Adapted Germplasm for the Great Basin: Tapertip Onion, Indian Ricegrass, Bluebunch Wheatgrass and Friends

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Other Cooperators

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- **USDA-ARS:** Tom Jones, Blair Waldron
- **BLM:** Scott Lambert, Mary Byrne

Adapted Germplasm for the Great Basin:

Steps:

1. Complete broad germplasm collections across the Basin
2. Establish plants from diverse collection locations in common gardens
3. Evaluate adaptive morphological and phenological diversity of collected germplasm
4. Determine if and to what extent genetic diversity varies across the landscape
5. Build regression models linking genetic traits and environmental factors; determine seed adaptation zones
6. Report results; presentations and publications

Why is this approach important?

Population from one area may be poorly adapted to other areas resulting in unsuccessful revegetation

Casler at al. 2007 Crop Sci. 47:2249
…Adaptation of Switchgrass Populations…

“Switchgrass populations for use in biomass production, conservation, or restoration should not be moved more than one hardiness zone north or south from their origin, but some can be moved east or west of their original ecoregion, if results from field test support broad longitudinal adaptation.”

Benefits

Many key native species have not been adequately collected and conserved within the National Plant Germplasm System. This is urgent needed in light of climate change and disturbances associated with exotic weeds and frequent fire.

Adaptation zones may be large, small, critical or minimally important. But without that information, land managers can not make informed decisions concerning what germplasm is best for revegetation

With knowledge of how genetic and environmental factors interact, science based *in situ* conservation sites can be established to compliment to *ex situ* conservation

Adapted Germplasm for the Great Basin:

Species under study with GBNPSIP support:

- ***Allium acuminatum*, Tapertip onion**
- ***Pseudoroegneria spicata*, Bluebunch wheatgrass**
- ***Achnatherum hymenoides*, *Indian ricegrass***

And friends (support through BLM & USFS):

- ***Bromus carinatus*, *Mountain Brome***
- ***Poa secunda*, Sandberg bluegrass**

