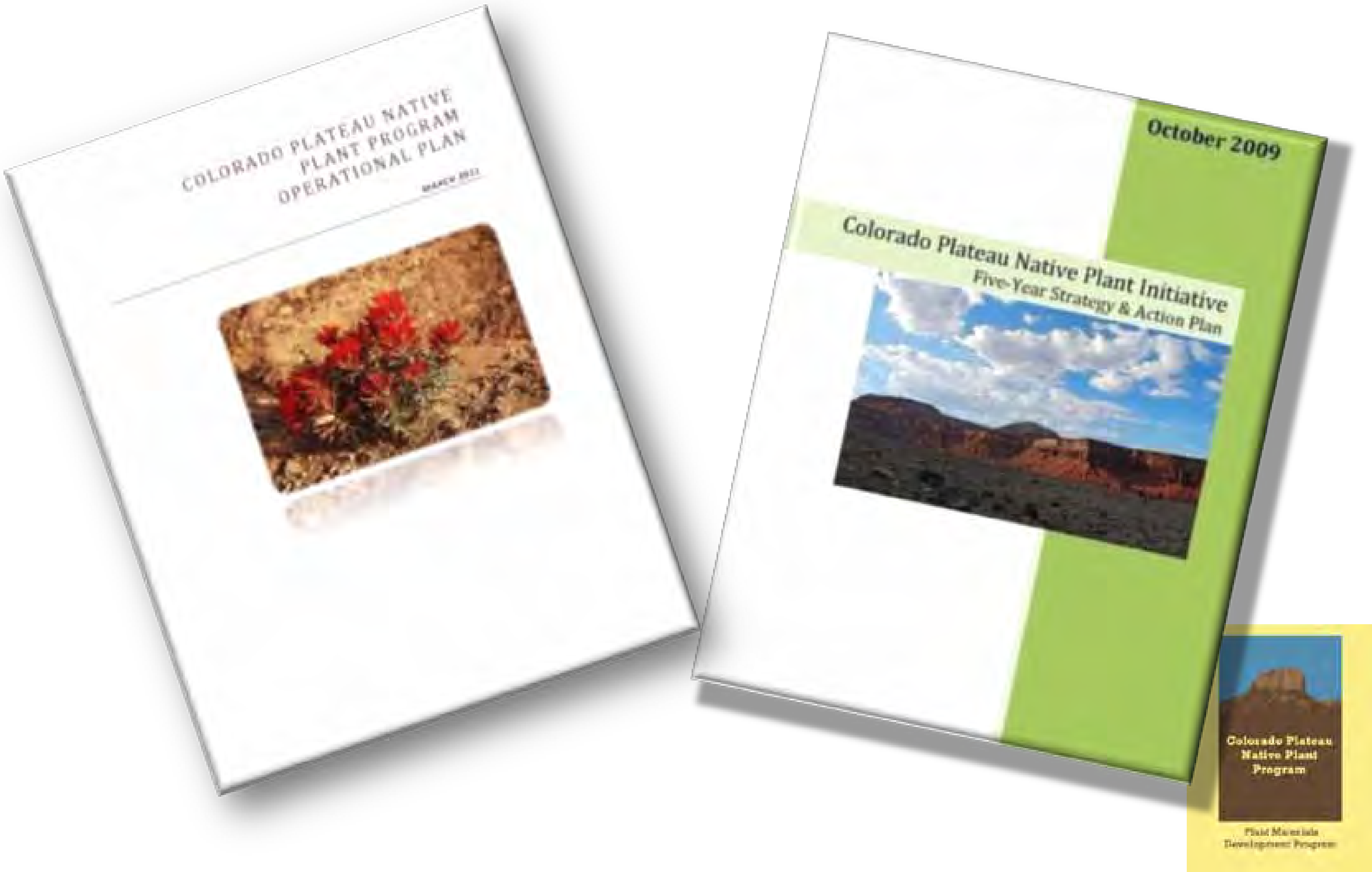
Operational Plan

Providing Direction and Guidance beyond the Five-Year Strategy and Action Plan.

- ROLES AND RESPONSIBILITIES
  - Partners
  - Committees
  - Working Groups
- PROGRAM COORDINATION AND MANAGEMENT
- PROGRAM GOALS
  - Short Term (1 yr) Goals
  - Mid Term (2 – 5 yr) Goals
  - Long Term (5+ yr) Goals
- PROGRAM EVALUATION
- BUDGET STRATEGY



COLORADO PLATEAU NATIVE PLANT PROGRAM
MAKING PROGRESS



The Dynamics of Native Seed Production:

A Growers Perspective

Stacey Plummer

L & H Seeds, Inc.
Herrman Northwest, Inc.

Connell, WA

Company Overview

- L & H Seeds, Inc.
- Herrman Northwest, Inc.
  - Located in Southeastern Washington
  - Land was developed in 1958
  - Native seed production began in the mid 1980's
  - Current production of around 80 different crops
  - Vertically integrated
    - Production, cleaning, and marketing

Northern Basin and Range Basin Wildrye
Leymus cinereus

Dry River Basalt Milkvetch
Astragalus filipes

Aridlands Western Prairieclover
Dalea ornata

Crooked River National Grassland Bottlebrush Squirreltail
Elymus elymoides

Combining

Swathing

Mechanical harvest of whole plant

Unloading into metal bins for small lots

Small lot seed cleaning

Seed blending/ Mixing

Large scale seed cleaning

Seed Drying

Uncompahgre Plateau Production

UP Dry Fork Germplasm Western Yarrow

Achillea millefolium

UP Sims Mesa Germplasm Prairie Junegrass

Koeleria macrantha syn. Cristata

White River Indian Ricegrass

Achnatherum hymenoides

CP-UP Colona Muttongrass

Poa fendleriana

Wild Collected Stock Seed

- Blended seed lots
  - Differing maturity
    - Harvest timing
  - Producers are making selections
- Evaluation for production potential
  - Production practices
  - Harvest and cleaning ease
  - Can it provide the amount and quality of seed needed for restoration projects?

Seed Zones

- New research to determine seed zones by species
- Still in development
- Example: Blue Mountains
    - 4 preliminary Seed Zones for Mt. Brome
  - Allocation of production resources
  - Scale of production
  - Risk and reward

Information Sharing

- Producers should be provided with Technical Guides
  - Establishment
  - Cultural Practices
  - Harvesting
- Reporting on experiments and trials
  - Making connections
  - Communication

Herbicides

- Lack of registered herbicides for use with native grasses and forbs
- Third Party Labeling
  - Working with Corey Ransom
  - We need a united voice in order to get results
- Increased cost will limit production

Contracts

- Current IDIQ’s
  - Small scale production of local Source ID Seed
    - What do you do when there is a large scale fire event?
  - Fixed period of time
    - Doesn't factor in long term investment in land and resources
  - Established, healthy, productive field
    - Keep field in and market on your own
    - Rotate field out

Reality Check: Crop Rotation

- Conservation Reserve Program (CRP)
  - Fall 2010 Brought many changes
    - Increase demand for seed
    - Emphasis on creating habitat for native pollinators
  - Result
    - A shift in how land and resources were delegated for Fall 2010 planting

Commodity price increase

- Limits the pool of native seed growers
  - Growers want low risk, low input, high payoff crops
- Increased competition for land
  - Higher rents

Bottom Line: Help us, help you

- Screening for traits that lend themselves to agronomic production
- Improved communication
- Agreement on seed transfer zones
- Herbicide research and labeling
- Contracts that consider investment and risk
- Consideration of exterior influences

Paul Herrman PaulH@lhseeds.com 509-234-4433
Stacey Plummer StaceyP@lhseeds.com

USDA

Establishment, Persistence, and Precipitation

Forage and Range Research Laboratory

Joseph G. Robins

USDA-ARS FRRL
Logan, UT

ars

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The Problem– Disturbed Rangelands

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Consequences of Disturbance

- At least temporary, loss of ecosystem function
- Loss of desirable, perennial plant material
- Top soil loss
  - Inches of unprotected top soil can blow or wash away in one weather event
  - Can take 1000s years to develop small amount of top soil
- Increased susceptibility to annual weed invasion
  - Further pressure on perennial plant stands
  - Increased fire frequency
  - Changed soil characteristics, including organic matter, C and N cycling, structure, and hydrology

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Disturbed Rangelands Require Revegetation

Seeding technique and equipment

Weed management

Plant materials

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Plant Materials can Stabilize Sites

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Proper Plant Materials

- The goal is stabilized sites and protection of soil resources
- If we can stabilize sites, the chances of maintaining or restoring ecosystem function improves
- Highly disturbed sites may never function the same again – they may be permanently changed
  - Thus, previously adapted plant materials may no longer be adapted
  - Particuarly, true on harsh, dry sites with strong annual weed pressure

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What is lacking?

- Information and decision-making tools for choosing best plant materials for each site!
- The information is out there, but is not available in a user-friendly, summarized form
- Objective: Characterize population and environmental effects for reseeding effectiveness
- All entries are not included at each location
  - Comparisons are to ‘Hycrest’ crested wheatgrass

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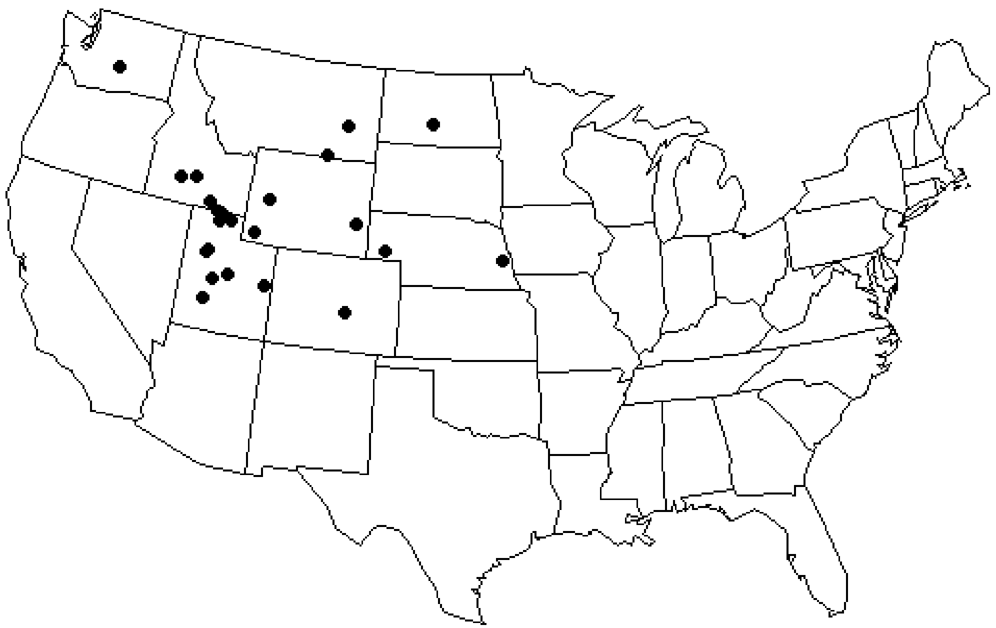
Evaluation Sites



- 34 field evaluations in Intermountain and Northern Great Plains
  - 23 locations
  - 7 states
  - 12 plant adaptation regions
- Site characteristics
  - 8 to 27 in annual precipitation
    - 15 evaluations ≤ 12 in annual precipitation
    - 19 evaluations > 12 in annual precipitation
  - 1190 – 7740 ft above sea level
  - 49 – 64 ° F mean maximum monthly temperature
  - 21 – 39 ° F mean minimum monthly temperature
  - 1983 – 2006
- Sites fall dormant-seeded based on PLS appropriate for each species

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Plant Materials

- 18 cool-season grass species
  - 9 native North American
  - 9 introduced
- 2 – 16 species evaluation
  - Only crested wheatgrass and Russian wildrye at each location
- 64 varieties or germplasms
  - All but one officially released

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Data Collection

- Visual evaluations prior to 1999
- Grid method after 1999
- Stand establishment evaluated first year post-seeding
- Persistence evaluated 2 – 8 years post-establishment
  - Site dependent

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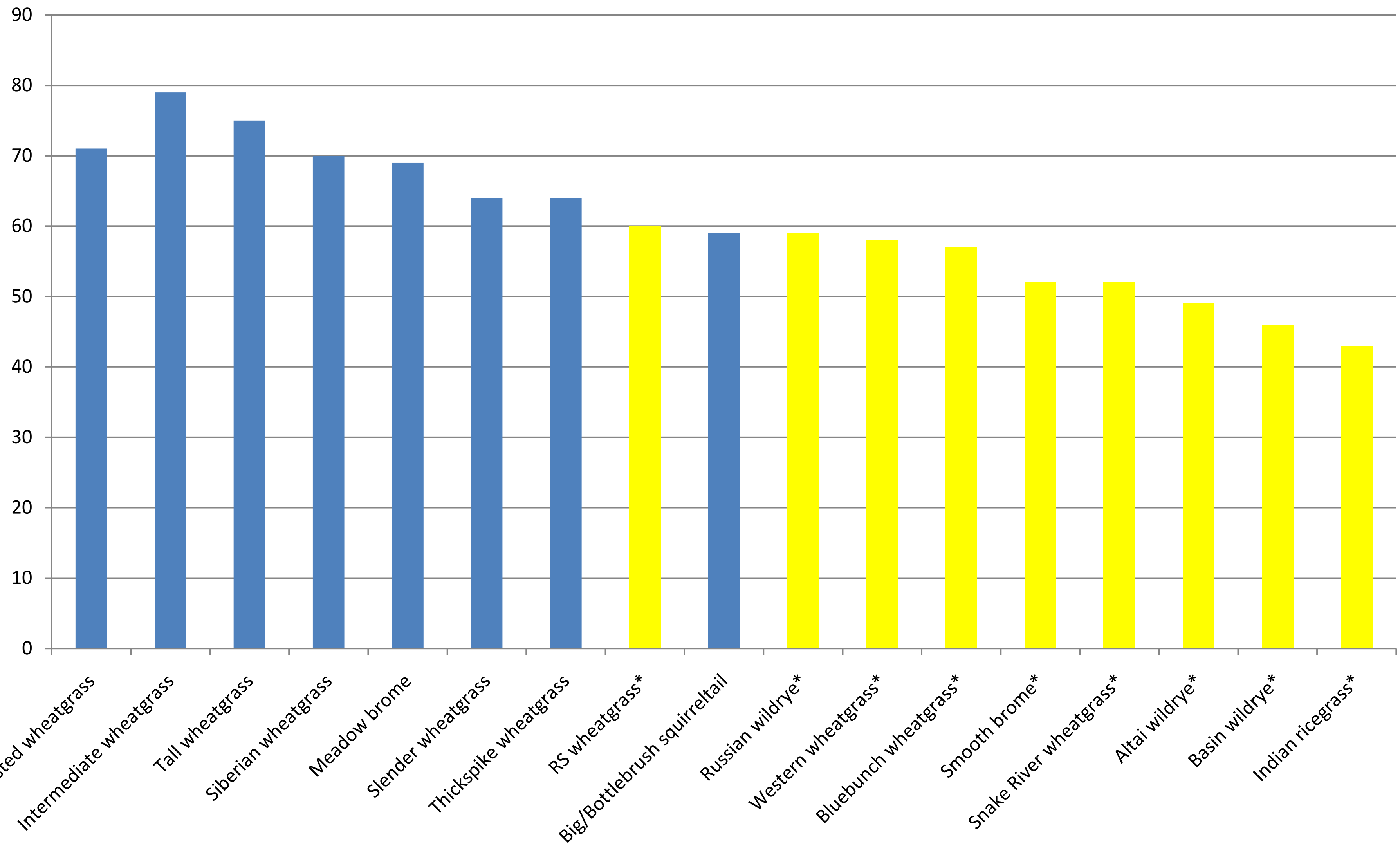
Overall Establishment



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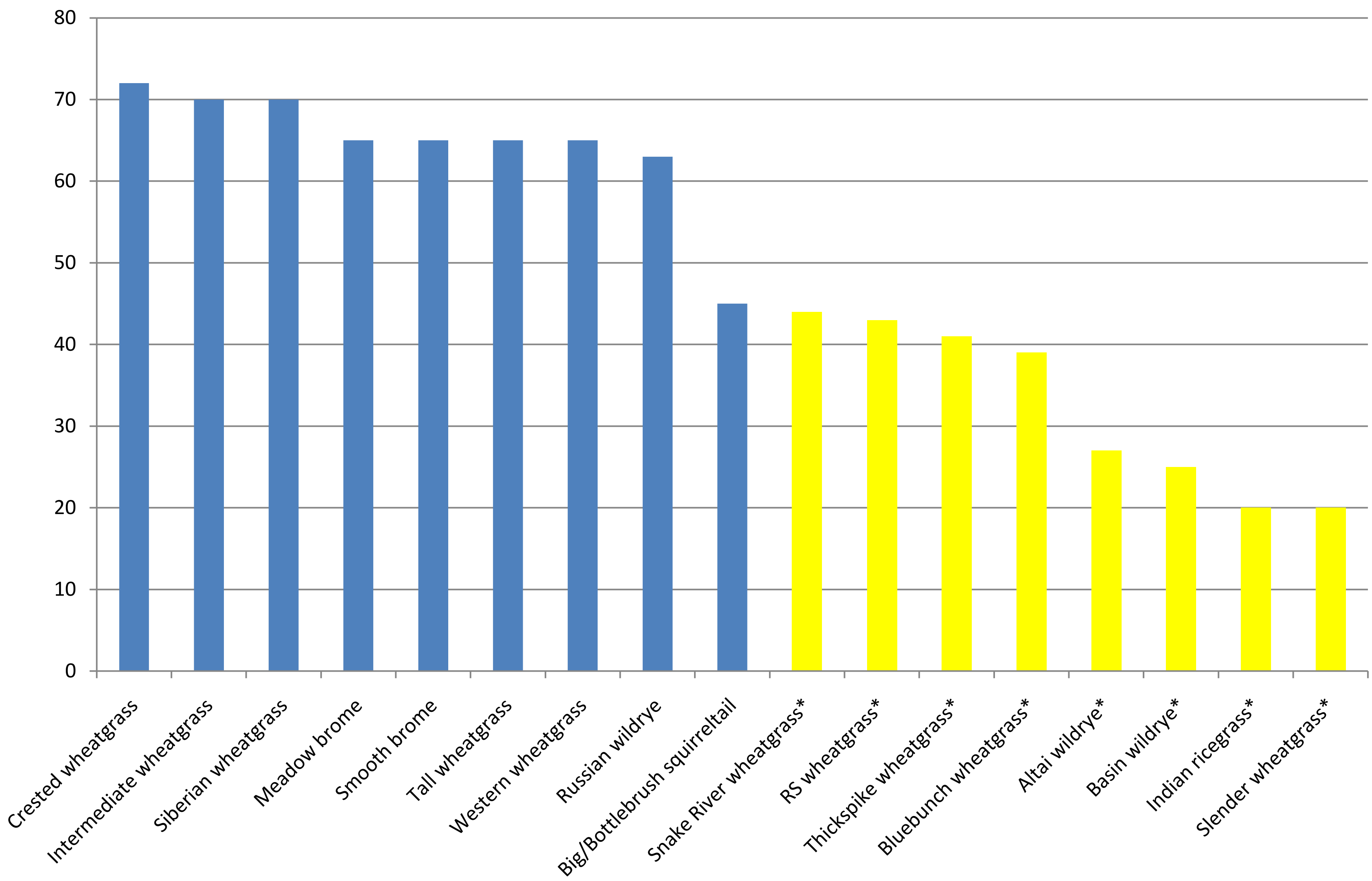
Overall Persistence



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Overall Conclusions

- Most species established
  - Most species established 50 – 60 %
  - Several above 70 %
  - Few below 50 %
- Clear separation for persistence
  - Above 60 % or below 45 %
- Genotype x environment interaction cannot be ignored
  - Differential performance at different sites
  - Phenotypic plasticity

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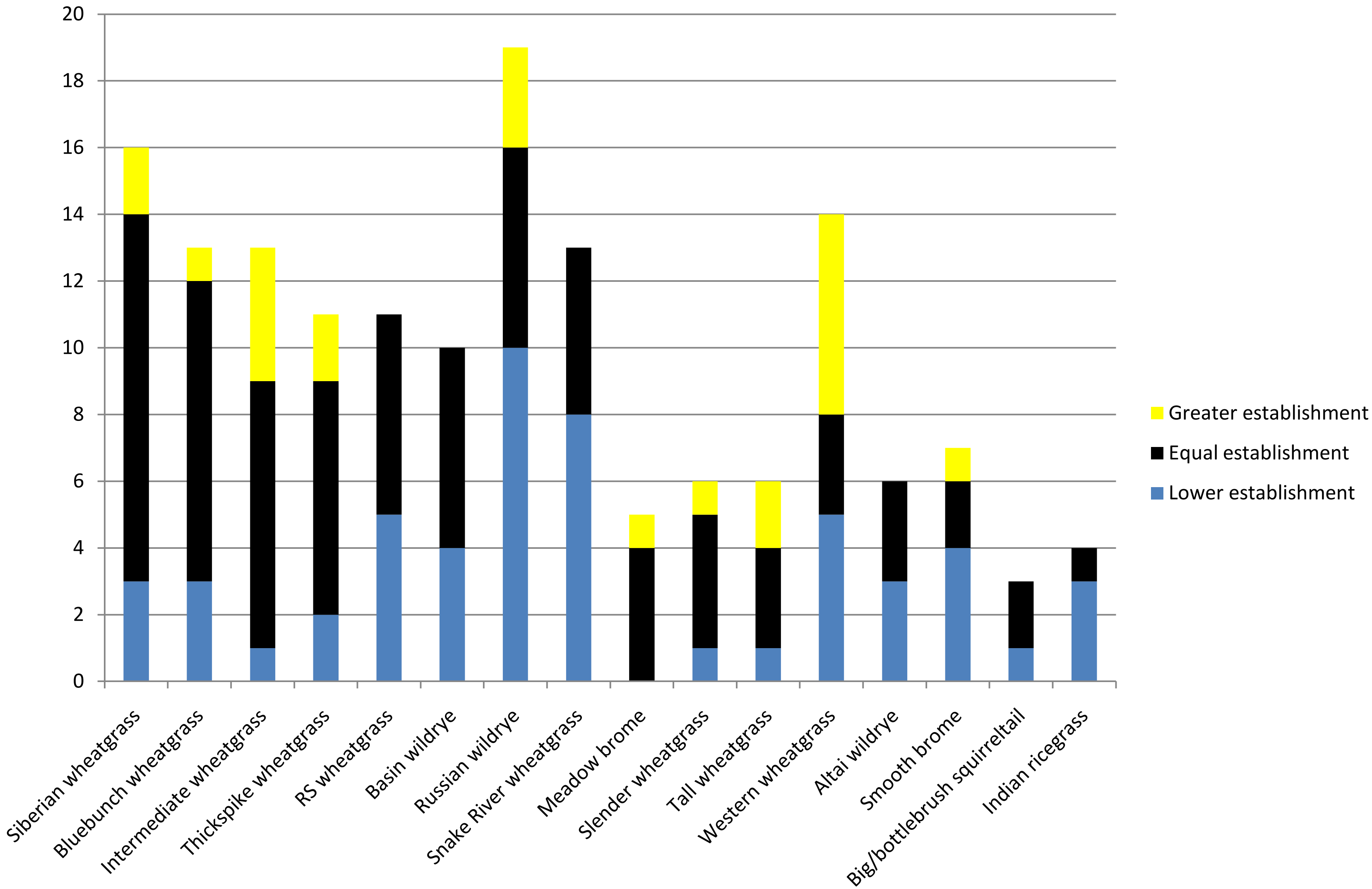
High Precipitation (> 310 mm) Establishment