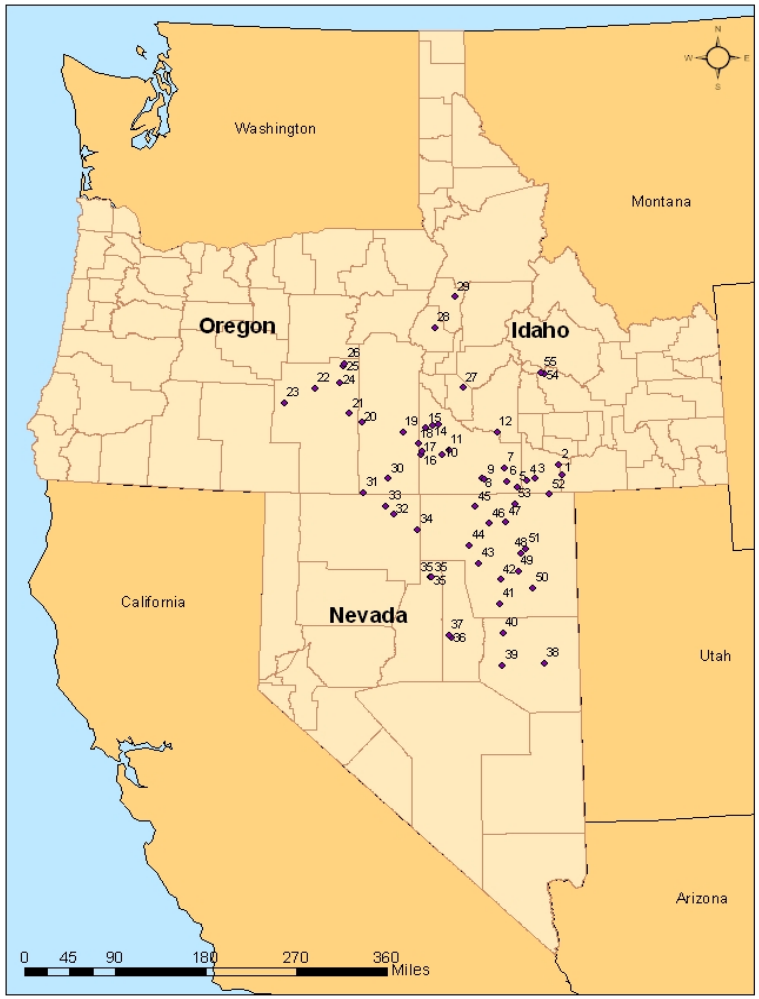
Allium acuminatum, Tapertip onion

Common and important Great Basin species associated with healthy rangeland and good habitat for sage grouse

Progress:

- ✓**Germplasm collection**
- ✓**Common gardens established**
- ✓**Evaluation of morphological and phenological diversity**
- ❖**Analysis of genetic diversity**
- ❑**Determine seed adaptation zones**
- ❖**Report results; presentation and publications**

Allium acuminatum (Taper-tip onion) collection, spring 2005



Twenty Level 4 Ecoregions	Collectionn sites
Semiarid Hills and Low Mountains	1
Southern Forested Mtns/Dry Partly Wooded Mtns	1
Mountain Home Uplands	1
Southern Forested Mountains	1
Pluvial Lake Basins	1
High Desert Wetlands	1
Continental Zone Foothills	1
Unwooded Alkaline Foothills	1
Semiarid Foothills	1
High Glacial Drift-Filled Valleys	1
Central Nevada Mid-Slope Woodland and Brushland	1
Central Nevada High Valleys	1
Carbonate Woodland Zone	2
Carbonate Sagebrush Valleys	2
Mid-Elevation Ruby Mountains	3
Semiarid Uplands	4
High Lava Plains	5
Upper Humboldt Plains	6
Owyhee Uplands and Canyons	8
Dissected High Lava Plateau	13

Collection essentials:

Plants, lunch, people

A. acuminatum field evaluation at Pullman and Central Ferry sites

ANOVA summary from *A. acuminatum* common gardens in 2007 at Central Ferry & Pullman WA

Trait	CV	Mean	P (site)	P (Loc)	P (site x Loc)
Leaf color (1-9)	13.1	3.02	0.085	0.005	0.010
Leaf habit (1-9)	8.25	7.26	<0.001	<0.001	0.154
Leaf width (mm)	17.8	2.65	0.001	<0.001	0.907
Leaf length (mm)	14.3	127	0.712	<0.001	0.222
Leaves plant^{-1}	20.9	2.55	0.244	<0.001	0.286
Bolting day	2.65	107	<0.001	<0.001	0.0782
Flowering day	1.46	147	<0.001	<0.001	0.298
Flower color (1-9)	17.0	7.11	0.024	<0.001	0.194
Flowers umbel^{-1}	31.1	28.6	0.006	0.018	0.856
Umbel dia. (mm)	17.1	52.4	0.840	0.005	0.027
Scape dia. (mm)	18.4	2.58	0.004	<0.001	0.652
Scape length (mm)	16.0	150	0.870	<0.001	0.464
Seed maturity day	1.74	175	<0.001	<0.001	0.059
Seeds plant^{-1}	37.6	65.4	<0.001	<0.001	0.558

Linear correlations between tapertip onion traits measured in 2007 and collection location environmental factors (n=55).