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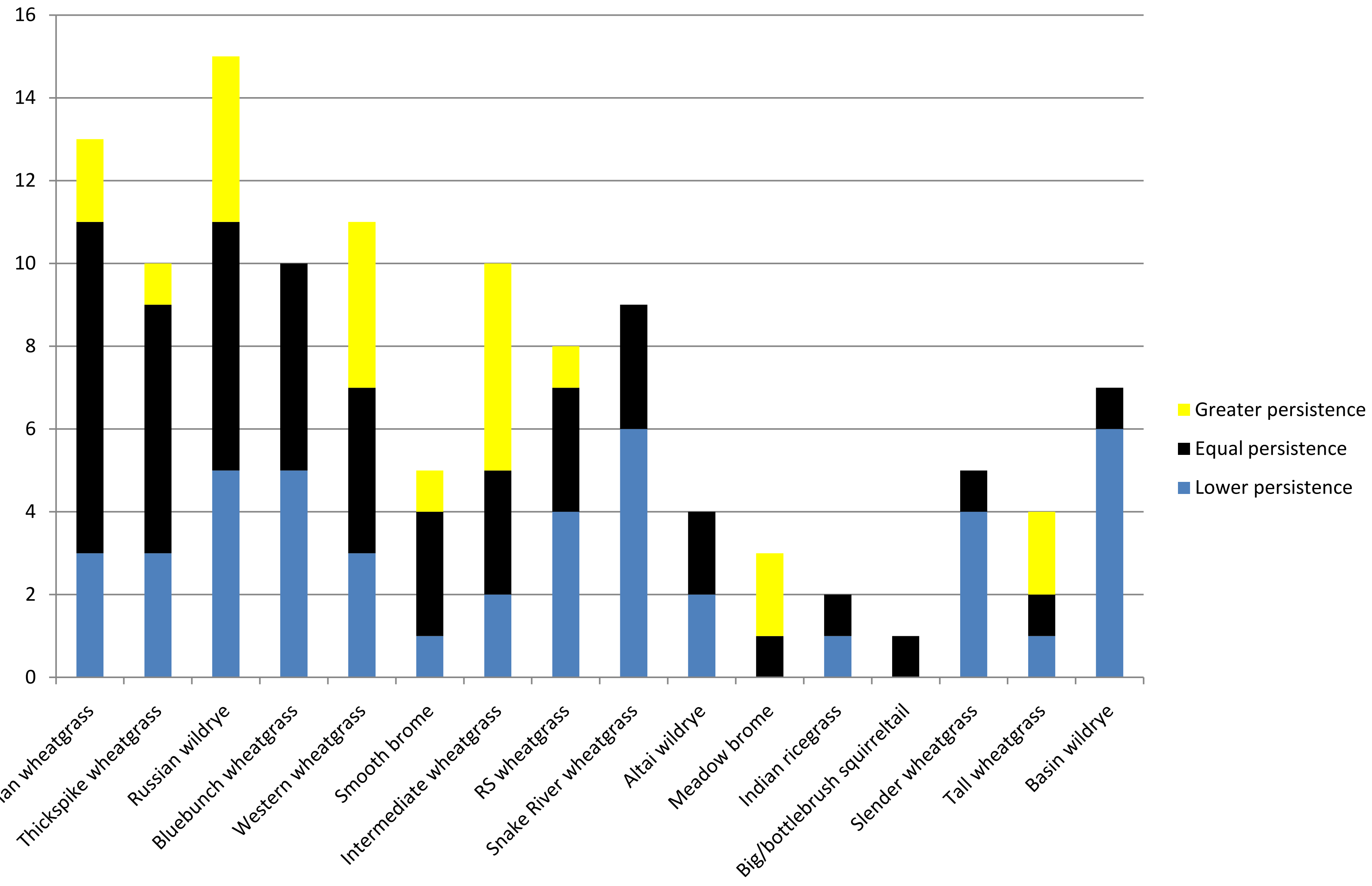
High Precipitation (> 310 mm) Persistence



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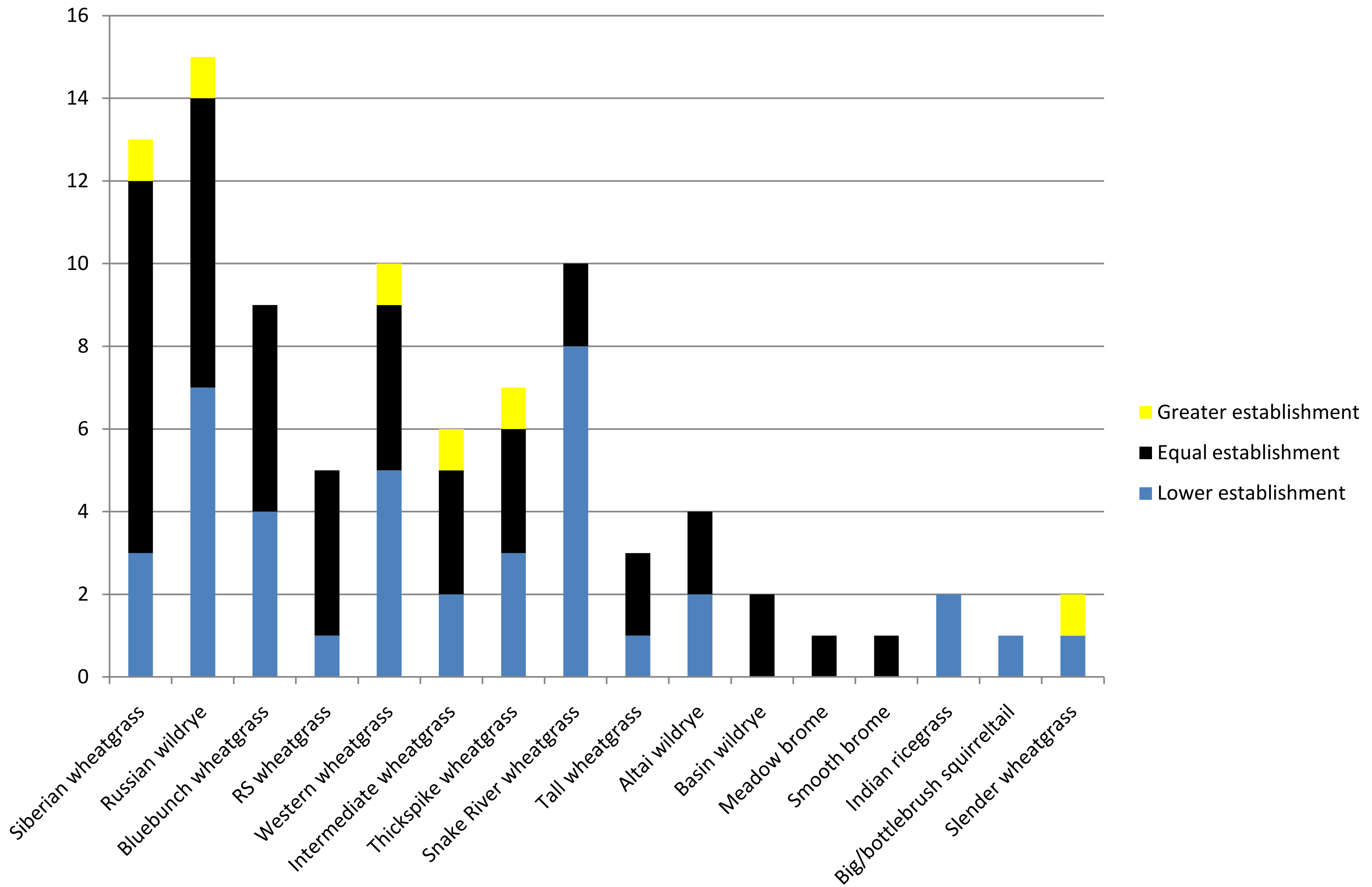
Low Precipitation (< 310 mm) Establishment



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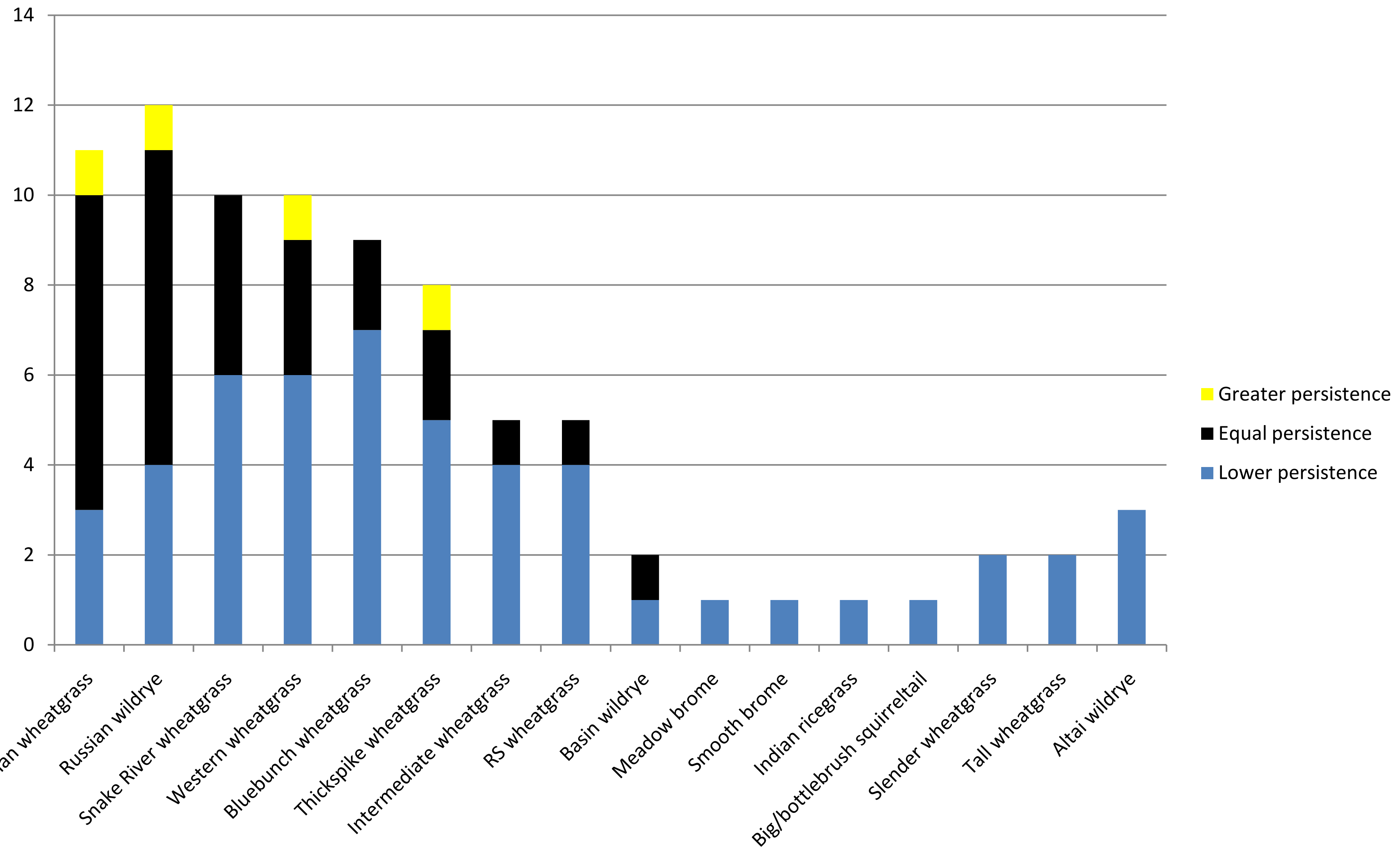
Low Precipitation (< 310 mm) Persistence



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Relationships with Environmental Factors

- Establishment most strongly effected by annual precipitation and site longitude
  - Less effected by elevation
- Persistence effected by annual precipitation, longitude, and year planted
- Other factors including max and min temperature, latitude, and year post-establishment did not seem to effect this dataset
- Newer, selected plant materials performed better than older materials

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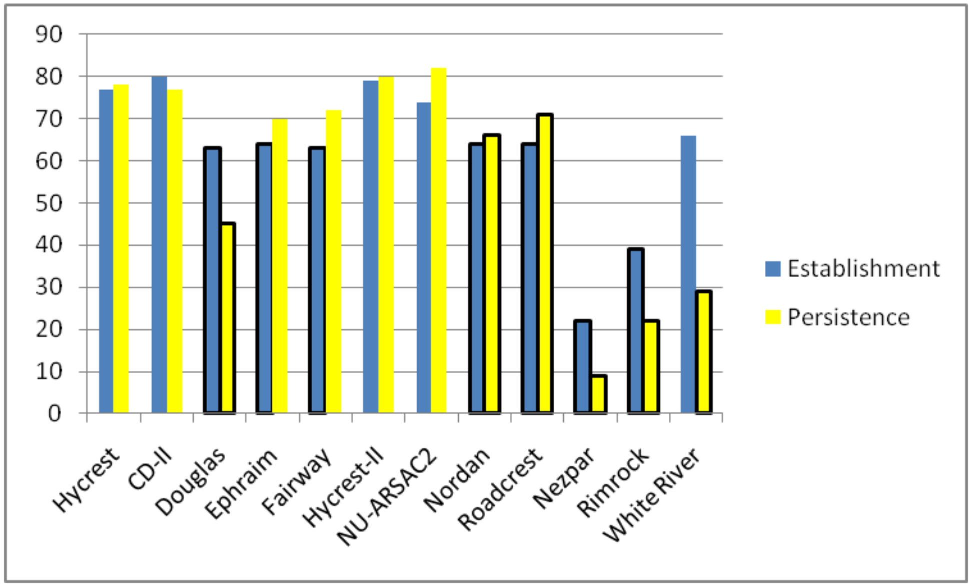
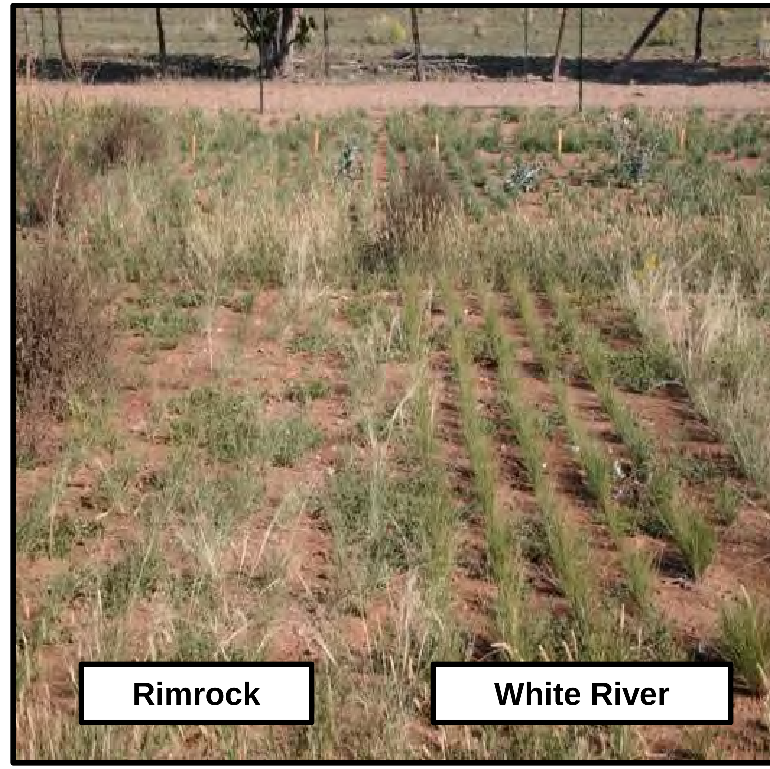
Indian Ricegrass





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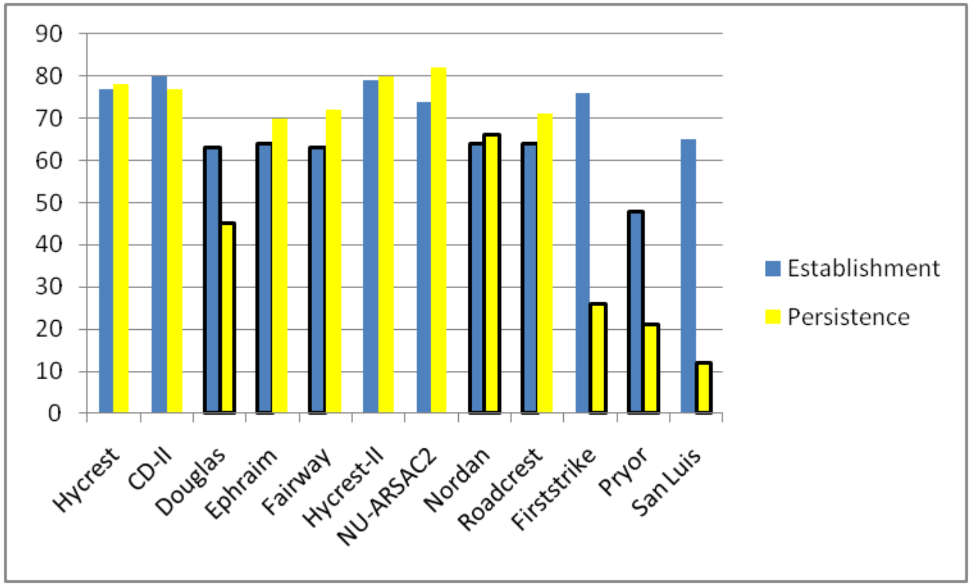
Slender Wheatgrass



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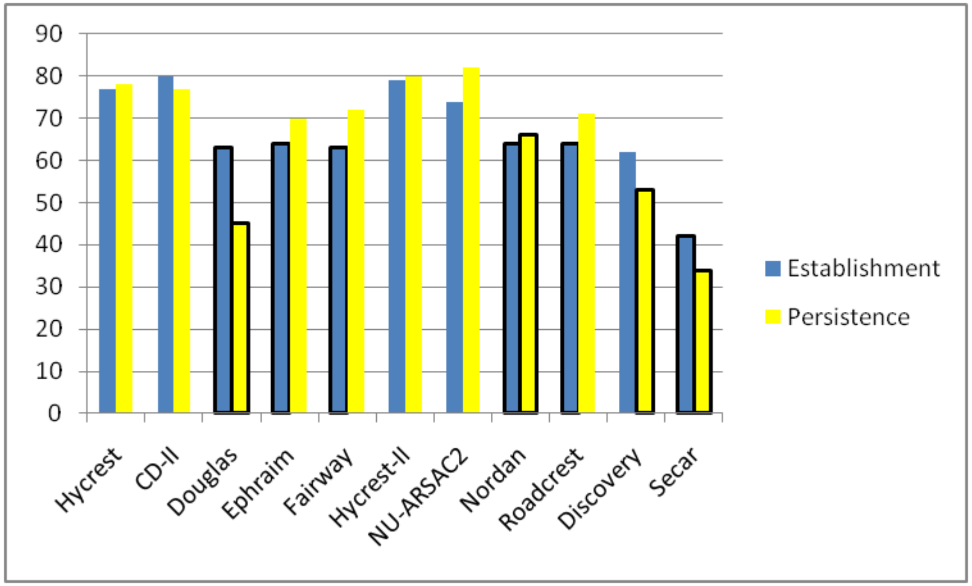
Snake River Wheatgrass



Discovery Snake River wheatgrass

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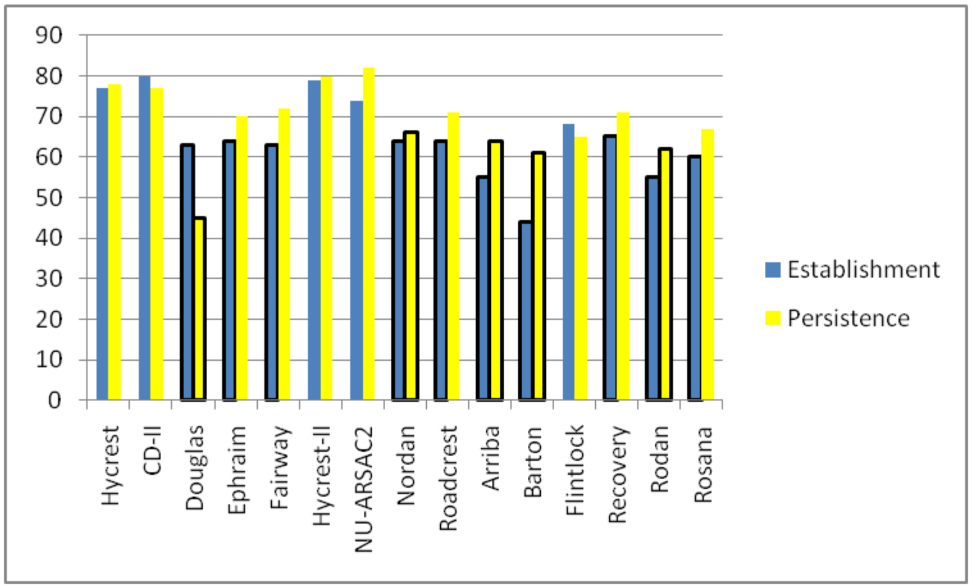
Western Wheatgrass

Recovery western wheatgrass



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Some Final Thoughts

- Wheatgrasses – crested and Siberian – perform best on severely disturbed, harsh sites
- The establishment gap is closing as native plant materials are improved
- Persistence is still an issue, although rhizomatous materials can be effective
- Expanded testing and data analysis is necessary to better make decisions and identify best materials – statistics are not straight-forward
- Land managers will make better decisions with more information
- Plant materials can be a great aid in the fight against degraded rangelands and annual weeds

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Acknowledgements

- Kay Asay, Jerry Chatterton, Doug Dewey, Bryant Gomm, Howard Horton, Tom Jones, Craig Rigby, Blair Waldron – FRRL
- John Berdahl, Marshall Haferkamp, Rob Mitchell, Ken Vogel – other ARS locations
- Tony Palazzo, Tim Cary – USACE CRRL
- Other FRRL Staff
- Land managers from public and private entities

Cause or Symptom?
Invasive species & EBIPM

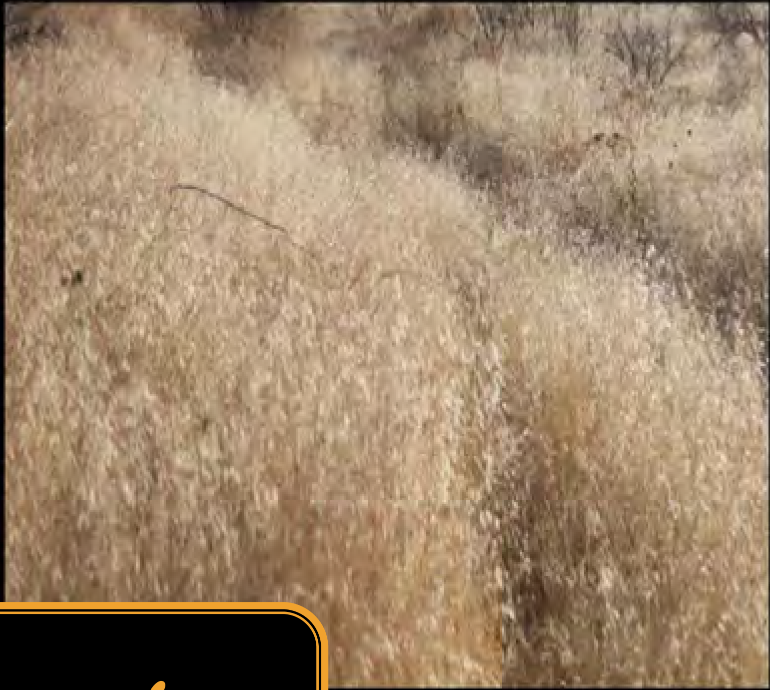
Brenda Smith, USDA-Agricultural Research Service
Burns, Oregon

ebipm (acronym); 1. framework used to successfully manage invasive species, 2. also based in ecological principles. [See also ecologically-based invasive plant management]

Getting organized…

1. *background and rationale*
2. *how to use ebipm*
3. *working examples*

The compelling issue of invasive annual grasses



a storm has been brewing

weigh expected benefits against expected costs

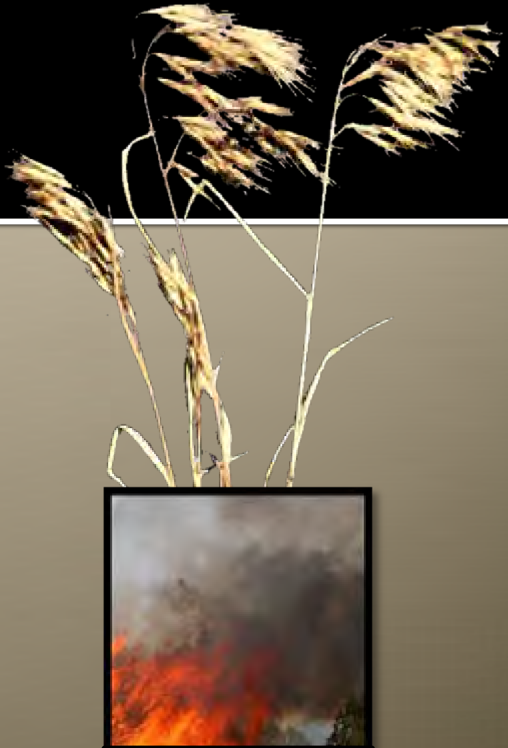

The LEGEND OF THE
LONE RANGER

the EBIPM concept

cause or symptom?

Poison Ivy

Cold virus

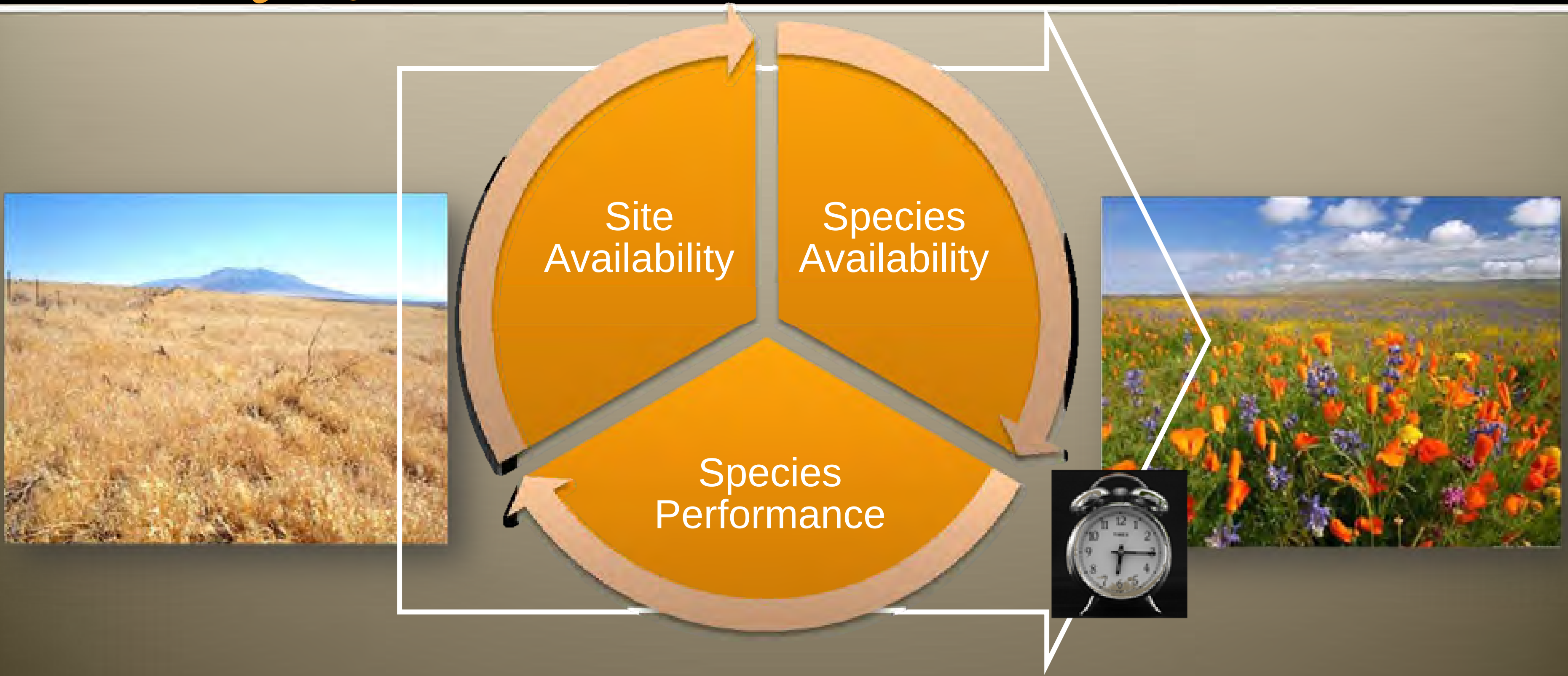


Ecological processes

Malheur wildlife refuge

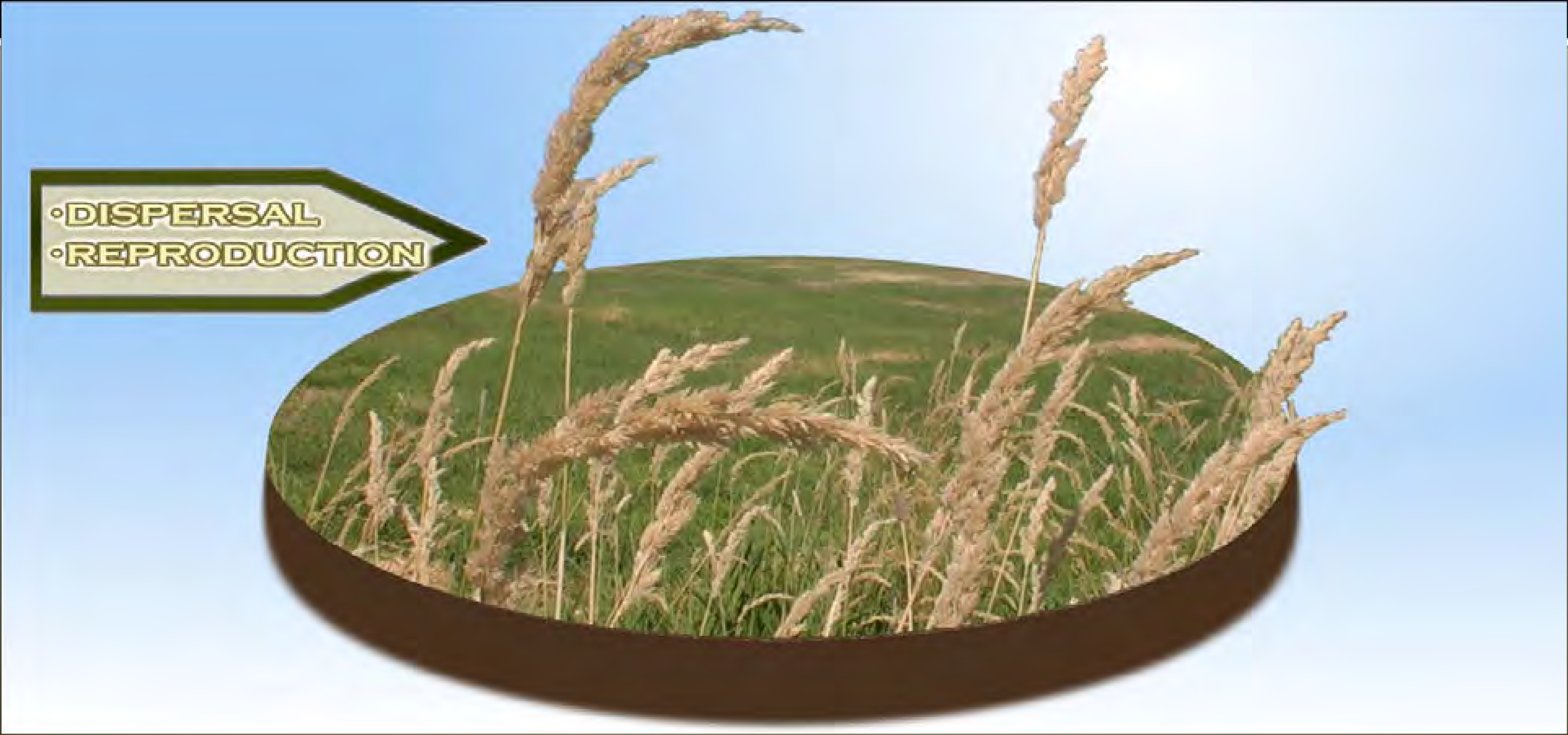
ecological causes

underlying basis for EBIPM



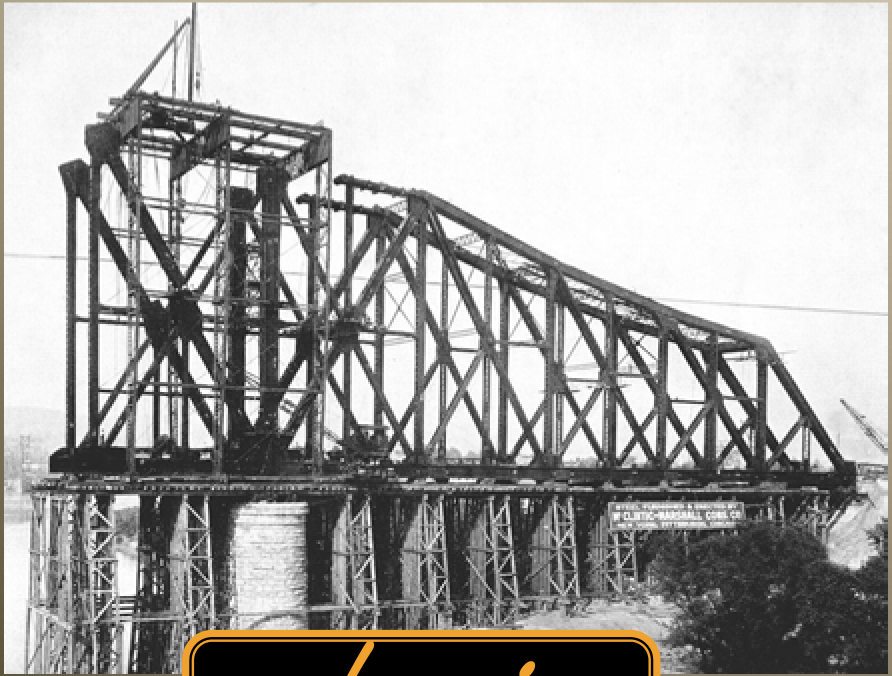
Processes affecting site availabilty

Processes affecting species availability



Processes affecting species performance

Principles = desired outcomes



physics

ecology

step by step

AREA-WIDE EBIPM

SCIENCE-BASED SOLUTIONS FOR INVASIVE ANNUAL GRASSES

Step 1:
Complete Rangeland Health As

Step 2:
Identify Cause of Invasion and Associated P not Function

Step 3:
Use Principles to Guide Decision Mal

Step 4:
Choose Appropriate Tools and Stra Based on Prin

Step 5:
Set Up a Plan and Know Whether it's Working

for example...

Step 1:

Complete Rangeland Health Assessment

for example...

Step 2:
Identify Cause of Invasion and Associated Processes Not Functioning

Causes of Plant Community Change	Processes Affecting Change
Site Availability	**Disturbance:** created by voles
Species Availability	**Reproduction:** insufficient propagules
Species Performance	**Resource Acquisition:** limited by dry soils

for example...

Step 3:
Use Principles to Guide Decision Making

Principles of Ecology

Lower disturbance frequency favors desired species

Seed desired species to shift plant community

Successfully manage initial establishment of desired species

for example…

Step 4:
Choose Appropriate Tools and Strategies Based on Principles

Tools & Strategies

Disturbance created naturally

Seeded with desirable species

Drill seed and provide temporary irrigation

for example...

Step 5:
Set Up a Plan and Know Whether It's Working

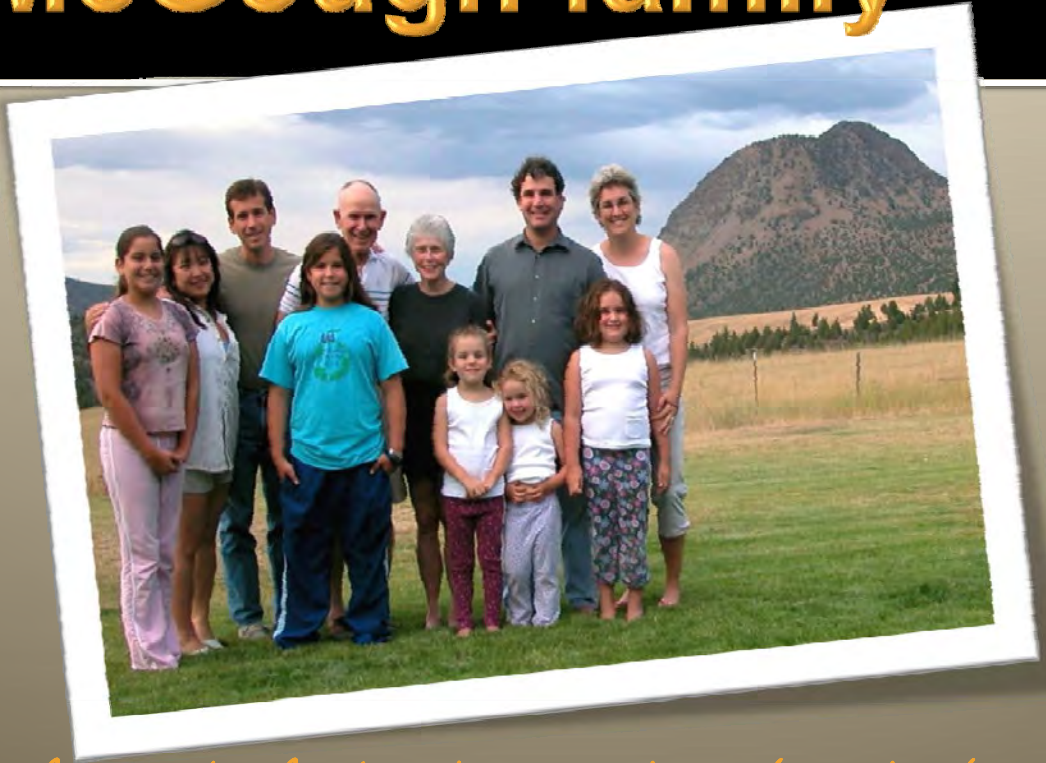
Integrated Planning and actions to be taken

Adaptive Management Applied

EBIPM on a ranch scale

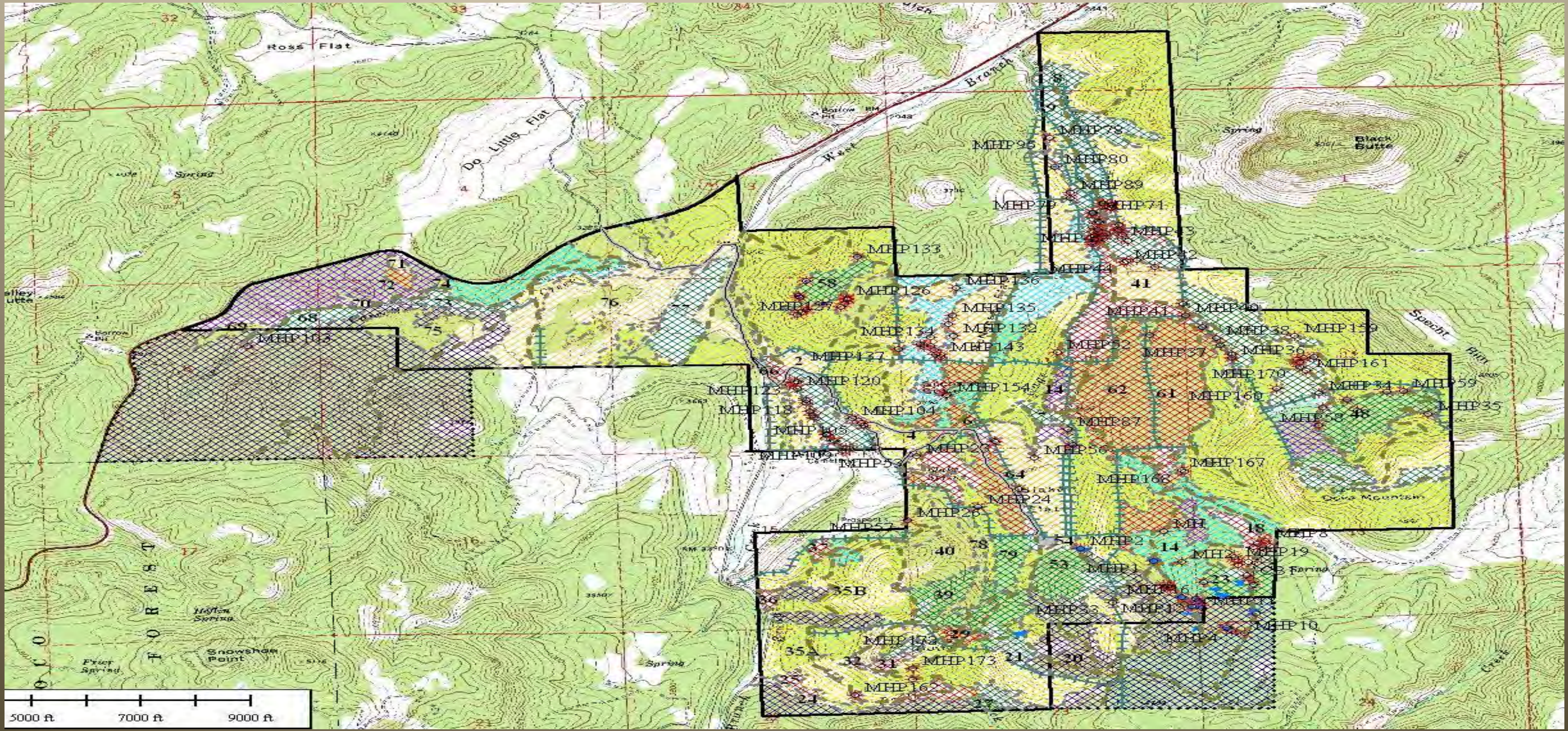
Mitchell, OR

The McGough family



"…we want to leave the land in better shape for the future generations…"

getting started



Processes in Disrepair

Site Availability:	• Historical disturbances
Species Availability:	• Heavy seed production and dispersal of medusahead
	• Few remaining desired species
Species Performance:	• Poor competition of desired species
	• Remaining desired species stressed – limited moisture, grazing pressures

Ecological Principles

Disturbance → Desired species favored by less intense disturbances

Seed Dispersal & Production → Prevent dispersal & decrease seed production to shift to desirable plants → **Herbicide Treatments**

Stress → Stress medusahead to favor desired species

herbicide treatments

- Imazapic for selectivity at 6-8 oz/acre
- Summer through fall, keeps seed production down, limits dispersal
- Sites marked for seeding in the fall

Ecological Principles

Disturbance

Desired species favored with less intense disturbance

Seed Dispersal & Production

•Match desired species seed numbers with available safe sites
•Early arrival of desired species can increase establishment

Life Strategy Interference

•Plant species with diverse growth patterns
•Plant species with similar traits for greater competition

Seeding Treatments

restoration

- No till drill minimize disturbances
- 2009 Seed mix to increase competition/ diverse growth patterns:
- Hycrest wheatgrass, Bluebunch wheatgrass, Intermediate wheatgrass, Ladac Alfalfa Sherman big bluegrass, Various forbs
- 15 lbs–30 lbs/ acre
- Seeded again & split seedings between fall and spring

Ecological Principles

Disturbance → Desired species favored by infrequent disturbances

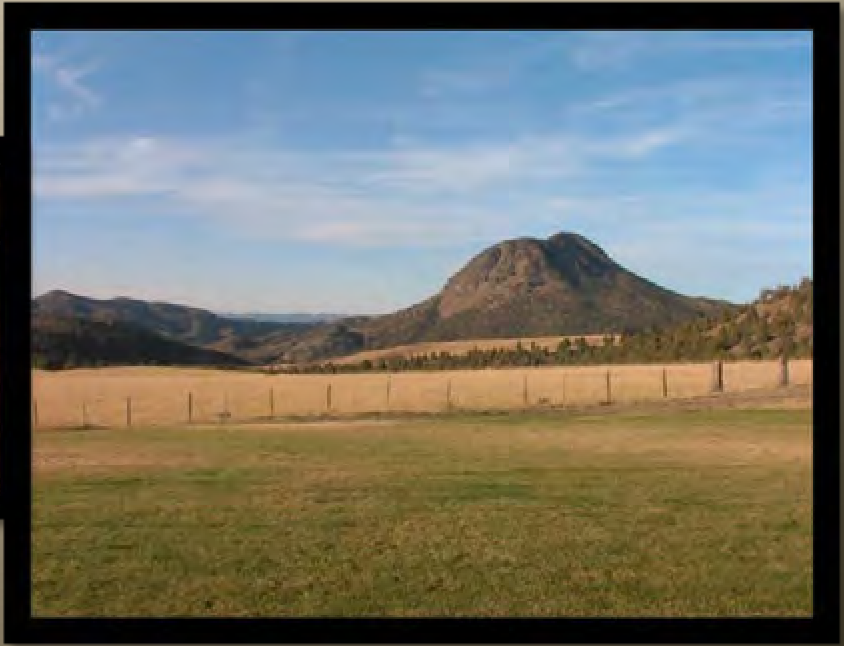
Seed Dispersal & Production →
- Control seed production of medusahead
- Don't damage desired species to enhance seed production