Traits	Lat.	Long.	Elev.	Slope	Aspect	Max. temp.	Min. temp.	Precip.
Bolting	ns	ns	0.46**	ns	ns	-0.50**	-0.56**	0.31*
Leaf color	ns	ns	ns	0.27*	ns	ns	ns	ns
Leaf habit	ns	ns	ns	-0.37**	-0.30*	ns	ns	ns
Leaf length	ns	ns	ns	ns	ns	ns	ns	ns
Leaf width	-0.31*	ns	0.26*	ns	ns	ns	ns	ns
Leaf number	0.28*	ns	ns	ns	ns	-0.35**	ns	0.54**
Flowering	ns	ns	ns	ns	ns	-0.28*	-0.34**	ns
Flower color	-0.36**	ns	0.32*	ns	ns	ns	ns	ns
Flowers/umbel	ns	ns	ns	ns	ns	ns	ns	ns
Umbel dia.	ns	ns	ns	ns	ns	ns	ns	ns
Scape dia.	ns	ns	0.29*	ns	ns	ns	ns	ns
Scape length	ns	ns	ns	ns	ns	ns	ns	ns
Seed maturity	ns	ns	ns	ns	ns	ns	ns	ns
Seeds/plant	ns	ns	ns	ns	ns	-0.28*	-0.30*	0.42**

*,**,ns, Significant at P<0.05, P<0.01, and not significant, respectively.

Summary for *A. acuminatum (*Tapertip onion)

- Collection location effects were strong showing genetic variation among across the Great Basin.
- Correlation of basic environmental factors with traits showed numerous significant associations, especially between bolting date and elevation, maximum and minimum temperature, and precipitation.
- Since populations collected at different locations varied in their response to environment, determining seed zones should be possible.

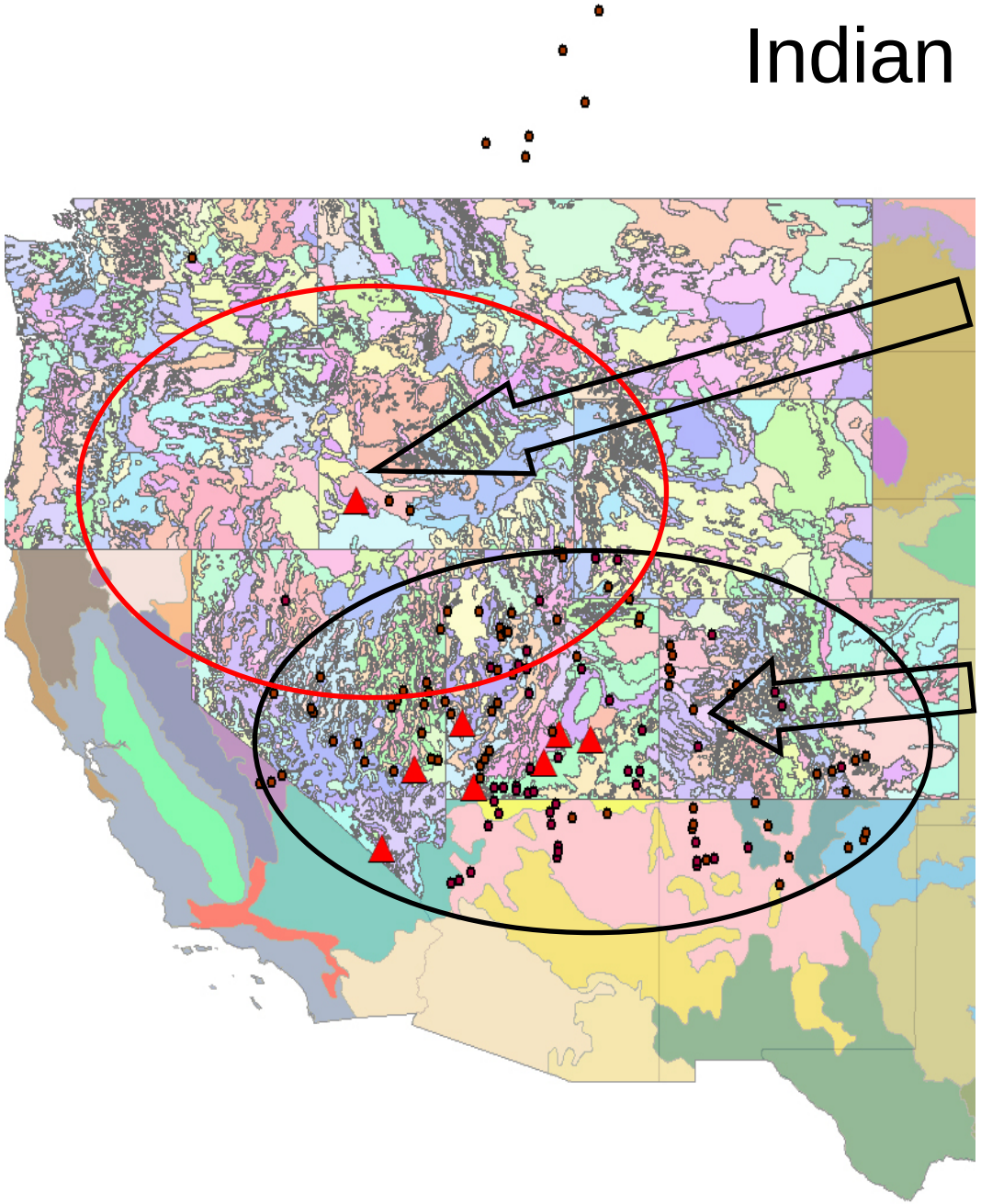
Achnatherum hymenoides, Indian ricegrass