Stress → Apply stress to medusahead
Remove stress for desired species

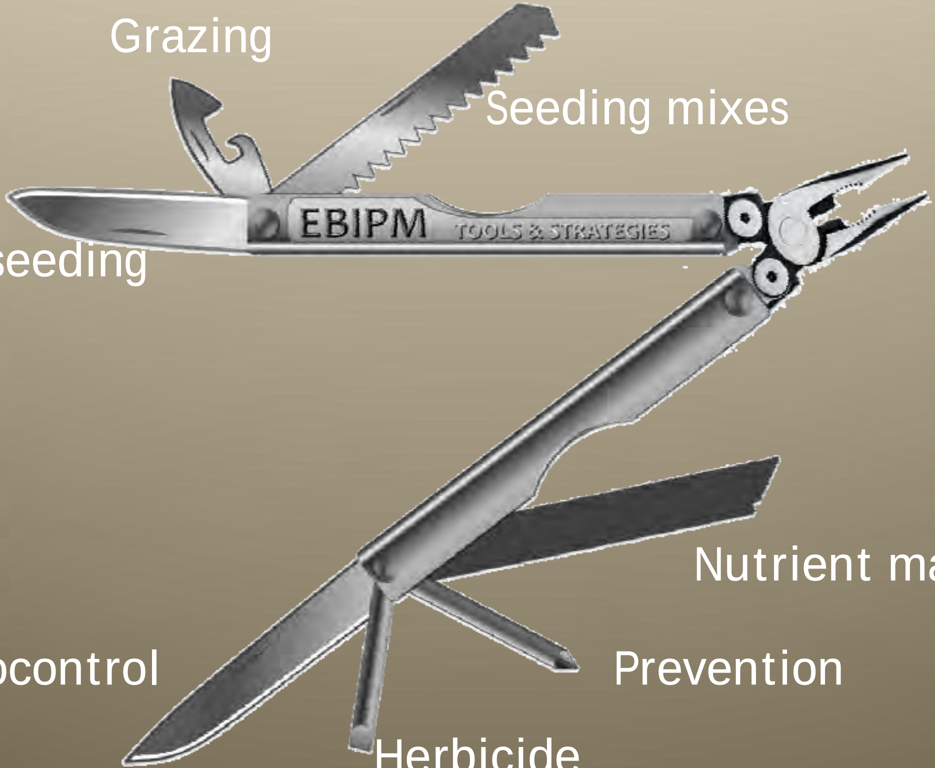
→ Grazing Treatment

grazing treatments

Early & Intensive

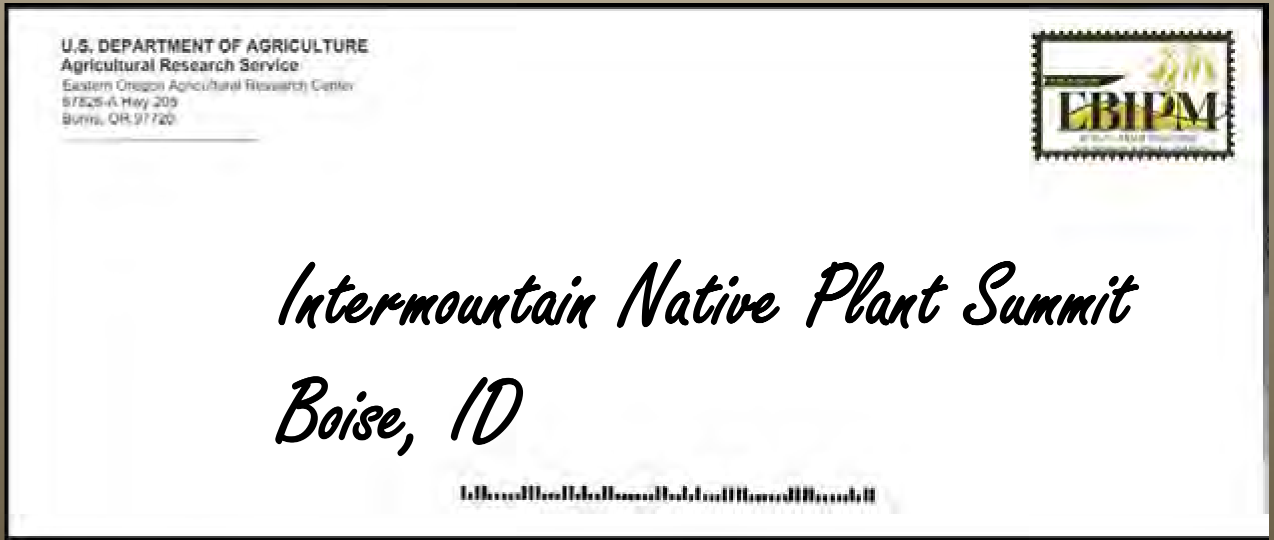


a link to Tools & Strategies

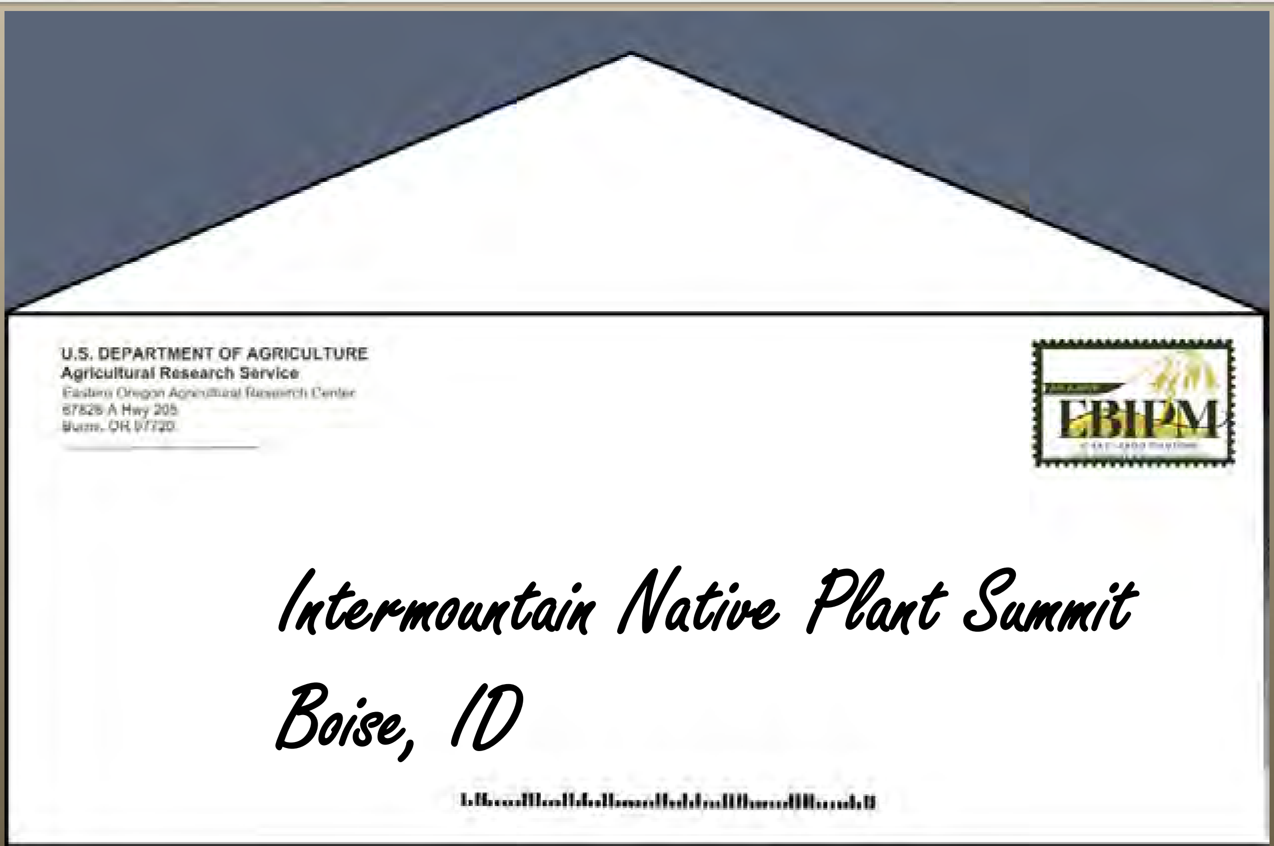



Or?
what will be here when we are gone?

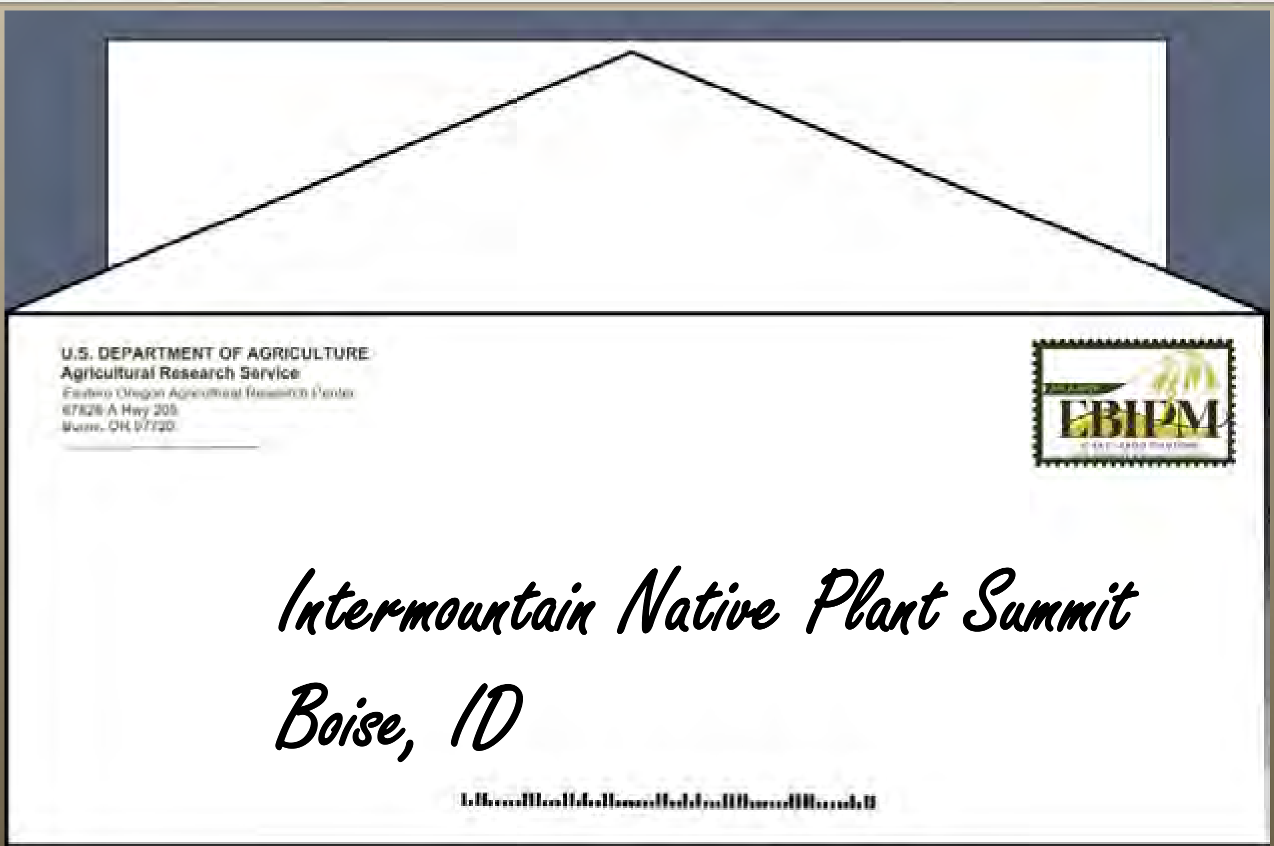
take home message

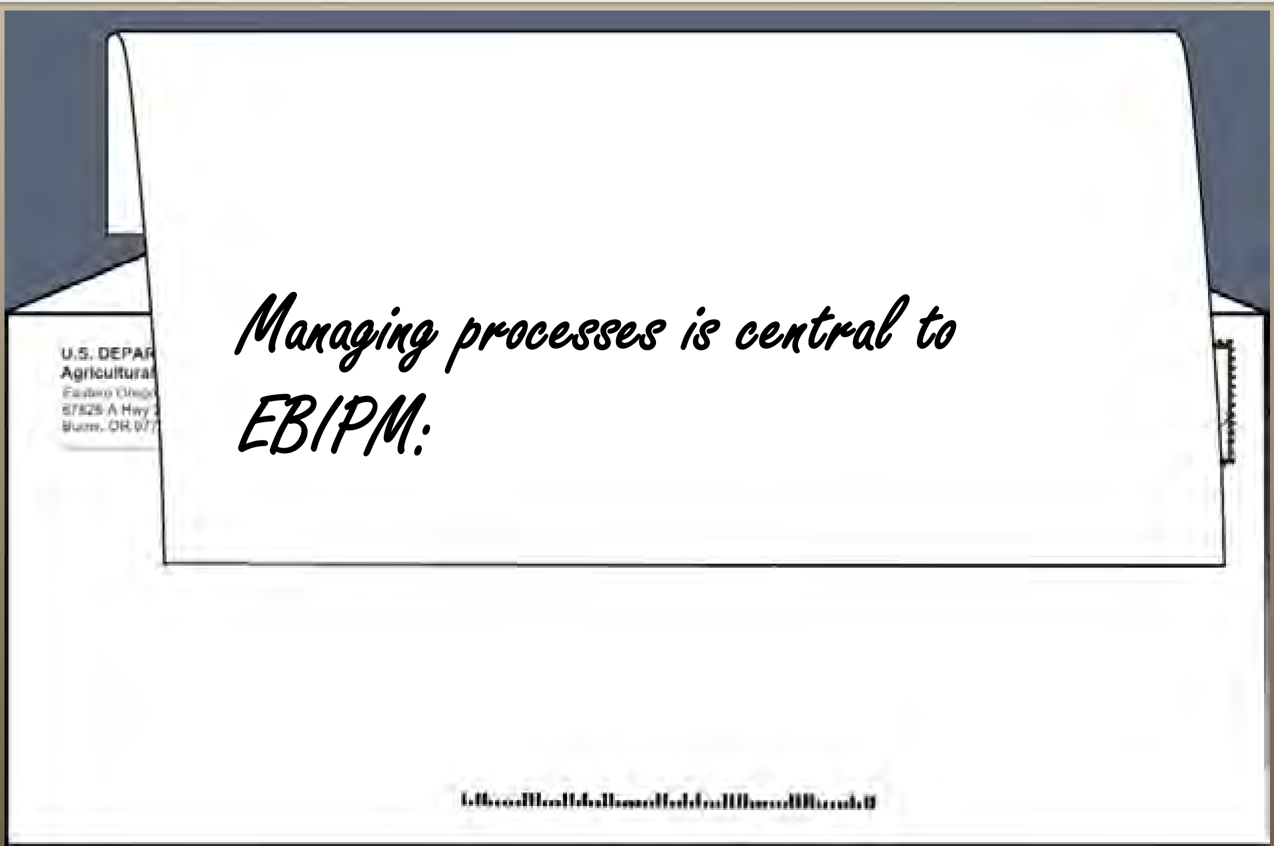


take home message



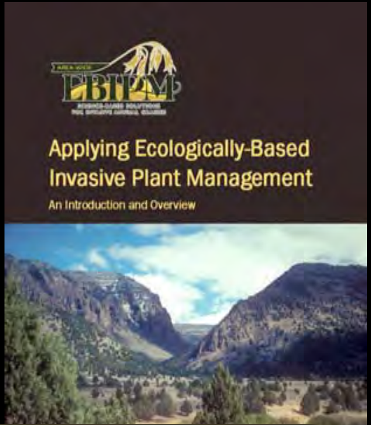
take home message

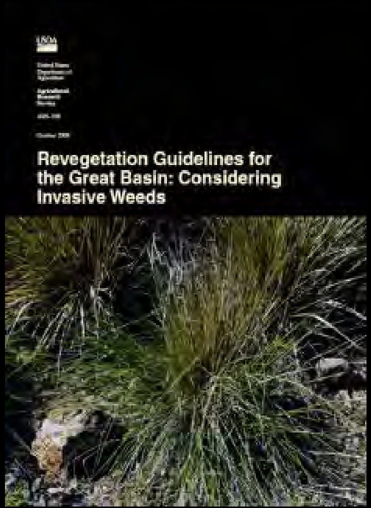


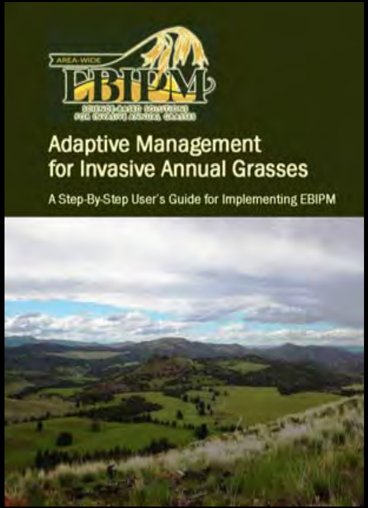


Managing processes is central to EBIPM:

And by using ecological principles to guide decision-making for holistic planning we have the opportunity to improve the land for the long term

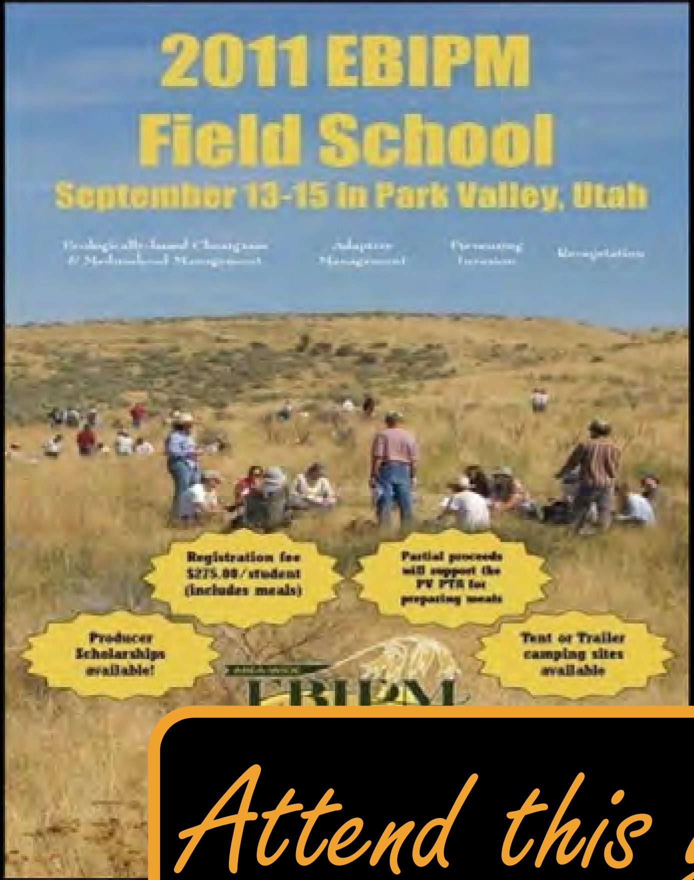






www.ebipm.org

A 2011 Product of the
AREA-WIDE PROJECT



Attend this year! Park Valley, UT

Seed Production of Native Plants in the Intermountain West

Natural Resources Conservation Service

Loren St. John

Aberdeen, Idaho Plant Materials Center


Aberdeen PMC
Home Farm
Office/Greenhouse

Good Old Days

Firecracker Penstemon

Venus Penstemon


“Branding Iron” Hole Jig


Seeding
Tube


“Jet” Harvester

TECHNICAL NOTE

USDA – Natural Resources Conservation Service

Boise, Idaho

PLANT MATERIALS NO. 56 OCTOBER 2010

The Jet Harvester: A Shop Built Tool for Harvesting Forb and Shrub Seed

Charles Bair, NRCS Plant Materials Center, Aberdeen, Idaho
Derek J. Tilley, NRCS Plant Materials Center, Aberdeen, Idaho

This Technical Note introduces a new seed harvester developed by the Aberdeen Plant Materials Center farm staff. The information presented here covers the design and use of the Jet Harvester. This technology significantly decreases the time and effort spent harvesting seed of native forbs and shrubs that are not readily harvested by traditional methods.

Bushel Scale

Seed Popper

TECHNICAL NOTE

USDA-Natural Resources Conservation Service
Boise, Idaho – Salt Lake City, Utah

TN PLANT MATERIALS NO. 35 **OCTOBER 2010**

Quick Methods to Estimate Seed Quality

Derek Tilley, PMC Agronomist
Dan Ogle, Plant Materials Specialist
Brent Cornforth, PMC Farm Manager

Abstract
Waiting for laboratory germination results to determine if seed lots require additional cleaning can be time consuming and expensive. The process can be shortened by making relatively accurate in-house measurements of seed quality.

The Aberdeen Plant Materials Center (PMC) uses two simple procedures to estimate seed quality prior to sending seeds lots to a lab for testing, the pop test and historic bushel weights. A series of tests were conducted at the PMC to evaluate the accuracy of the pop test when compared with germination and tetrazolium results obtained from a certified lab. Popping reactions were observed and divided into three categories, 1) seeds that popped explosively and audibly, 2) seeds that rolled or moved but did not pop, and 3) no response. Means obtained from the pop test were used to create 90 and 95% confidence intervals (CI), and compared with results from the Idaho State Seed Lab. Our results indicate that the pop test is a good predictor of seed fill in newer lots of seed of many species tested. Combined pop and movement responses were well aligned with lab results. Lab tests fell within the 95% CI 15 of 30 times, and the 90% CI 25 of 30 times. Our results indicate that seed with any movement should be counted as viable, and not just those with a distinctive pop. Accuracy decreases with seed age, because seed embryos die at a quicker rate than seeds lose moisture.

This paper also discusses the use of bushel weights to estimate seed quality and provides tables of historic seed bushel weights of several native range and pasture grass, forb and shrub species.

Nomenclature: USDA-NRCS (2010)

http://www.id.nrcs.usda.gov/programs/plant.html

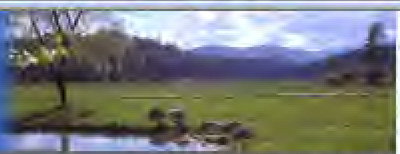
Idaho Plant Materials Program | Idaho NRCS

Page ▾ Tools ▾

United States Department of Agriculture

NRCS Natural Resources Conservation Service

Idaho



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- ontacts for Programs nd Technical esources
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- arm Bill
- rassland Reserve rogram (GRP)
- rganic EQIP
- ant Materials rogram
- esource onservation & evelopment (RC&D)

Plant Materials Program - Idaho and Utah

The National Plant Materials Program web site provides information on conservation plant materials.

Aberdeen Plant Materials Center Home Page

The Aberdeen (Idaho) Plant Materials Center tests and develops new varieties of grasses and shrubs for use in the Intermountain West. This site contains information about the Center, current studies and activities, plant releases, riparian and wetland tools, technical notes, and plant fact sheets.

Other PMC Home Pages

- Bridger, MT Plant Materials Center
- Los Lunas, NM Plant Materials Center
- Meeker, CO Environmental Plant Center
- Pullman, WA Plant Materials Center
- Tucson, AZ Plant Materials Center

TECHNICAL REFERENCES - PLANT RELEASE BROCHURES, TECHNICAL NOTES, PLANT GUIDES, RIPARIAN/WETLAND TOOLS AND WINDBREAKS

Agroforestry Notes

Plant Release Brochures - Aberdeen PMC and Others

Plant Materials Technical Notes - Idaho and Utah **Updated 3-1-11**

Local intranet | 100%

Loren St. John

PMC Team Leader

Aberdeen Plant Materials Center

P.O Box 296

Aberdeen, ID 83210

208-397-4133

loren.stjohn@id.usda.gov

Natural Resources Conservation Service

THE FORAGE AND RANGE RESEARCH LABORATORY

Forage and Range Research Laboratory

Is genetic change a factor in the consideration of local is best?

Jack E. Staub

FRRL

FRRL

PLANTS FOR THE WEST

Our Mission

Provide an array of improved plant materials and management alternatives for sustainable stewardship of rangelands and pastures in the western U.S.

Products provide materials and best management practices for improved client productivity.

What are you going to hear?

- ✓The mechanisms of genetic change
  - Why? Because they affect how we do business
- ✓An example of genetic change
  - Why? Change can be monitored to allow us to act
- ✓What makes populations change
  - Why? If we understand change, then we can act
- ✓Simulation of genetic change
  - Why? To allow us to see the consequences of actions

Genetic Shift vs. Genetic Drift

Genetic Shift (Selection)

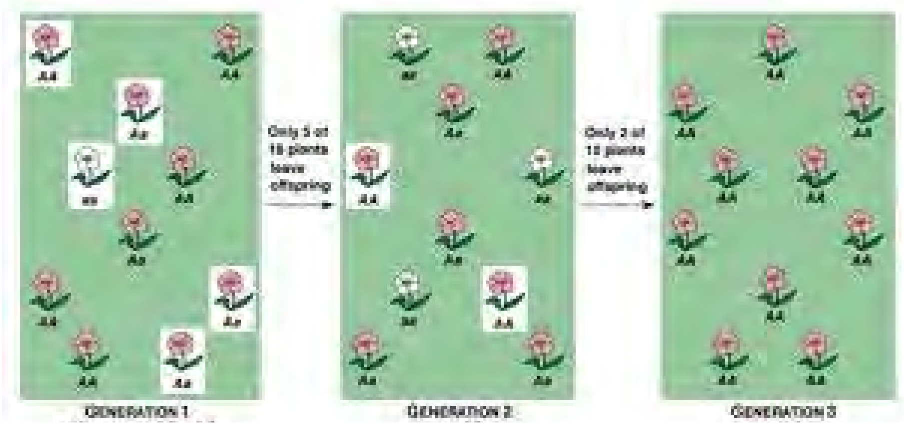
Can be an abrupt, major change in a population

[Black Death (1348-1350) and Influenza Pandemic (1918-1919)]

1) 30-60% Europe/450 M
2) 675,000 USA/20-40 M
3)

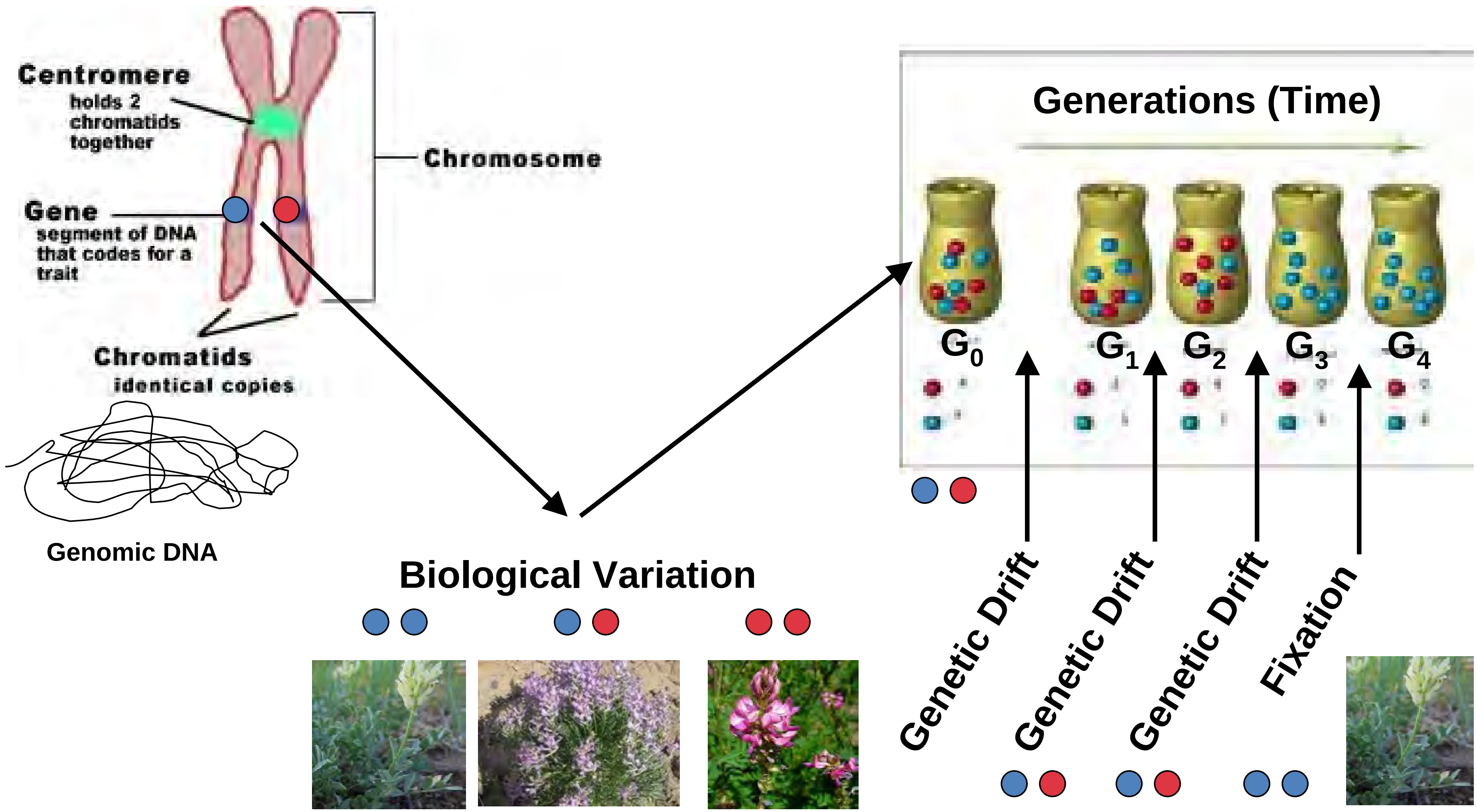
Genetic Drift (Random)

Ongoing, often subtle changes in a population



Utah Sweetvetch (*Hedysarum boreale*)

Simple Genetic Drift



Genetic Drift and Seed Production

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Plant Collection

Seed Production

Seed Warehousing

Biological Variation

Plant Breeding

Planting

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Genetic Drift and Change: An Example

Known Sources of Drift

Plant Collection

Seed Production

Plant Breeding

Seed Warehousing

Planting

Bushman et al. 2009

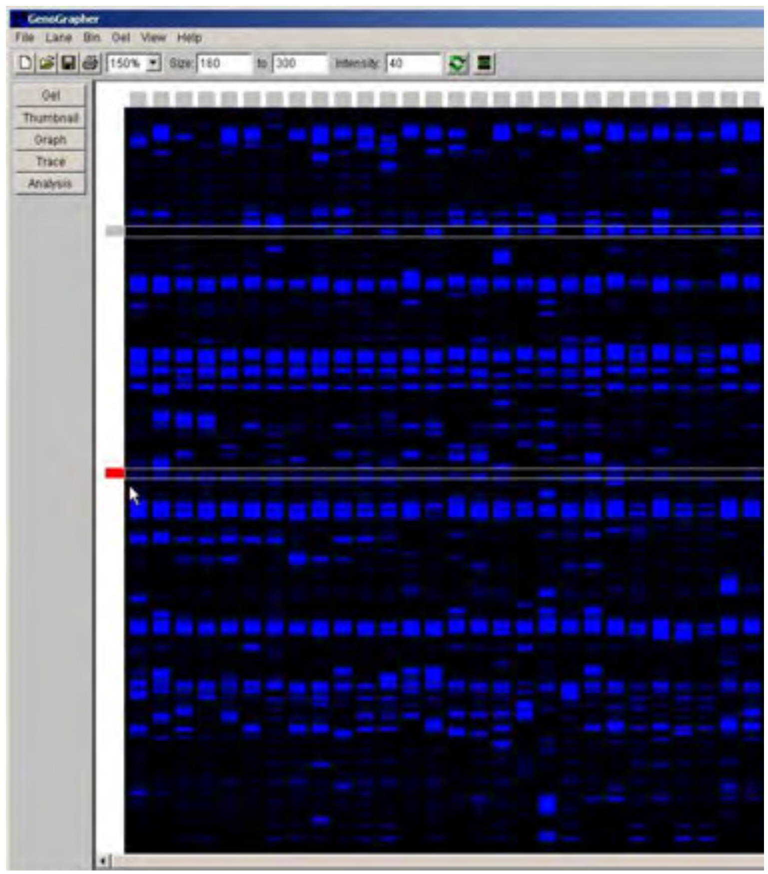
Location ID	N
Orem Water Tank	20
Dry Fork	20
south of Payson, Utah Co.	20
San Rafael Swell	20
Rabbit Gulch Starvation	20
12 mile canyon above Mayfield.	20
Nine Mile Lower	20
Echo Reservoir	20
Cutoff	20
Willow Creek	20
Escalante	19
Antelope Butte	20
Collected in Jefferson Co. CO.	6
Wasatch Front, Rita Jo Anthony, Wild Seed Inc.	13
Collected July 2000, Alaska. Ssp. mackenziei	19
Moose Lake, Custer Co., ID	20
0.5 mi N of Provo Canyon mouth, E of Orem.	19
variety non-specified	19
Nine Mile Lower H. occidentalis	20
Joes Valley Dam 2 of 4 H. occidentalis	4
Joes Valley H. occidentalis	20

18 *boreale*

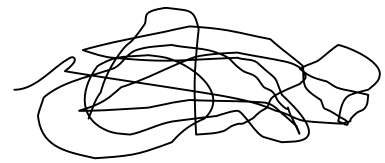
3 *occidentalis*

Genotyping of Collections

Biological Variation



Genomic DNA



AFLP data is recorded as the presence or absence of a band

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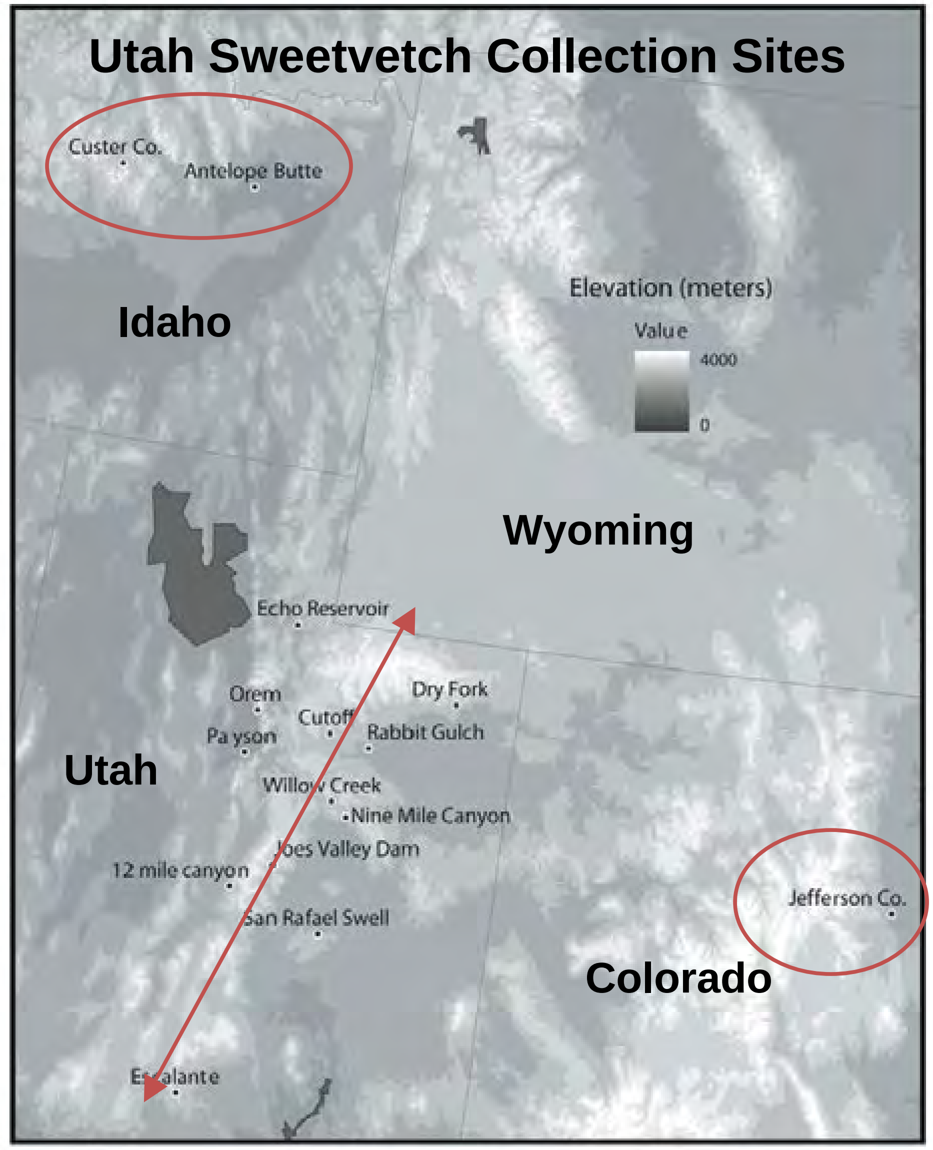
What can DNA bands tell you?

Total number of markers (bands available) = 1629

Location ID	N	Average Number of Bands / Population	Average Within-population similarity
Orem	20	387.00	0.825
Timpanogas	19	386.42	0.809
Dry Fork	20	381.70	0.789
Payson	20	374.90	0.839
San Rafael Swell	20	377.25	0.816
Rabbit Gulch	20	382.95	0.807
12 Mile Canyon	20	378.15	0.802
9 Mile Canyon	20	379.80	0.808
Echo Reservoir	20	386.95	0.819
Cutoff	20	378.85	0.791
Willow Creek	20	376.35	0.797
Escalante	18	374.67	0.838
Antelope Butte	19	360.58	0.871
Custer Co., ID	20	364.05	0.848
Jefferson Co., CO	6	362.67	0.828
Alaska	19	366.11	0.859
Wasatch Front	13	369.85	0.802
Variety not specified	19	374.89	0.814

Average number of bands per population = 375 (23% of total). Average within population similarity = 82%.



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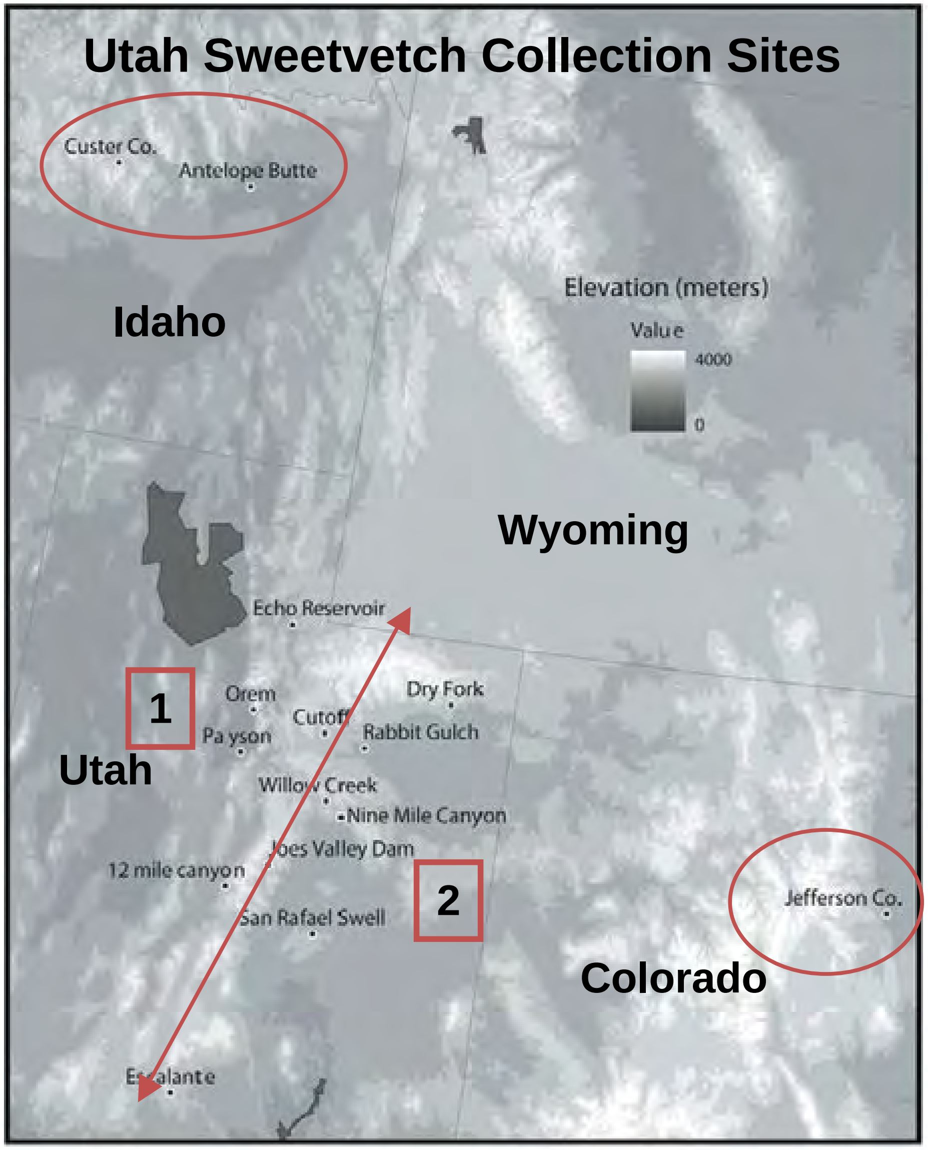
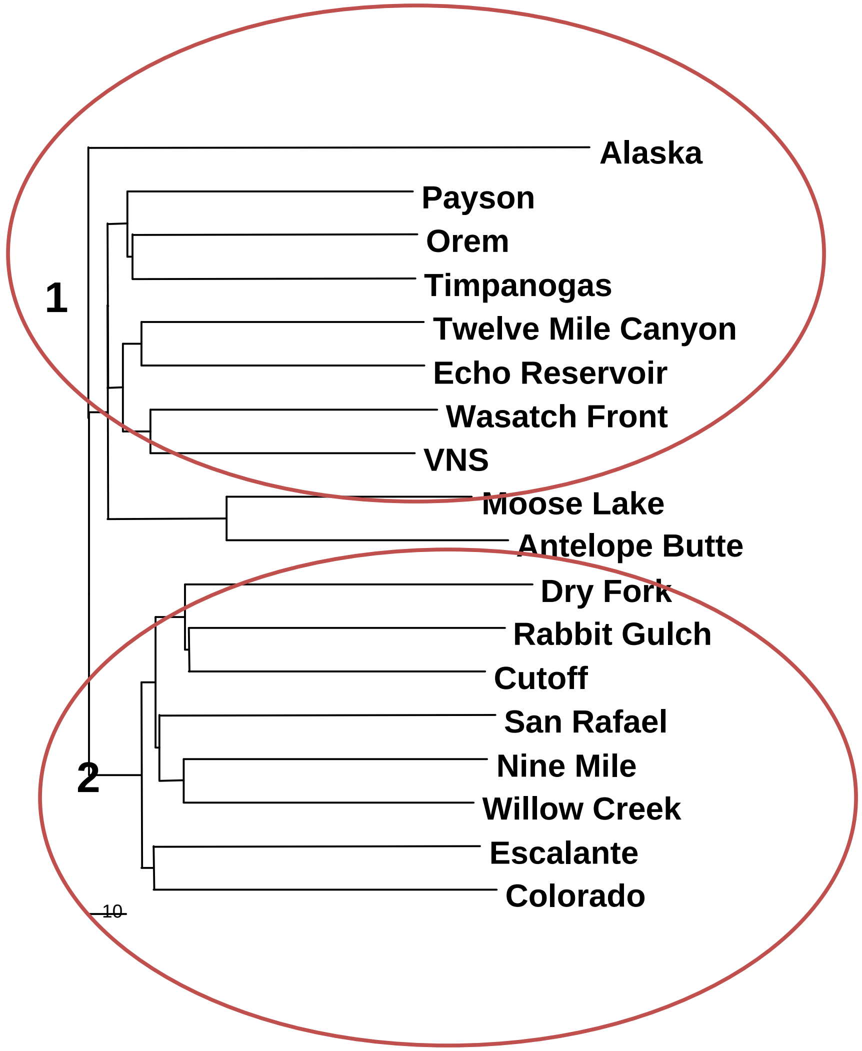
What can DNA bands tell you?





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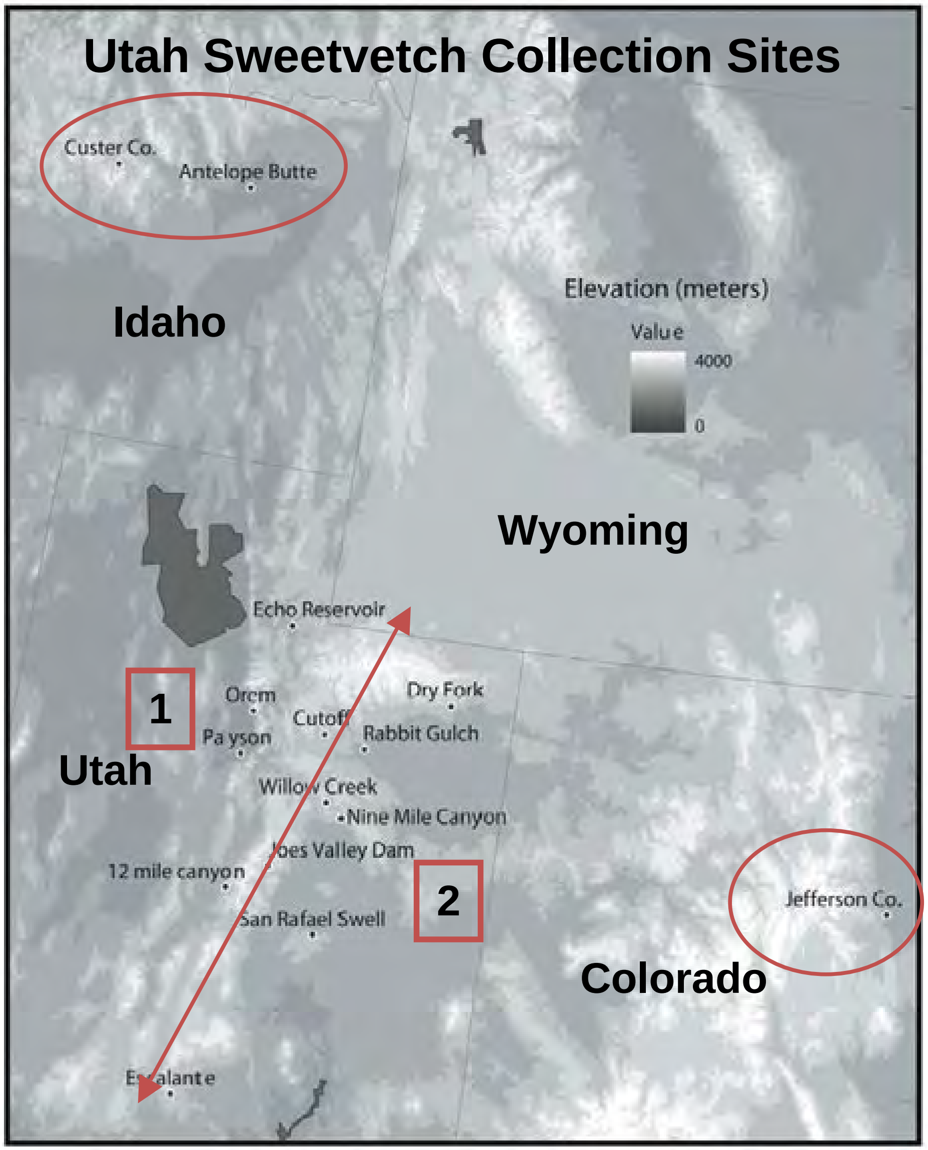
Genotype vs. Phenotype



Habitat is Important

Low Elevation & Water

High Elevation & Low Water

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What you see

		Average of Plant Height cm			Average of Vigor			Average of Seed Prduction		
		Mean	Standard Dev.	Range	Mean	Standard Dev.	Range	Mean	Standard Dev.	Range
Orem	1	42	13	8-68	3.7	1.2	1-5	1.6	1.2	0-5
12 mile canyon		40	11	15-59	3.4	1.1	1-6	2.1	1.6	0-5
Payson		42	9	19-58	4.0	1.1	1-5	1.8	1.4	0-5
T6"TIMP" T6		49	10	28-67	4.2	0.8	3-5	3.3	1.4	1-7
Echo Reservoir		39	10	22-59	4.0	0.8	2-5	2.3	1.2	0-4
Antelope Butte		44	12	25-73	3.5	1.1	2-5	2.5	1.1	1-4
San Rafael		52	14	18-75	3.0	1.1	1-5	1.5	0.8	0-3
Rabbit Gulch		42	9	17-55	3.3	0.7	2-4	0.8	0.6	0-2
Nine Mile Lower	2	34	8	20-51	2.8	0.9	1-4	1.1	1.0	0-3
Cutoff		37	8	21-53	3.1	0.8	2-4	0.9	0.8	0-3
Willow Creek		35	13	4-56	3.3	1.1	1-5	1.0	1.0	0-4
Dry Fork		44	10	23-68	4.3	1.5	1-6	2.8	1.8	0-5
Escalante		41	7	22-54	2.5	0.8	1-4	1.0	1.1	0-4

Height in cm **Subjective 1-5** **Subjective 1-5**

The ranges and standard deviations are large.