Important forage species for many parts of the Great Basin.
One study ongoing another planned from new collections

Progress:

- ✓ **Germplasm collection (Tom Jones plus new)**
- ✓ **Common gardens established (2007) (new 2009)**
- ✓ **Evaluation of morphological and phenological diversity (2007-08) (new 2009)**
- **Analysis of genetic diversity**
- **Determine seed adaptation zones**
- **Report results; presentation and publications**

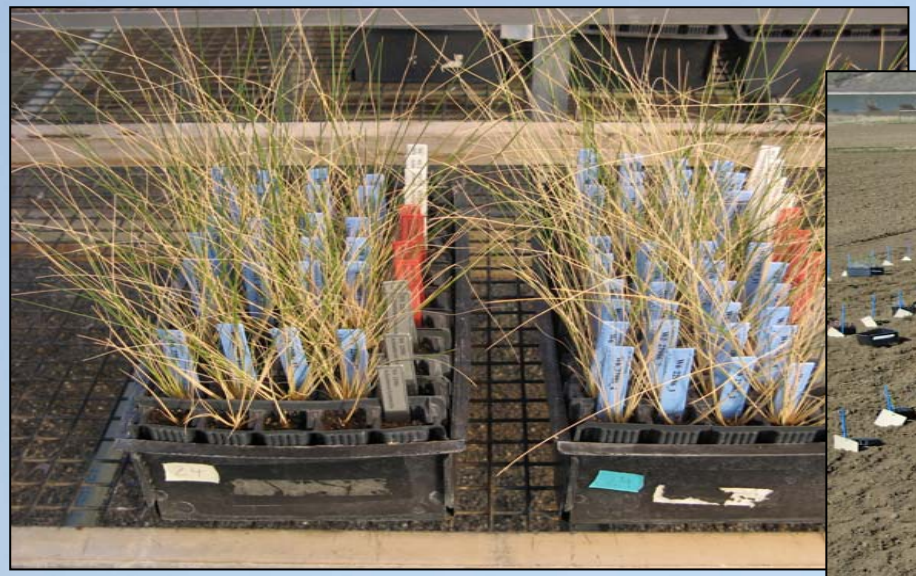
Indian ricegrass collections

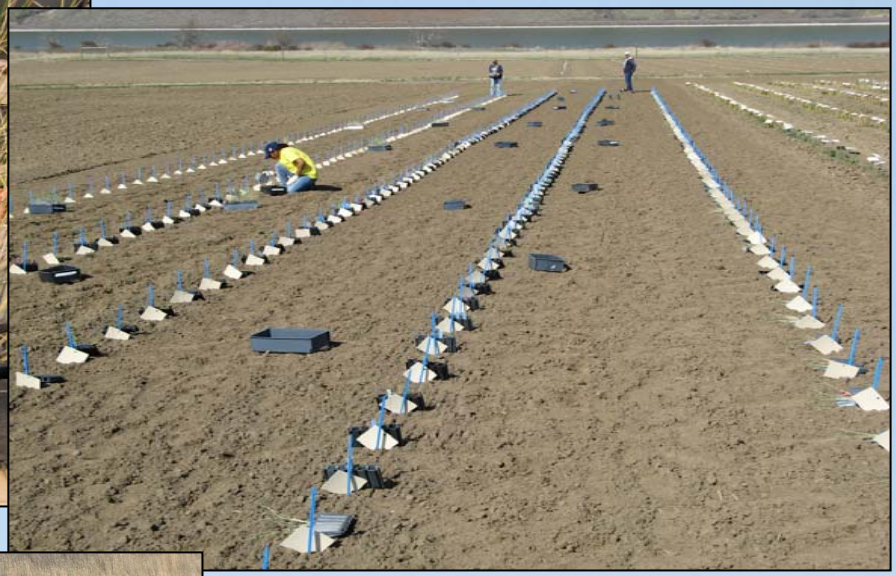


Great basin collections of Indian ricegrass needed, currently about 50 acquired

Indian Ricegrass collections at the Pullman gene bank currently being used on common gardens and molecular research, 2006-2008

Indian ricegrass, Central Ferry WA, 2007





ANOVA summary for 2007 Indian ricegrass common gardens, most traits.

Variable	Mean	CV	Environ, P	Location, P	Environ*Loc, P