What you see and don't see

How Many Genes ?

High Elevation & Low Water

How Many Genes ?

Few Genes Big Effects

Environmental Effects

Changes in Population Structure

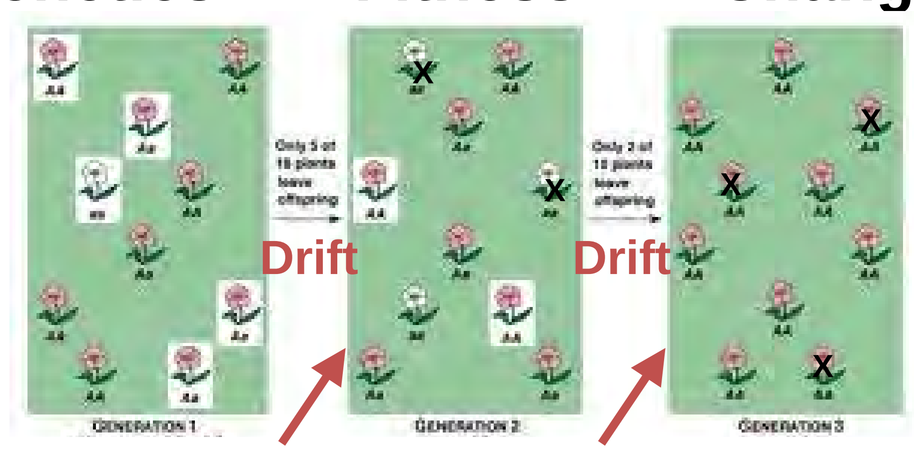
How do populations change?

Populations change due to fitness or genetic drift

- **Cause plant to plant variation**
- **Cause changes in genetic diversity**

Plants differ in fitness

- **Natural selection and Artificial selection**
  - **Environment + Genetics ---> Fitness ---> Change**



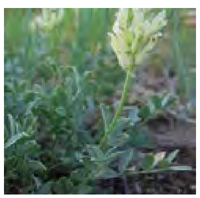
Changes in Population Structure

How do populations change?

Selection causes changes in populations

Selection and drift act to change

Selection and drift can change what you see



Using a knowledge of populations and expected change, population change can be simulated (modeled)

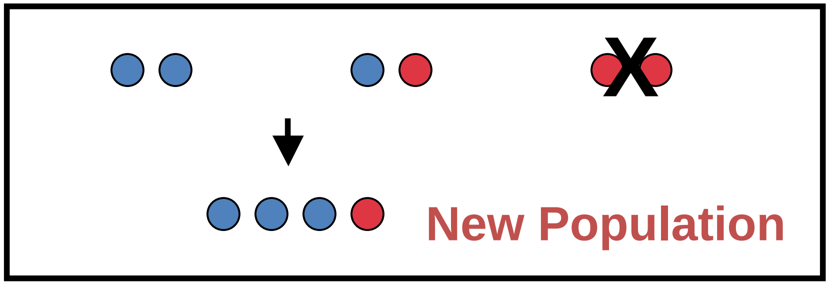
Simulations of genetic change

Factors involved with genetic change

Selection operates to change:

1) The rate of increase of a genotype

2) The probability of survival to reproductive age
3) The amount of off-spring produced
4) The rate of one genotype for another



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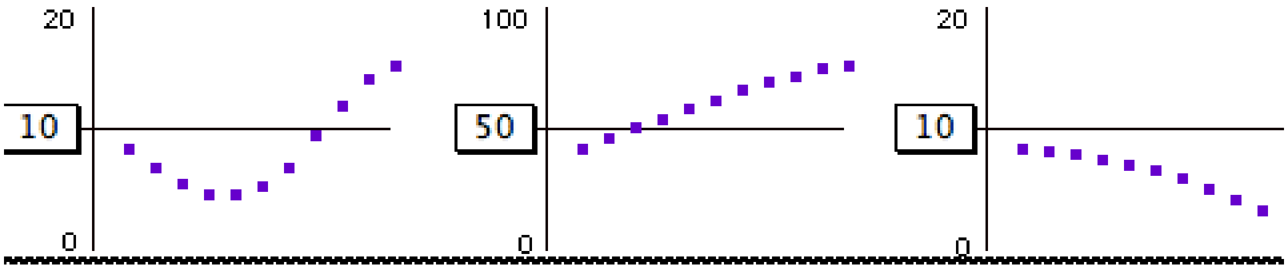
Simulation: Environmental Change

Genetic Drift and/or Selection

Population 1 | Population 2 | Population 3

Case 1

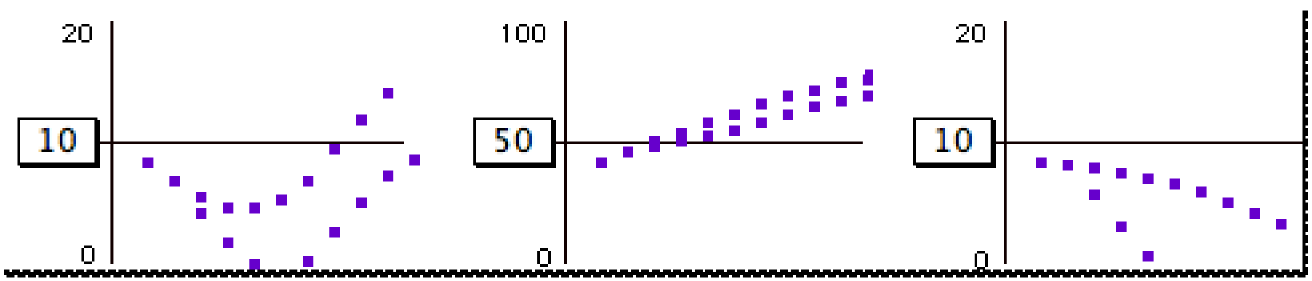


Individuals of a particular genotype **fluctuate**

Individuals of a particular genotype **increase**

Individuals of a particular genotype **decrease**

Case 2



Uniformly changing the probability of survival to a certain age in the early generations (5) and then allowing survival to be resumed at previous rate

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Conclusion:
Genetic drift and selection can cause changes

Plant Collection

→

Drift & Selection

Seed Production

→

Drift & Selection

Seed Warehousing

↓

Biological Variation

→

Drift & Selection ↑

Plant Breeding

Drift & Selection ↓

Planting

Colorado Plant Materials Program

Christine Taliga
Plant Materials Specialist
Colorado NRCS

USDA NRCS

United States Department of Agriculture
Natural Resources Conservation Service

Plant Materials Program…..

We <u>select plants and develop plant technology</u> for the successful conservation of our nation's natural resources.

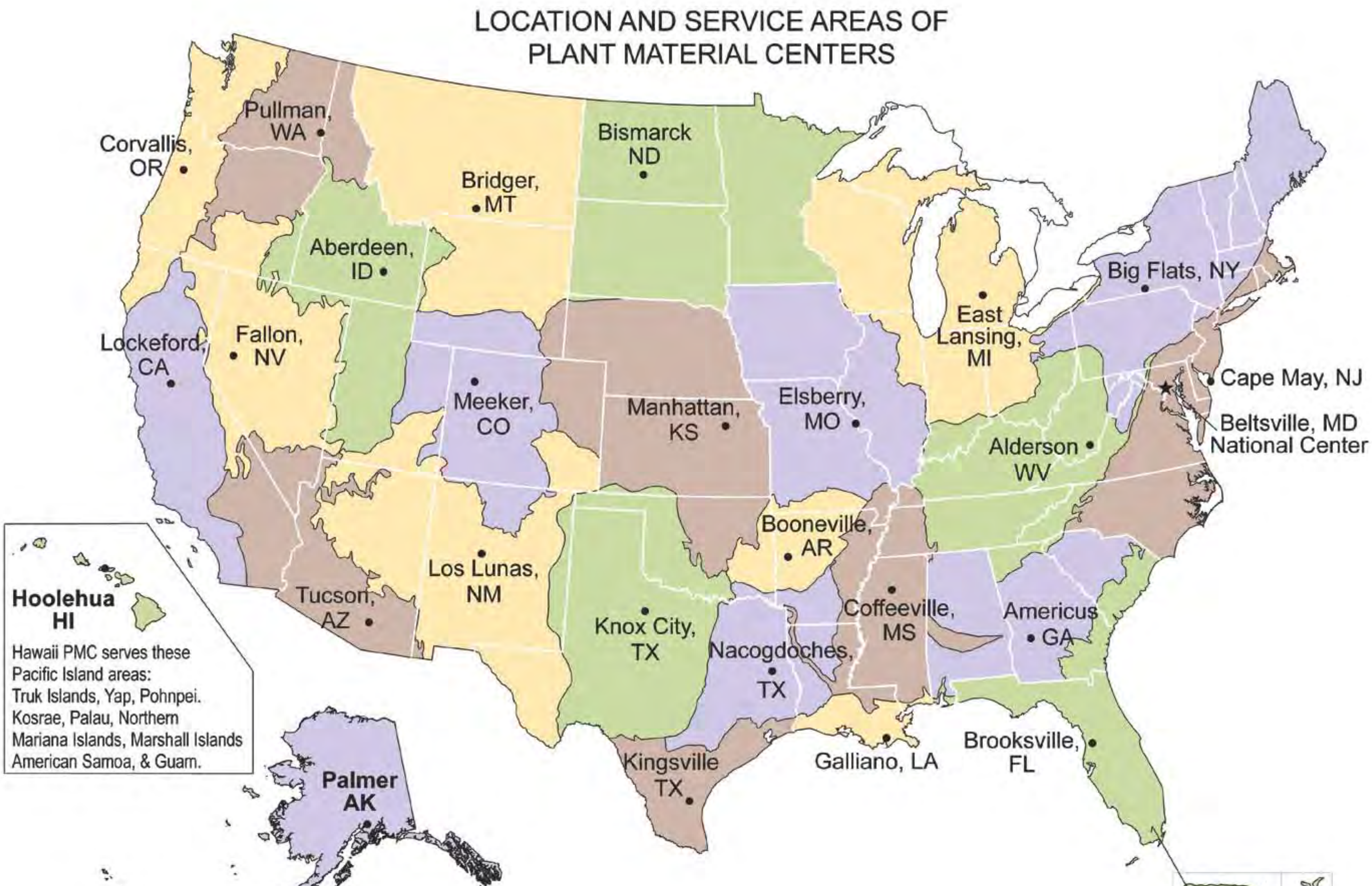
Plant Materials Program Purpose

- Assemble, test, and release conservation plant materials.
- Determine techniques for use and management of plants.
- Facilitate the commercial increase of plants.
- Transfer of plant science technology to solve conservation problems.

Species are chosen NOT based on the species BUT to solve resource conservation problems.

Example…to replace an invasive exotic …

Service Areas of the Plant Materials Centers



Colorado Plant Materials

Technology Transfer

among Centers & NRCS Field Offices & On the Job Training

Feedback from the field

- Lack of available native forbs
- Establishment techniques
- **Competitors for invasive species**

Where to Start?

- What do we know and understand about the modern day North American landscape
- Plant Ecology and Plant Communities Principles
- How can we apply these principals in addressing the needs of our field offices?

A disturbance evolved human influenced landscape…..

It is clear that North America's landscape owes much of its Holocene vegetational development and aboriginal biodiversity to choices that human cultures made locally to sustain a diverse array of biological resources for food, shelter, tools, clothing, medicine, and representations of beauty and art. These views most recently have been articulated by Mann (2002).

"But Native Americans had three powerful technologies: fire, the ability to work wood into useful objects, and the bow and arrow. …There is ample evidence that Native Americans greatly changed the character of the landscape with fire, and that they had major effects on the abundances of some wildlife species through their hunting." Botkin, Daniel B. 1990.

A disturbance evolved human influenced landscape…..

- Dust bowl

A disturbance evolved human influenced landscape…..

- The advent of agriculture
- 100 fire prevention

Our Historic Approach

- Focus on the desired state (target community)

Disturbance

Late seral perennials & shrubs

Restoration of Plant Communities is difficult…

- Costly
- Difficult
  - Weather
  - Seeding Method
  - Seeds
  - Species Mixes

Our tendency

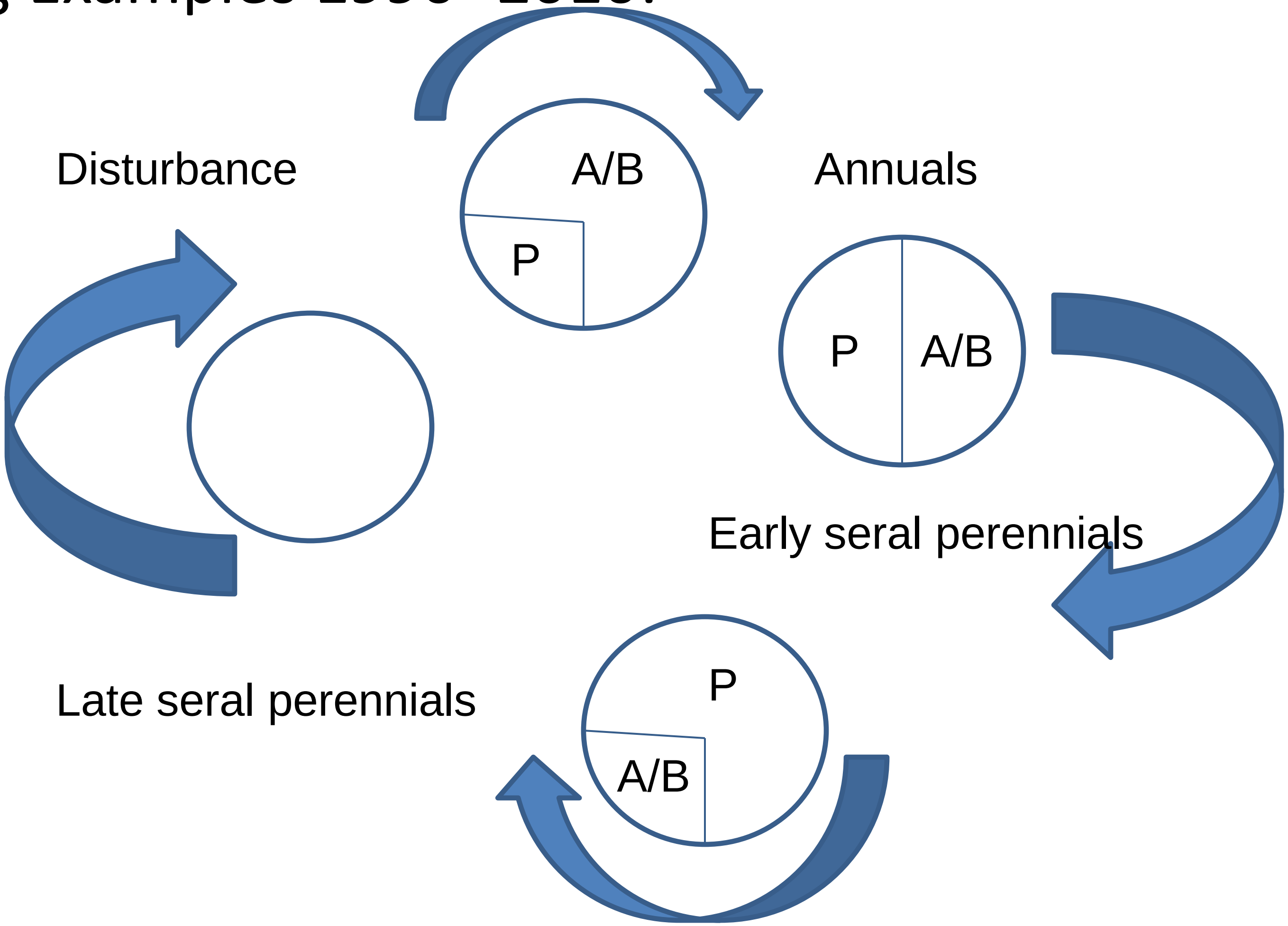
- Focus on the desired state (target community) at times ignoring or lack of understanding....

- Ecological plant community processes?

"We will now discuss in a little more detail the Struggle for Existence."
…..Charles Darwin

Ecological Cycles & Landscape History

Monitoring Examples 1990- 2010:



What is currently in our toolbox

"Everything should be made as simple as possible, but not simpler."

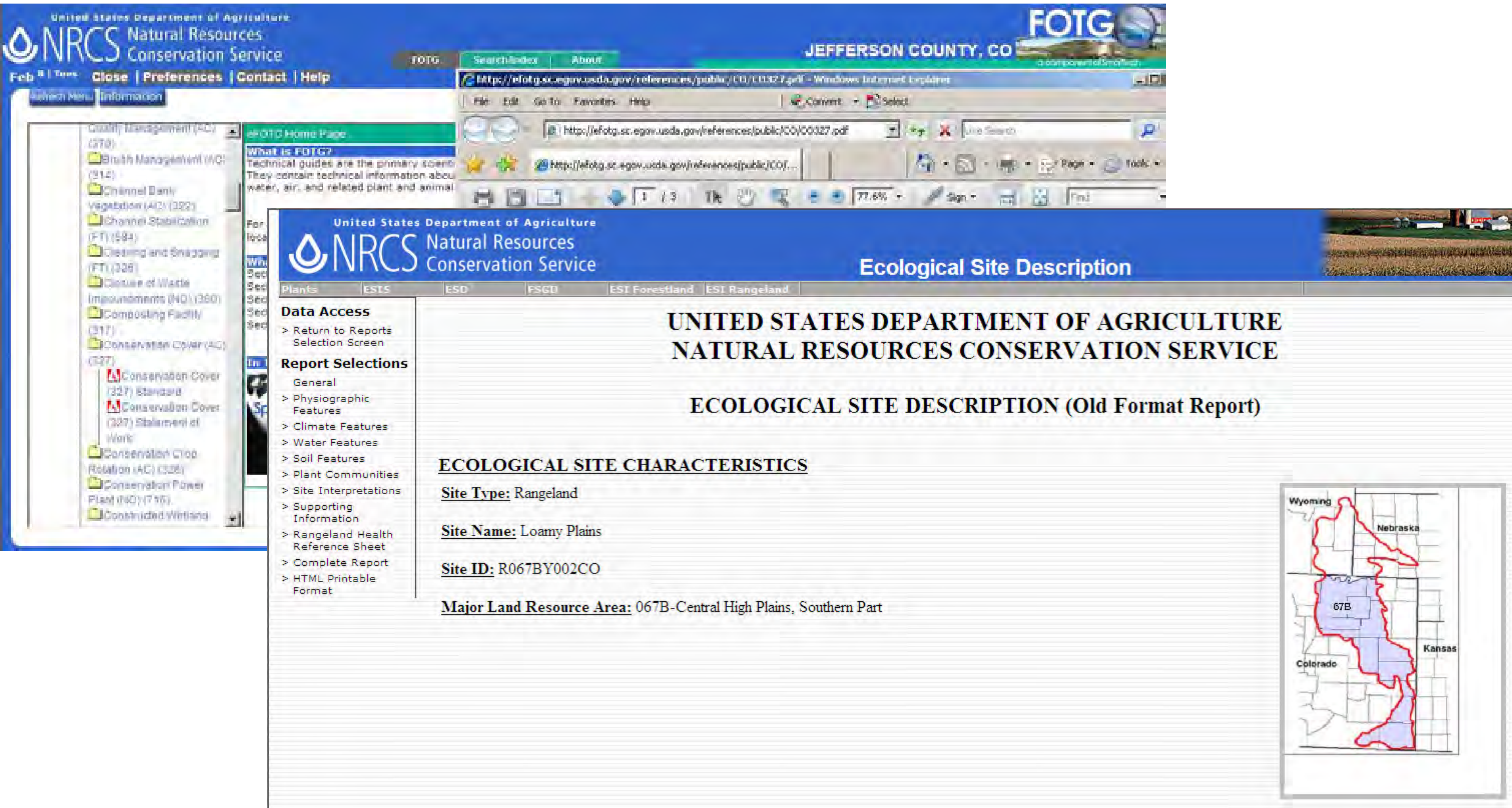
Albert Einstein

What is currently in our toolbox

Colorado Plant Materials Technical Note No. 59 (revised) Seeding Rates

Table 5. Graminoid, Forb and Shrub Seeding Rates for Conservation Plantings within Colorado

Genus species (common name - Cultivar)	Notes		Seeds per pound (1,000s)	Seeds per square foot per pound planted per acre	Solid Stand Seeding Rates 1) pounds PLS (pure live seed) per acre					
					Irrigated		Nonirrigated		Critical, Riparian, Grassed Waterways	
					drill	broadcast	drill	broadcast	drill	broadcast
Achillea millefolium occidentalis (*western yarrow*)	NF	2)	2,790	64.0	drill 0.05 or broadcast 0.1 pounds PLS per acre with grass mixture					
Achnatherum hymenoides (Indian ricegrass - Nezpar, Rimrock)	NCB	2) 4) 5)	235.0	5.4	8.0	16.0	4.0	8.0	8.0	16.0
Achnatherum hymenoides (Indian ricegrass - Paloma)	NCB	2) 4) 5)	140.0	3.2	12.0	24.0	6.0	12.0	12.0	24.0
Agropyron cristatum X *desertorum* (crested wheatgrass - Hycrest)	ICB	2)	302.0	6.9	6.0	12.0	3.0	6.0	6.0	12.0
Agropyron cristatum (crested wheatgrass - Ephraim)	ICB	2)	302.0	6.9	6.0	12.0	3.0	6.0	6.0	12.0
Agropyron desertorum (crested wheatgrass - Nordan)	ICB	2)	190.0	4.4	10.0	20.0	5.0	10.0	10.0	20.0



United States Department of Agriculture
NRCS Natural Resources Conservation Service
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Ecological Site Description
Data Access
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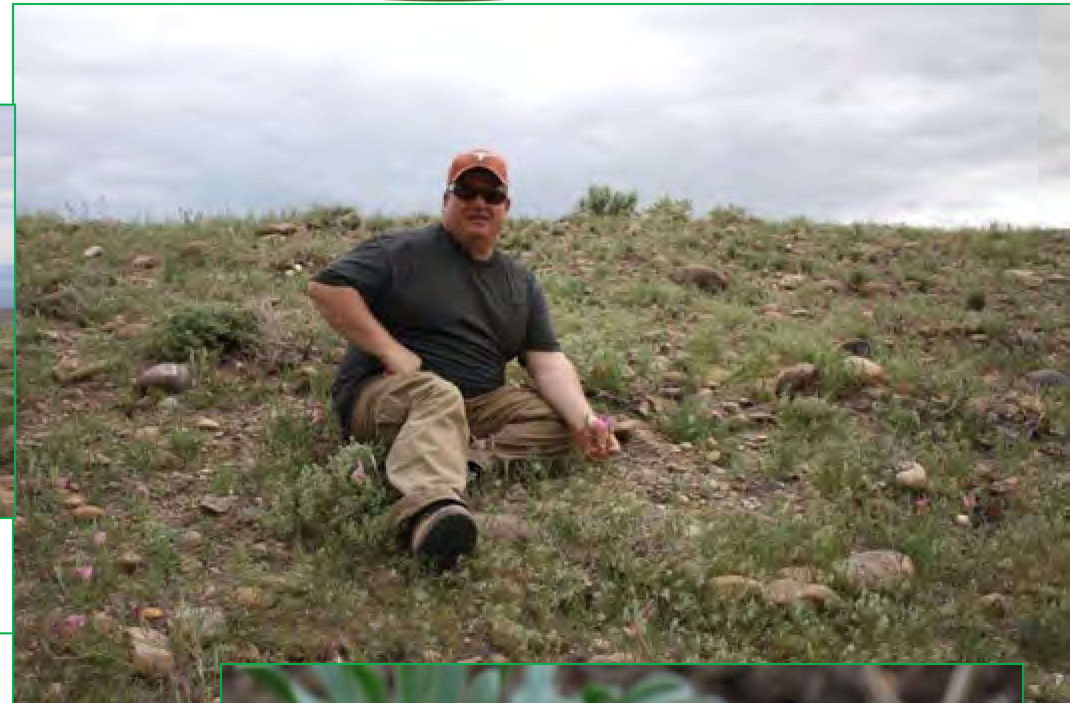
General
> Physiographic Features
> Climate Features
> Water Features
> Soil Features
> Plant Communities
> Site Interpretations
> Supporting Information
> Rangeland Health Reference Sheet
> Complete Report
> HTML Printable Format
UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
ECOLOGICAL SITE DESCRIPTION (Old Format Report)
ECOLOGICAL SITE CHARACTERISTICS
Site Type: Rangeland
Site Name: Loamy Plains
Site ID: R067BY002CO
Major Land Resource Area: 067B-Central High Plains, Southern Part
Wyoming
Nebraska
67B
Kansas
Colorado

Do our recommendations reflect target historic plant communities?

- ❖Grasses perhaps 1 or 2 annuals
- ❖Forbs perhaps 1 or 2 annuals
- ❖Sedges
- ❖Shrubs
- ❖Vines
- ❖Trees
- ❖What about the cryptogams?
- ❖What could the implications of whole scale exclusion of groups of the native flora mean to native rangeland restoration and weed invasion?

Roosevelt, Utah



Larimer County, Colorado

Arapaho National Forest

Erigeron formosissimus var. *viscidus*
Potentilla gracilis var. *pulcherrima*
Sambucus racemosa var. *microbotrys*
Heterotheca fulcrata
Castilleja sulphurea
Poa secunda
Festuca brachyphylla var. *coloradensis*
Castilleja miniata var. *miniata*
Thermopsis montana var. *divaricarpa*
Viburnum edule
Eremogone fendleri
Vaccinium myrtillus var. *oreophilum*
Packera fendleri
Solidago simplex var. *simplex*
Zigadenus elegans
Cymopterus lemmonii
Campanula rotundifolia
Arctostaphylos uva-ursi
Cirsium clavatum var. *americanum*
Juncus arcticus var. *balticus*
Pinus flexilis
Juniperus communis var. *depressa*
Pinus contorta var. *latifolia*
Boechera stricta
Oryzopsis asperifolia
Drymocallis fissa
Phleum pratense var. *pratense*
Heracleum maximum
Calamagrostis canadensis var. *canadensis*
Moneses uniflora
Elymus trachycaulus var. *trachycaulus*
Conioselinum scopulorum
Picea engelmannii var. *engelmannii*

Geranium richardsonii
Oxypolis fendleri
Osmorhiza depauperata
Mitella pentandra
Pyrola asarifolia var. *asarifolia*
Populus tremuloides
Epilobium saximontanum
Carex disperma
Mertensia ciliata var. *ciliata*
Achnatherum nelsonii ssp. *nelsonii*
Platanthera purpurascens
Aconitum columbianum ssp. *columbianum*
Saxifraga odontoloma
Alnus incana var. *occidentalis*
Lonicera involucrata var. *involucrata*
Equisetum arvense
Luzula parviflora
Symphyotrichum foliaceum var. *canbyi*
Galium boreale
Sedum rhodanthum
Achillea millefolium
Geum rivale
Stellaria longifolia
Trifolium hybridum
Conioselinum scopulorum
Dasiphora fruticosa
Swertia perennis
Orthilia secunda
Cardamine cordifolia var. *cordifolia*
Senecio triangularis
Carex microptera var. *microptera*
Veronica americana
Mimulus guttatus

Baca County SE Colorado

801 Taxa noted from the Comanche National Grassland In southeastern Colorado

The significant problems we have cannot be solved at the same level of thinking with which we created them.

Albert Einstein

Are we falling into this pattern when we are in direct combat with invasive species?

What are the growing requirements of Native and Non-native Vegetation?

- **Natives**
  - **Tolerate and thrive in low N situations**
  - **Late seral state vegetation particularly forbs need certain soil microrhizae fauna in order to establish (many orchids, Lithospermum, …)**
  - **Some native annuals are necessary for the correct soil microrhizal interactions in order for some species of sage brush to establish**
  - **Some native species influence species composition**

- **Non-Natives**
  - **Tolerate and thrive in high N situations**
  - **Soil disturbances increase available N by removing resident vegetation, reducing N uptake or altering N cycling. Removing invasive species chemically or mechanically, may provide temporary control, but is unlikely to limit reinvasion while N availability remains high. Disturbance associated with chemical or mechanical control may even increase N availability, facilitating reinvasion.**
  - **In some areas repeated burning may be an affordable tool to lower N availability. Fire may cause an initial flush of inorganic N , repeated fires can lower soil N availability in many grasslands (Ojima eta al 1994).**

Potential Native Species for Mitigating Fire and Weed Invasion

Considerations from the components of Colorado's flora

- 506 introduced species (USDA Plants Database)
- 2685 native plant species (133 species endemic to Colorado, Colorado Heritage Program)
- 1929 native forbs (393 annuals)
- 415 graminoids (378 perennial 36 annual)
- 275 shrubs
- 25 tree species
- 39 vines

  (7 annual vines 32 perennial vines)

Annuals… stigma?

- ❖Many native annuals unfortunately have the name "weed"
- ❖For many native annual and biannual forbs (also gramenoids) the pre-settlement range and extent is not well known nor documented as many have been extripated out of much of the native rangeland. Therefore the native annual seedbank in many cases has been eliminated.

Characteristics of annuals/biennials

- Easy to establish
- Abundant seed producers
- Tasty to herbivores
- Their job is to move or colonize when the opportunity presents itself!

Impacts on Plant Community Assembly

- Soil primers for mycorrhizae (arbuscular mycorrhizal fungi AMF)
- Soil stabilizers
- Higher N tolerance
- Facilitation of regeneration of post-disturbance plant communities
- Adverse effect on non-native annuals
- Ecosystem function and interaction (plants continually interact and compete for space)

A disturbance evolved human influenced landscape continues…..

- Re-introduction of prescribed fire
- Wildfire
- Wildlife
- Development
- Conservation easement programs

We select plants and develop plant technology for the successful conservation of our nation’s natural resources.

What’s our role in conservation, plant community restoration, plant materials development, rangeland restoration.
Not for every conservation application
…..
Perhaps for some????

http://www.nwf.org/News-and-Magazines/National-Wildlife/Gardening/Archives/2010/Native-Plants-for-Pollinators.aspx

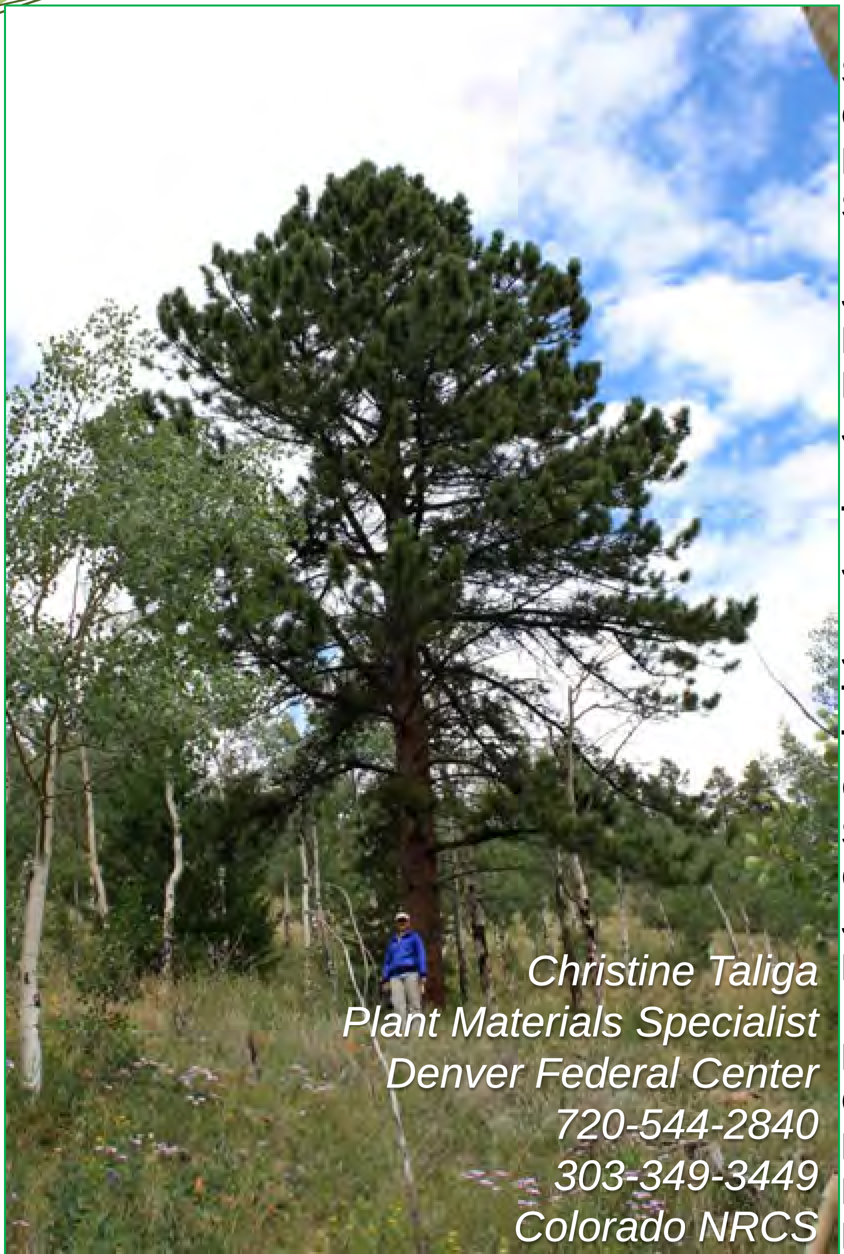
Potential Applications

- Agronomic applications – one on one combat -no
- Long-term easement programs (WRP)
- Restoration Projects (WHIP)
- Post-Fire (EWP Emergency Watershed Programs)

FO Application?

- Demonstrations
- Field Trials
- Seed Collections
- Partnerships

Thank You!



Steve Parr, Upper Colorado Environmental Plant Center
Greg Fenchel, NRCS Los Lunas Plant Center
Loren St. John, NRCS Aberdeen Plant Center
Susan Winslow, NRCS Bridger Plant Center

Jim Briggs, NRCS Regional Plant Materials Specialist
Pat Davey, NRCS Vegetation Specialist NPS
Dan Ogle, NRCS Plant Materials Specialist
Jim Jacobs, NRCS Plant Materials Specialist

Tom Jones, ARS Logan Utah
Jack Staub, ARS Logan Utah

Jim Spencer, NRCS Biologist, Roosevelt Utah
Terri Sage, NRCS Biologist, Denver, Colorado
Tim Steffens, NRCS Range Conservationist, Baca County, Colorado
Sylvia Hickenlooper, Don Graffis, NRCS Longmont Field Office
John Fusaro, NRCS, Fort Collins Field Office
Rachel Murph, NRCS, State Range Conservationist Denver

Mark Paschke, Colorado State University
Claire De Leo, Boulder County
David Anderson, Colorado Heritage Program
Dina Clark , Denver Botanic Garden
Ron Hartman and Ernie Nelson, Rocky Mountain Herbarium

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Investigations of Wetland Seed Establishment

Derek Tilley
Aberdeen Plant Materials Center

NRCS
Natural Resources Conservation Service

The Problems

1. Germination requirements
   - Light
   - Heat
   - Moisture

2. Seeds float
   - Can't drill
   - Can't broadcast

Seed cost per pound of common Intermountain wetland species (2010)	
Carex nebrascensis	$90
Carex rostrata	$150
Eleocharis palustris	$100
Juncus balticus	$125
Juncus ensifolius	$200
Schoenoplectus acutus	$70

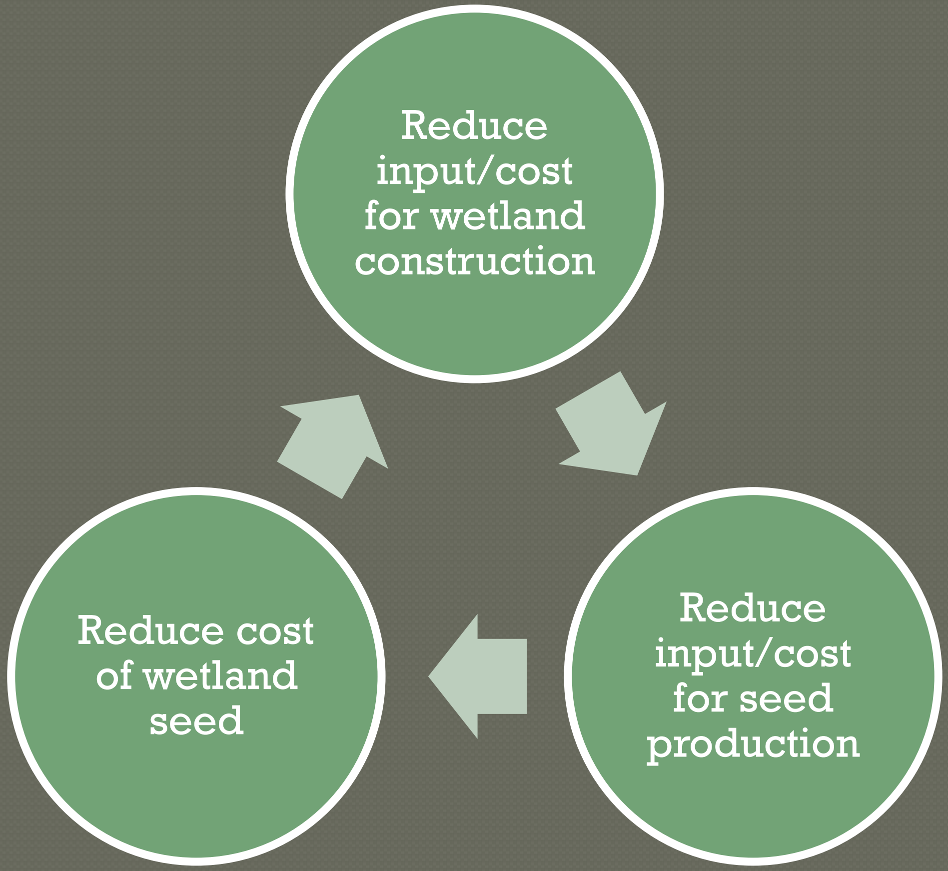
The Standard

•10 ci greenhouse grown plants
•planted at 12-18” spacing
•approximately 25 PLS per cell

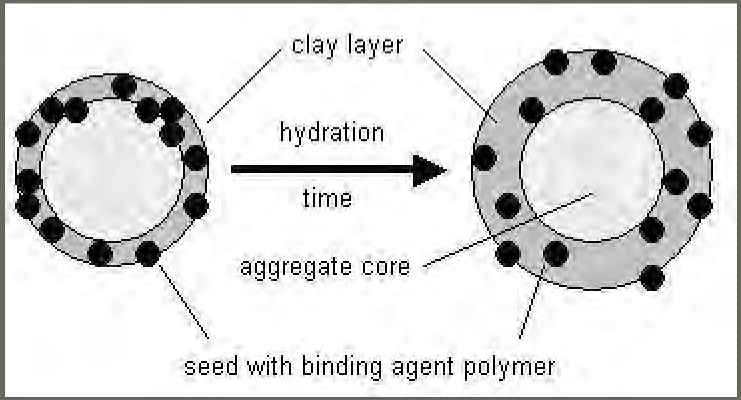
For one acre that amounts to 19,000 plants from approximately 500,000 seeds.

Estimated cost for greenhouse plug production including delivery and installation is $2.00 per plant or $38,720/ac (2007).


The Goal: Develop a technique for direct seeding of wetland grass-like species



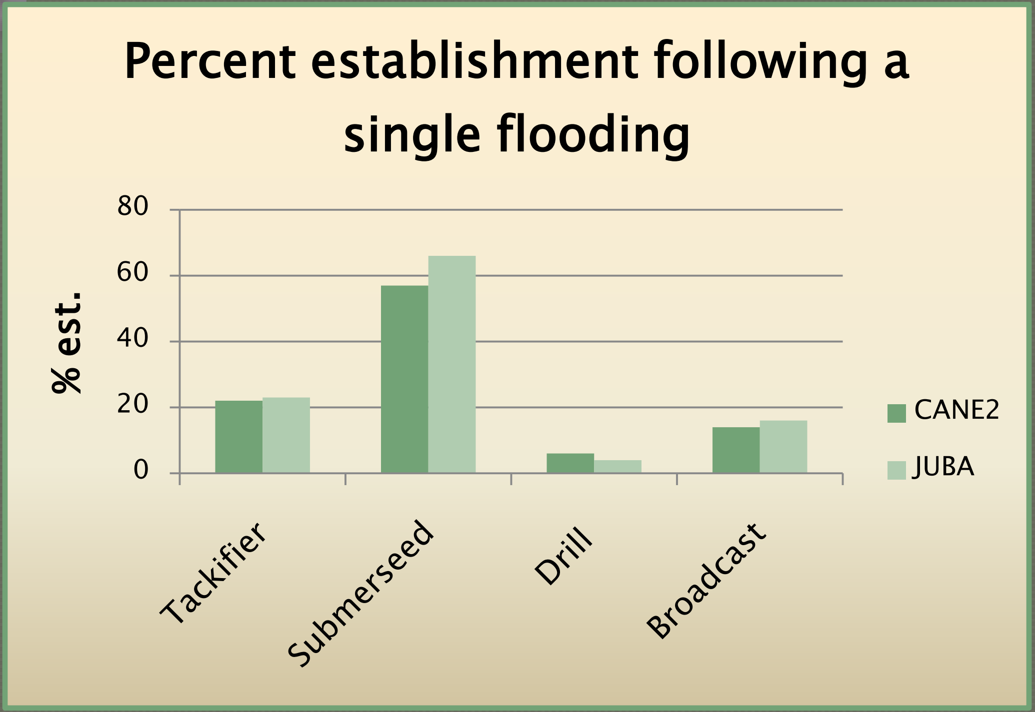
Submerseed®



clay layer
hydration
time
aggregate core
seed with binding agent polymer

2005 Submerseed Initial Evaluation

Carex nebrascensis
Juncus balticus



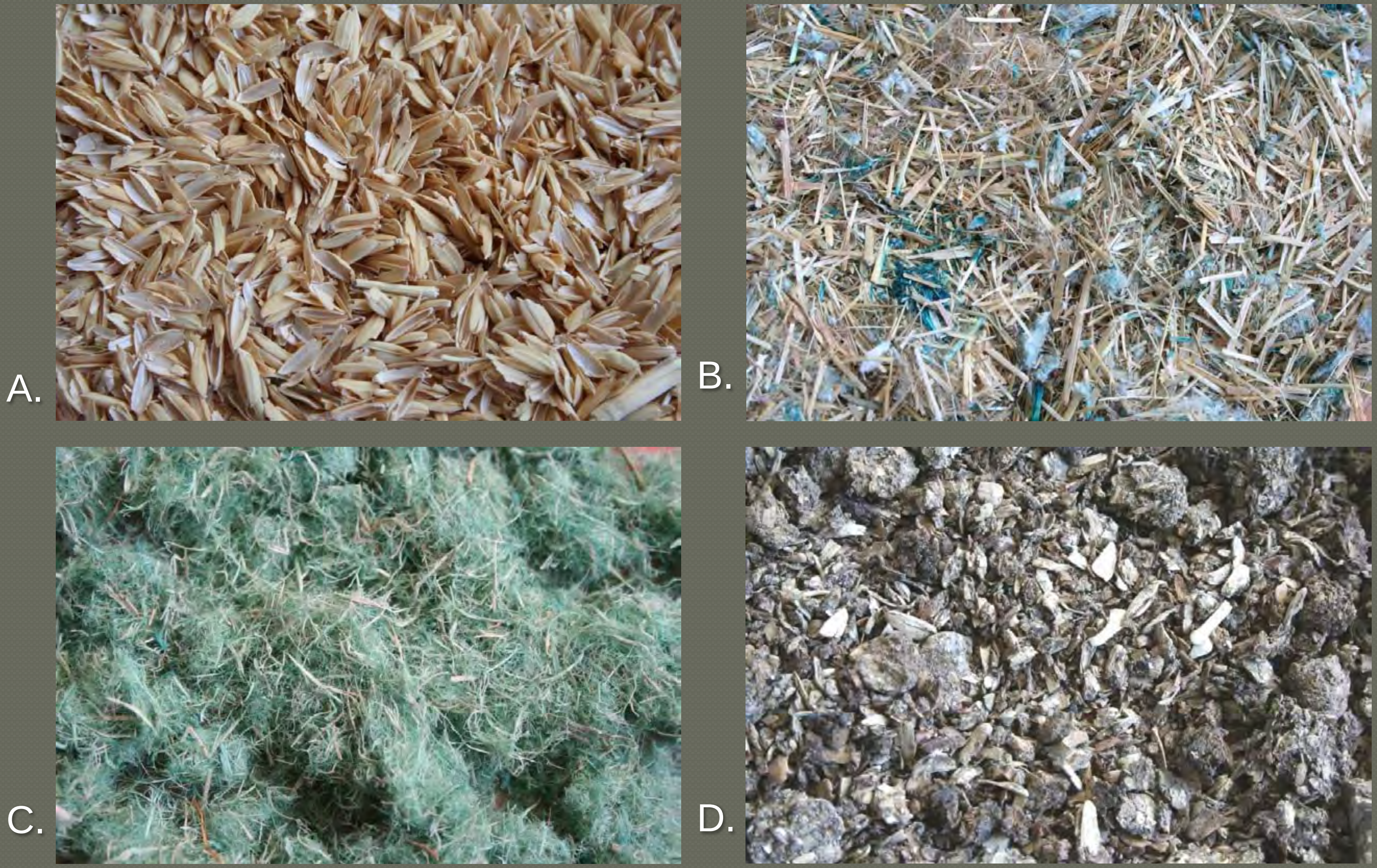
4 Treatments

1. **Hydroseeding tackifier**
2. **Submerseed**
3. **Drill (0.25 in)**
4. **Broadcast (surface)**