Heading date	191.10	6.90	< 0.01	< 0.01	0.66
Bloom date	179.49	6.68	< 0.01	< 0.01	0.06
Mature date	205.11	6.24	< 0.01	< 0.01	0.59
Leaf width, mm	1.88	36.93	< 0.01	< 0.01	0.43
Leaf length, mm	14.86	29.60	0.93	< 0.01	0.93
Lf length/Lf width	8.92	45.18	< 0.01	< 0.01	0.64
Lf length*Lf width	29.64	56.15	0.12	< 0.01	0.73
Inflores./plant	13.45	73.89	< 0.01	< 0.01	0.36
Seeds/Inflor	9.31	121.36	< 0.01	< 0.01	< 0.01
Culm length,cm	25.46	21.54	0.35	< 0.01	0.51
Inflores. length,cm	15.16	26.57	0.13	< 0.01	0.67
Habit, 1-9	5.49	21.28	0.32	< 0.01	0.47
Height/Habit	8.18	52.51	0.14	< 0.01	0.72
Leaf texture, 1-9	5.16	24.58	< 0.01	< 0.01	0.18
Leaf abundance, 1-9	4.82	23.19	0.15	< 0.01	0.22
Lf Text/Lf width	3.47	49.91	< 0.01	< 0.01	0.35
Leaf roll, 1-9	4.46	37.11	0.03	< 0.01	0.36
Dry wt., g	51.1	36.1	< 0.01	< 0.01	0.33

Linear correlations between selected traits measured at Central Ferry 2007 and environmental factors at collection locations for Indian ricegrass (n=112).

Trait	Elev.	Slope	Aspect	Lat.	Long.	Max. Temp.	Min. Temp.	Precip
Plant habit	ns	ns	ns	**-0.38****	ns	**0.26****	ns	ns
Culm length	ns	ns	**-0.20***	**0.19***	**0.21***	ns	ns	**0.28****
Seeds/inflor.	**-0.25****	ns	ns	**0.40****	ns	ns	ns	ns
Inflor. num	ns	ns	ns	**-0.22***	ns	**0.33****	**0.32****	**-0.20***
Leaf rolling	**0.28****	ns	ns	ns	**0.26****	ns	**-0.24***	ns
Leaf lth*wth	**-0.34****	ns	ns	**0.21***	ns	ns	**0.23***	ns
Anthesis	**0.24***	**0.20***	ns	ns	ns	**-0.34****	**-0.35****	**0.19***
Ht/habit	ns	ns	ns	**0.36****	ns	**-0.29****	ns	**0.28****
Dry wt.	**-0.30****	ns	ns	ns	ns	**0.19***	**0.29****	ns
Regrowth	**-0.28****	ns	ns	ns	ns	**0.25****	**0.32****	ns

*,**,ns, Significant at P<0.05, P<0.01, and not significant, respectively.

Summary for Indian ricegrass

- Common gardens were established at Central Ferry WA in spring 2007, and first year evaluations completed.

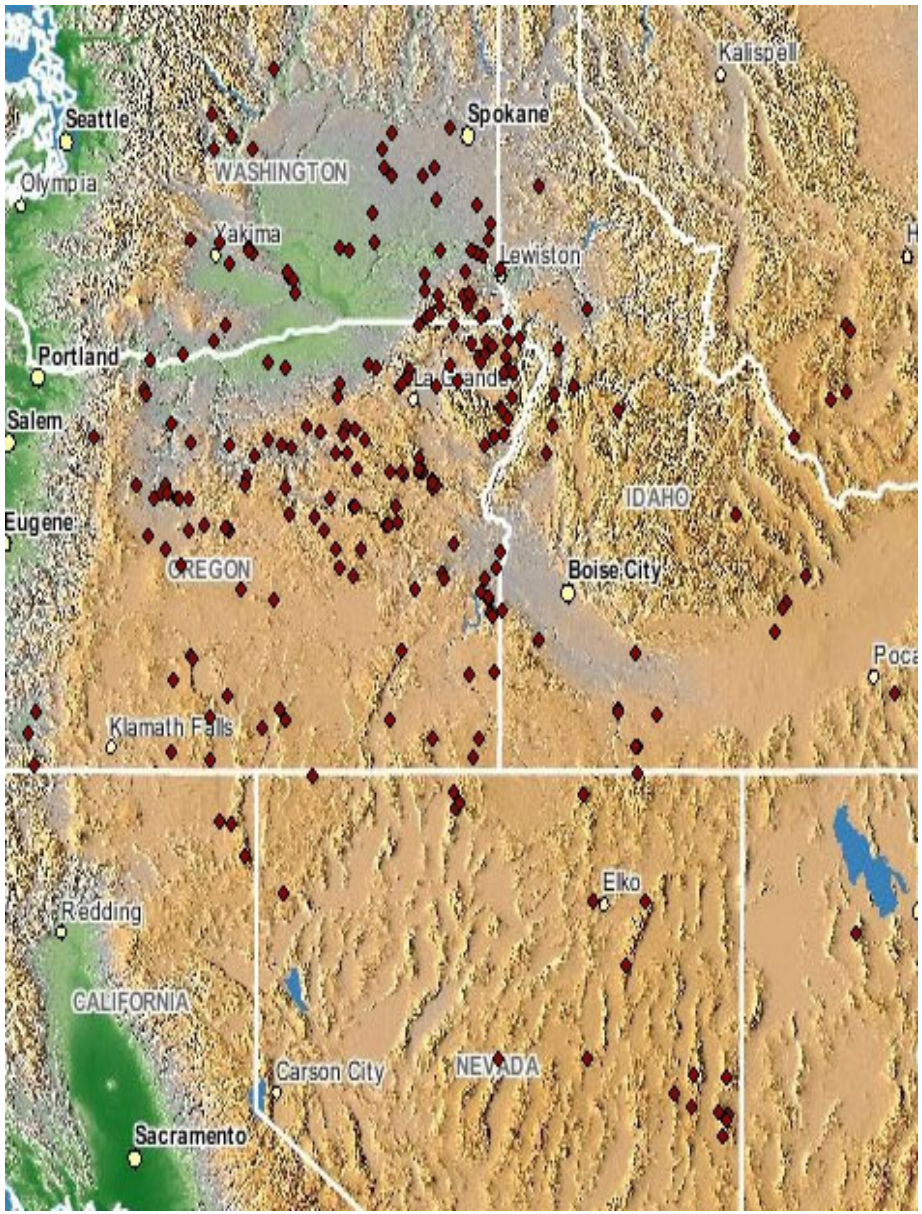
- Strong collection locations effects were present for all traits measured showing genetic variation across the landscape.