CANE2 185 PLS/ft; JUBA 770 PLS/ft
Flood & wash over
Temps 100-110 F

Submerseed Field Evaluation

Inert Carriers and Hydroseeding

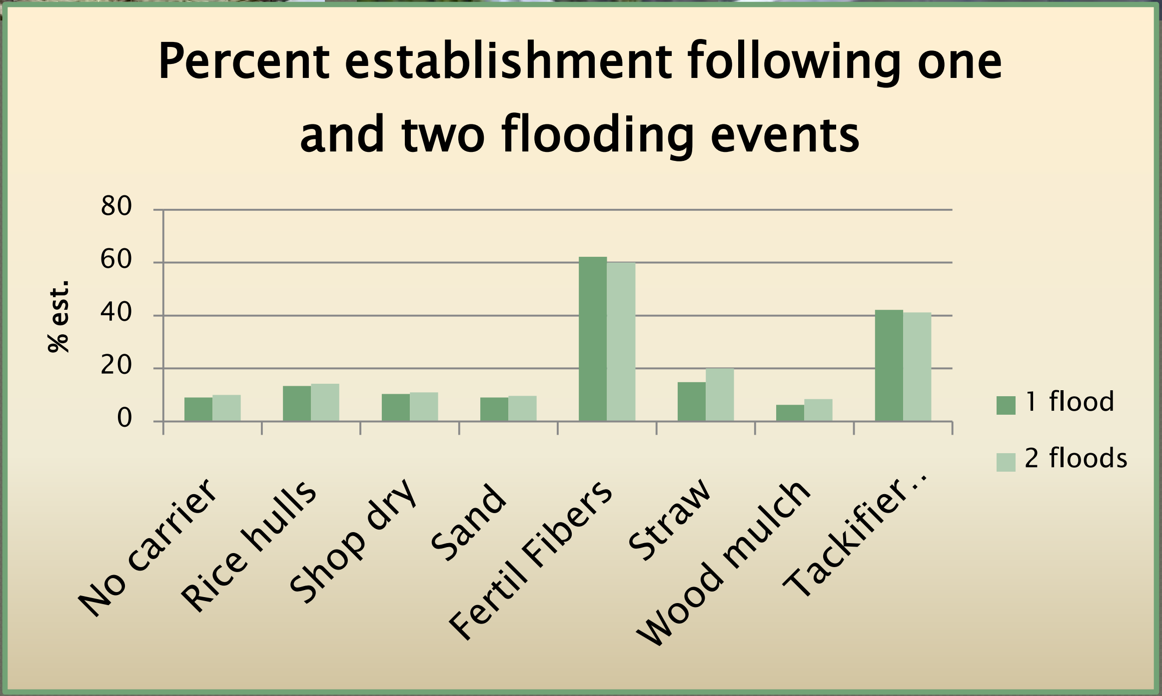


A. Rice hulls, B. Straw mulch, C. Wood fiber mulch , D. Fertil Fibers

Hydromulch Initial Evaluation 2006

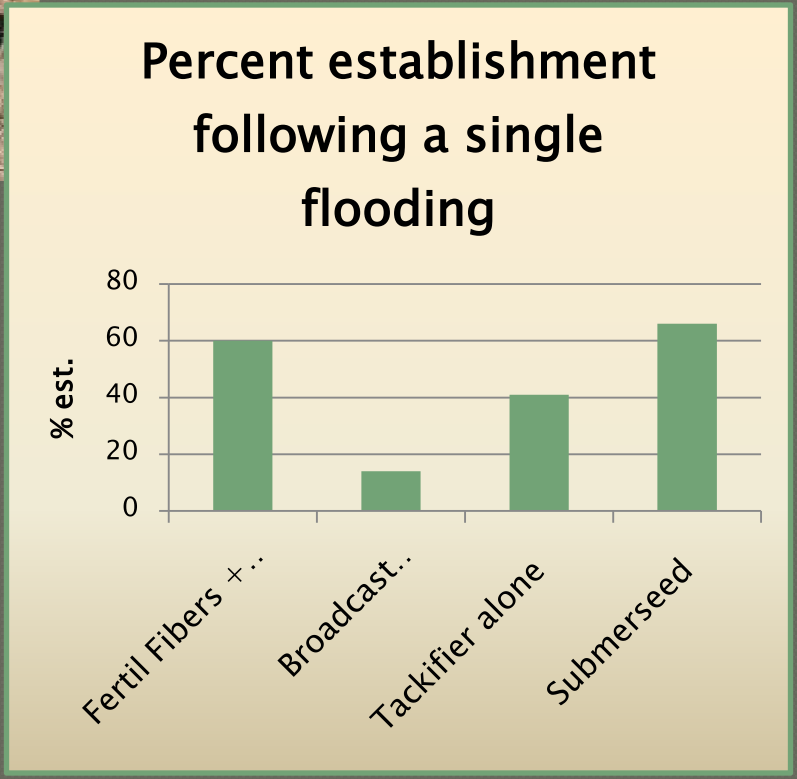
JUBA

- **FF, Straw and wood mulch with tackifier**
- **Other treatments broadcast dry + pressed**



Juncus 07 Outdoor Tank Evaluation

100 PLS/ft²



Expanded outdoor trial (2008)

- Submerseed
- Fertil Fibers hydro
- Straw mulch hydro
- Broadcast (ricehulls) followed by lawn roller

- 100 PLS/ft²

Results= 0

Temp?
Moisture?

Have to find a way to better control temps and hydrology, and create correct environment.

CAPMC Pollinator Hedgerow 2009

- •Temperature buffer
- •Increased soil and surface moisture
- •Up to 80% light penetration
- •Protection from birds

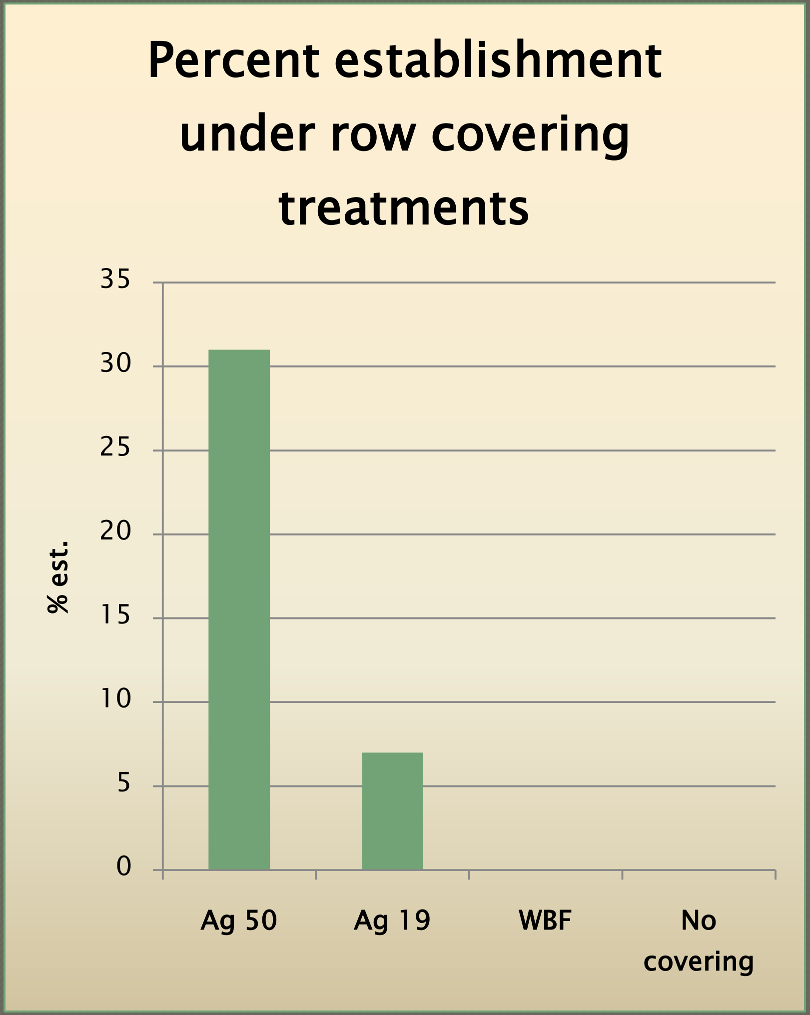
Floating Row Cover for sedge establishment

Treatments

1. Ag 19
2. Ag50
3. WBF
4. No cover

- Plots: 6x8’
- Irrigated with micro-spray emitters

Carex praegracilis, a CA wet meadow sedge



Ag 50- 31%

Ag 19- 7%

Floating Row Cover, 2010 with flood irrigation

- Planted 7/17
1000PLS/m²

- CANE2 and JUBA
- Ag19
- Ag50
- Non-covered Control

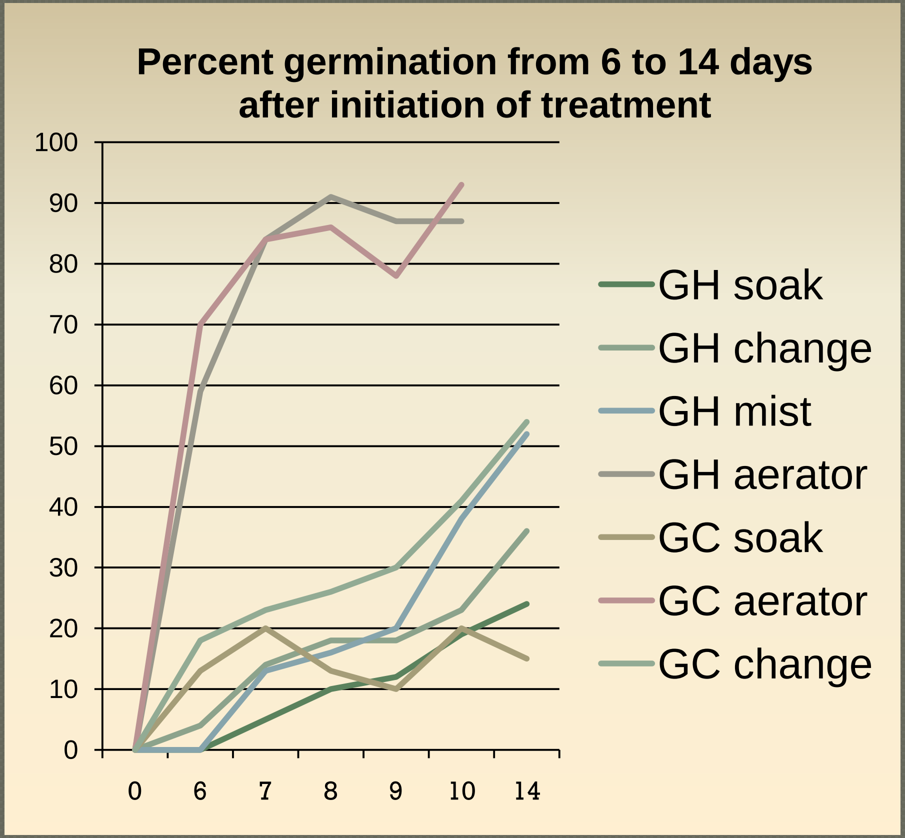
- Covered 4 wks or 8 wks

CANE2 Ag19 4wk:
5 plants/m² (0.44%)

Pre-germinated Seed

Can you germinate the seed, and then sow it into a wetland?

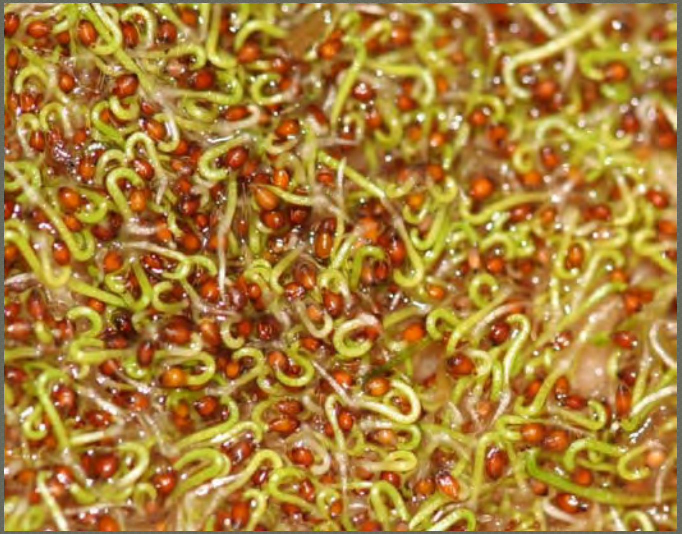
Nebraska Sedge



GH=greenhouse conditions
GC=Growth chamber

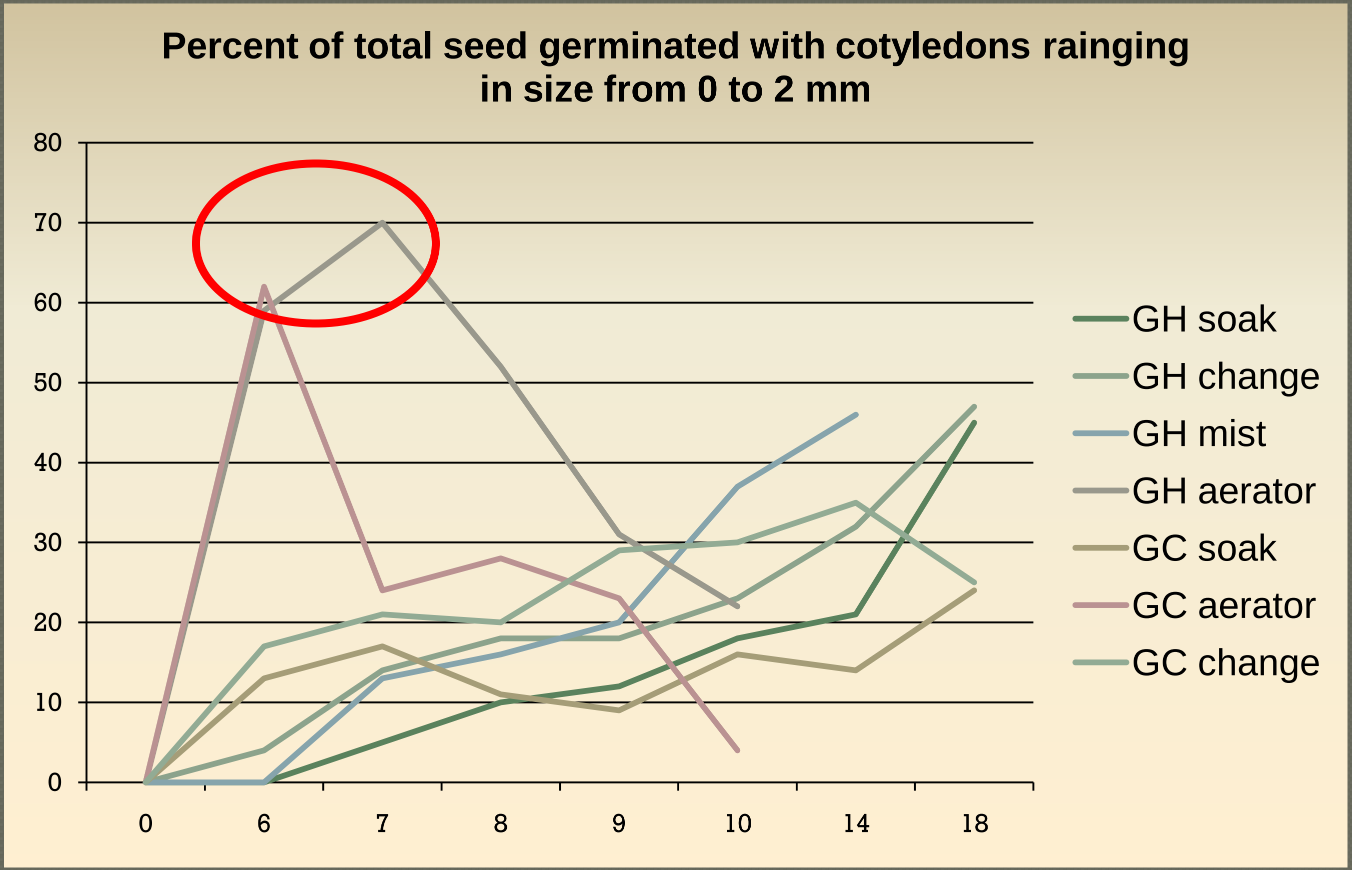
Nebraska sedge germination rate and total percent germination after 10 days.			
Treatment		Germination rate[1]	Germination (10 DAI)[2]
			---%---
GC aerator		13.10 a	93 a
GH aerator		12.90 a	87 a
GC change		4.24 b	41 b
GH mist		2.47 c	38 b
GH change		2.21 c	23 c
GC soak		2.49 c	20 c
GH soak		1.30 d	19 c
P=		<0.001	<0.001
LSD (0.05)		0.83	9.8

Nebraska sedge



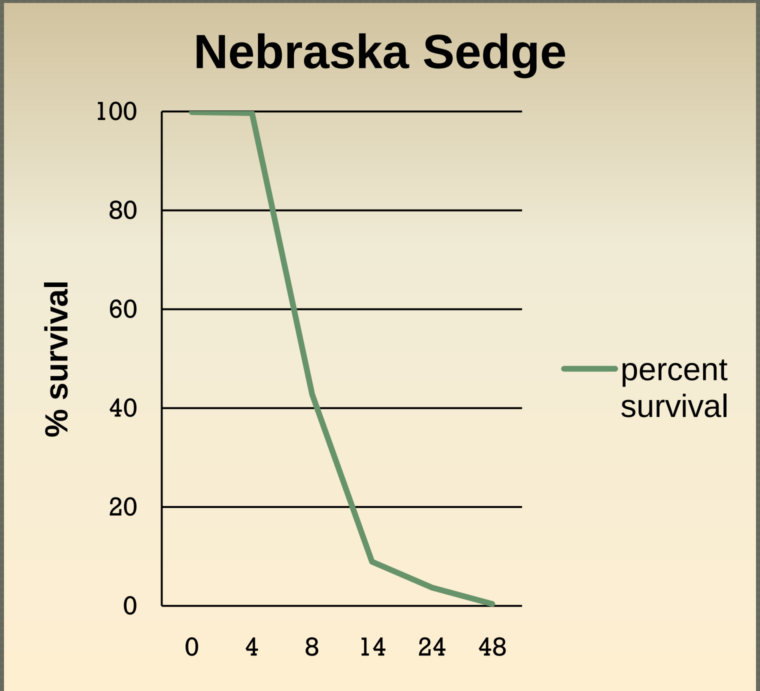
Baltic rush

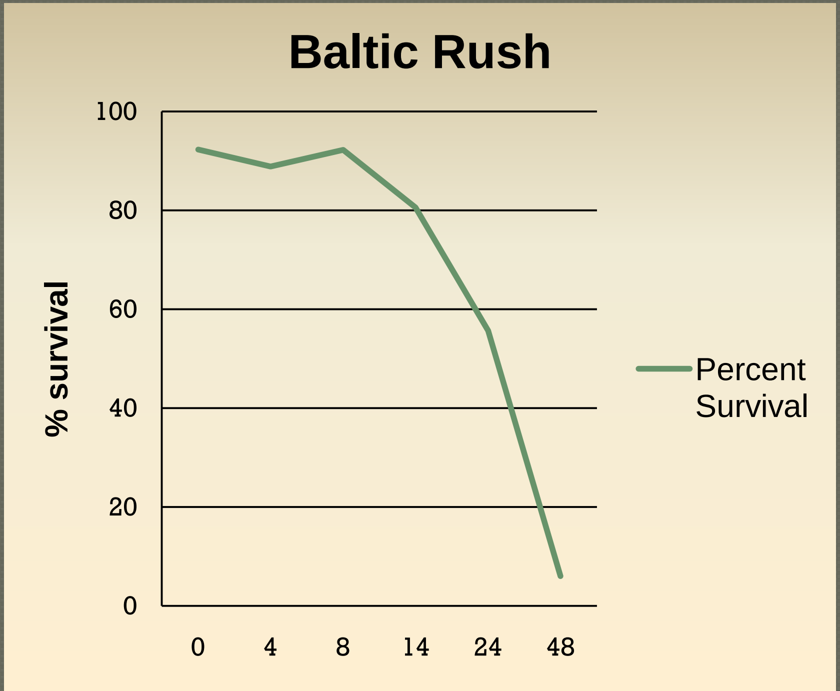
Developing Pre-germination Protocols



Can our wetland species be dried and broadcast like rice?

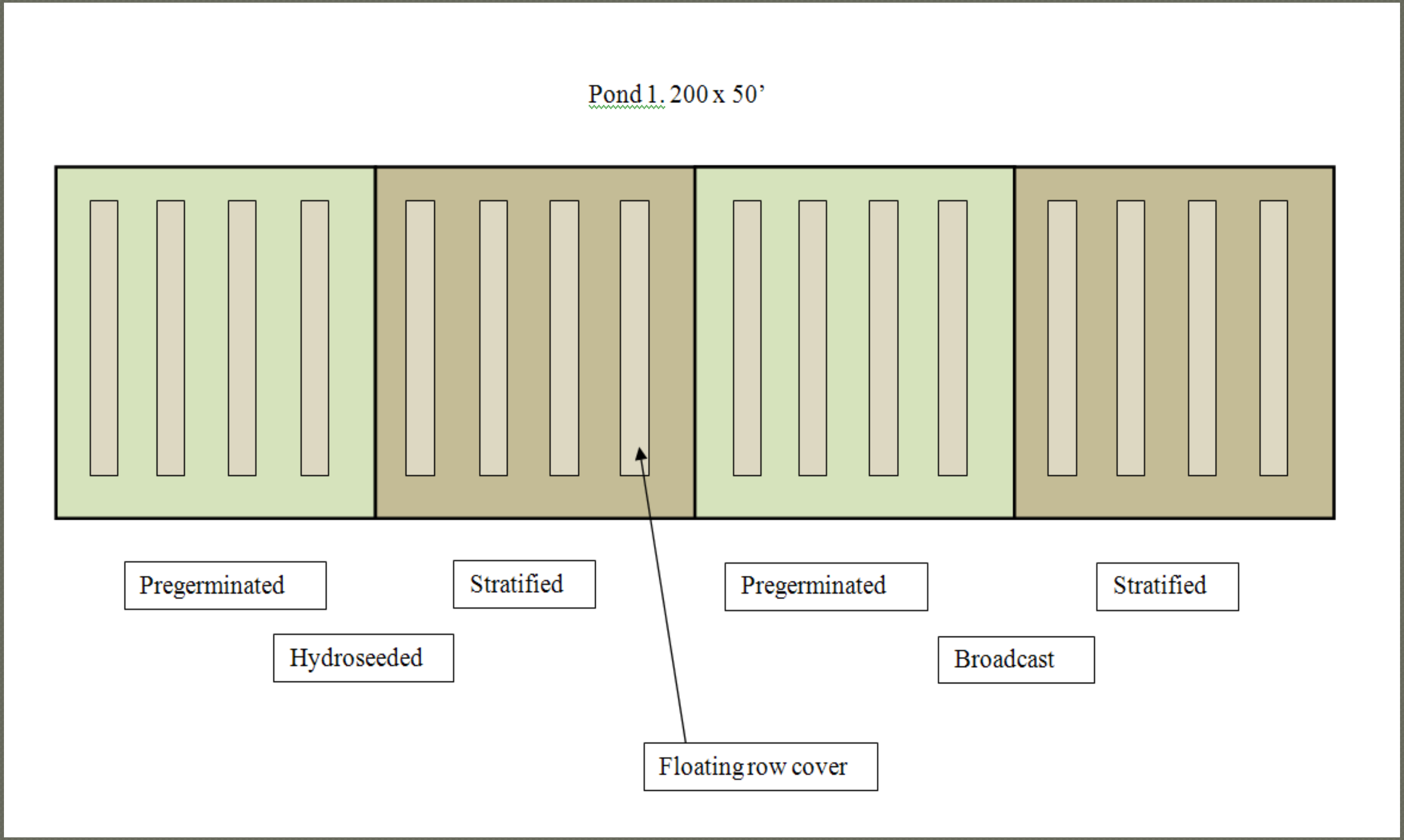
percent survival after drying following a 7d aerated pre-germ





Needs to be dry enough that it doesn’t stick to equipment or other seed

2011 NPS Project Design



2 ponds, 1 is slurried, 1 is traditionally prepped

Cost breakdown for establishing constructed wetlands*

	GH plugs (18" spacing)	Broadcast	Hydroseed (FF)	Hydroseed (tackifier alone)	Submerseed	Row Cover
Seed ($150/lb) @ 0.2 lb/ac	$10	$30	$30	$30	$30	$30
Shipping	included	na	$440	na	included	$100
Carrier	na	Rice hulls $ negligible	Fertil fibers $670	na	SS	Rice hulls $ negligible
Tackifier	na	na	$60	$60	na	na
Equipment needed	na	Spreader Imprinter	Hydroseeder $200	Hydroseeder $200	Spreader, ATV	Fabric $700 Staples $100
Labor @$20/hr	included	8=$160	8=$160	8=$160	8=$160	8=$160
Total	$40,000 (includes installation)	$200	$1,560	$520	$1,000-8,000	$1,100

***Costs do not reflect bed preparation**

Aberdeen Plant Materials Center
P.O. Box 296/ 1691 A South 2700 West
Aberdeen, ID 83210-0296

Telephone: 208.397.4133
FAX: 208.397.3104