- Numerous correlations between collection environment and evaluation traits were significant suggesting potential for determining seed zones.

Pseudoroegneria spicata, Bluebunch wheatgrass

Progress:

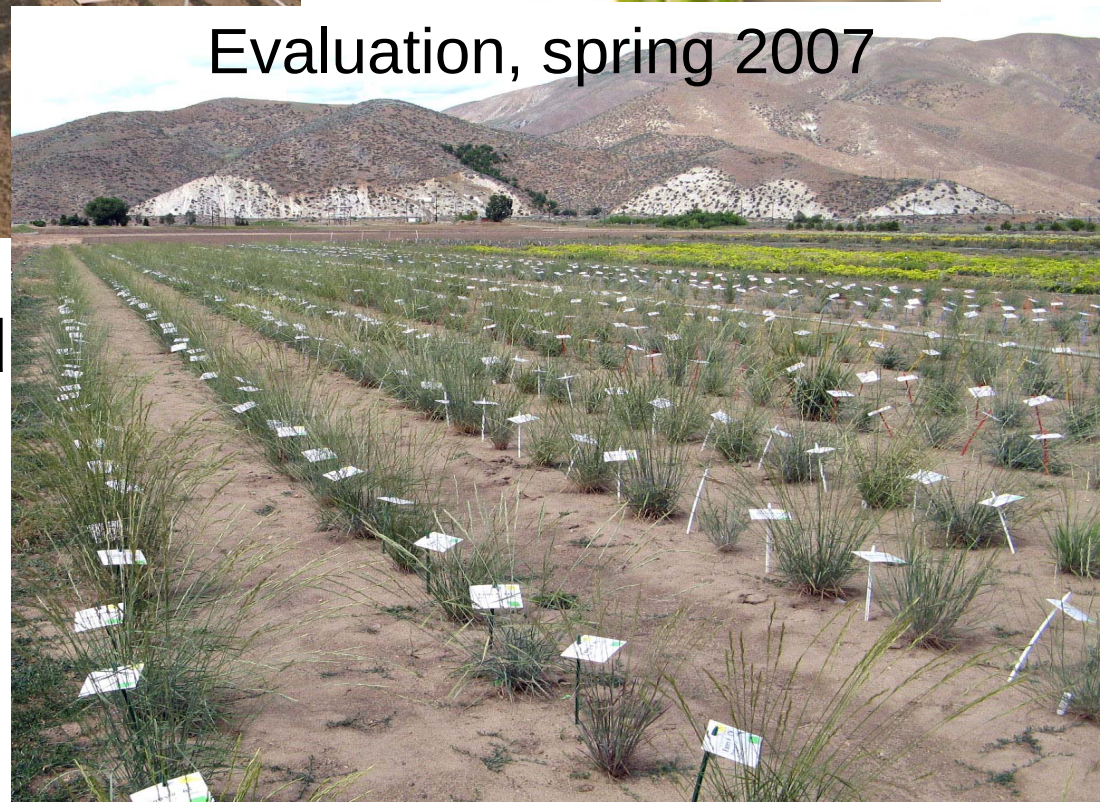
- ✓Germplasm collection
- ✓Common gardens established
- ✓Evaluation of morphological and phenological diversity (2007)
- ❖Analysis of genetic diversity
- ❑Determine seed adaptation zones
- ❖Report results; presentation and publications



Collection of Bluebunch wheatgrass, 2005,led by Brad St. Clair with the US Forest Service. Common garden studies were started in the fall, 2006, at Pullman, Central Ferry, and Lucky Peak. Cooperative project with ARS, USFS, and BLM.

Transplanting Bluebunch Wheatgrass, Lucky Peak, fall 2006

Evaluation, spring 2007



Twenty traits measured

- Phenology
- Morphology
- Biomass

ANOVA summary for selected traits of Bluebunch wheatgrass measured at Pullman and Central Ferry WA, and Lucky Peak ID, 2007

Trait	CV	Mean	P Site	P Loc	P Site x Loc
Pt. habit, 1-9	16.9	6.25	0.0100	<0.0001	<0.0001
Leaf pubes.,1-9	29.0	4.74	0.0747	<0.0001	<0.0001
Leaf width, mm	92.7	0.55	0.4683	<0.0001	0.9893
Leaf length, mm	23.9	14.7	<0.0001	<0.0001	0.0184
Leaf color, 1-9	69.0	3.28	0.5314	<0.0001	0.1194
Heading date	5.08	133	<0.0001	<0.0001	0.0009
Plant ht, cm	23.9	36.6	<0.0001	<0.0001	<0.0001
Culm length, cm	21.8	40.9	<0.0001	<0.0001	<0.0001
Anthesis date	14.1	148	<0.0001	0.0002	0.1535
Inflor. num	65.1	29.2	<0.0001	<0.0001	<0.0001
Spikelets/spike	29.7	10.0	<0.0001	<0.0001	0.0327
Awn length, 1-9	34.1	4.48	0.9343	<0.0001	0.0163
Maturity date	4.7	189	<0.0001	<0.0001	<0.0001
Dry wt., g	56.1	42.0	<0.0001	<0.0001	<0.0001
Crown Width, cm	30.8	5.53	0.0003	<0.0001	0.0183

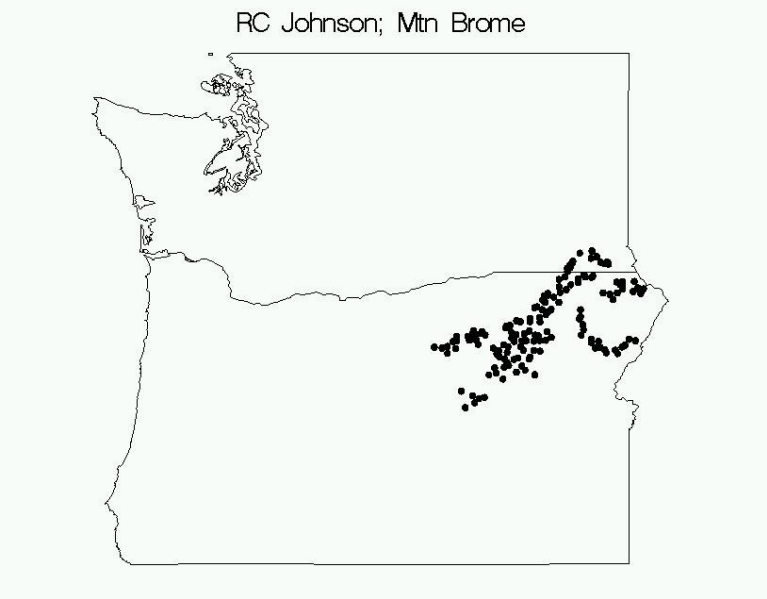
Summary Bluebunch wheatgrass, 2007

- The strong collection location effects show there is substantial genetic variation across the landscape and potential for genecology analysis
- The majority of traits had a significant site by locations interaction showing that growth and development of Bluebunch wheatgrass from diverse locations can not be predicted based on evaluation at any one site.

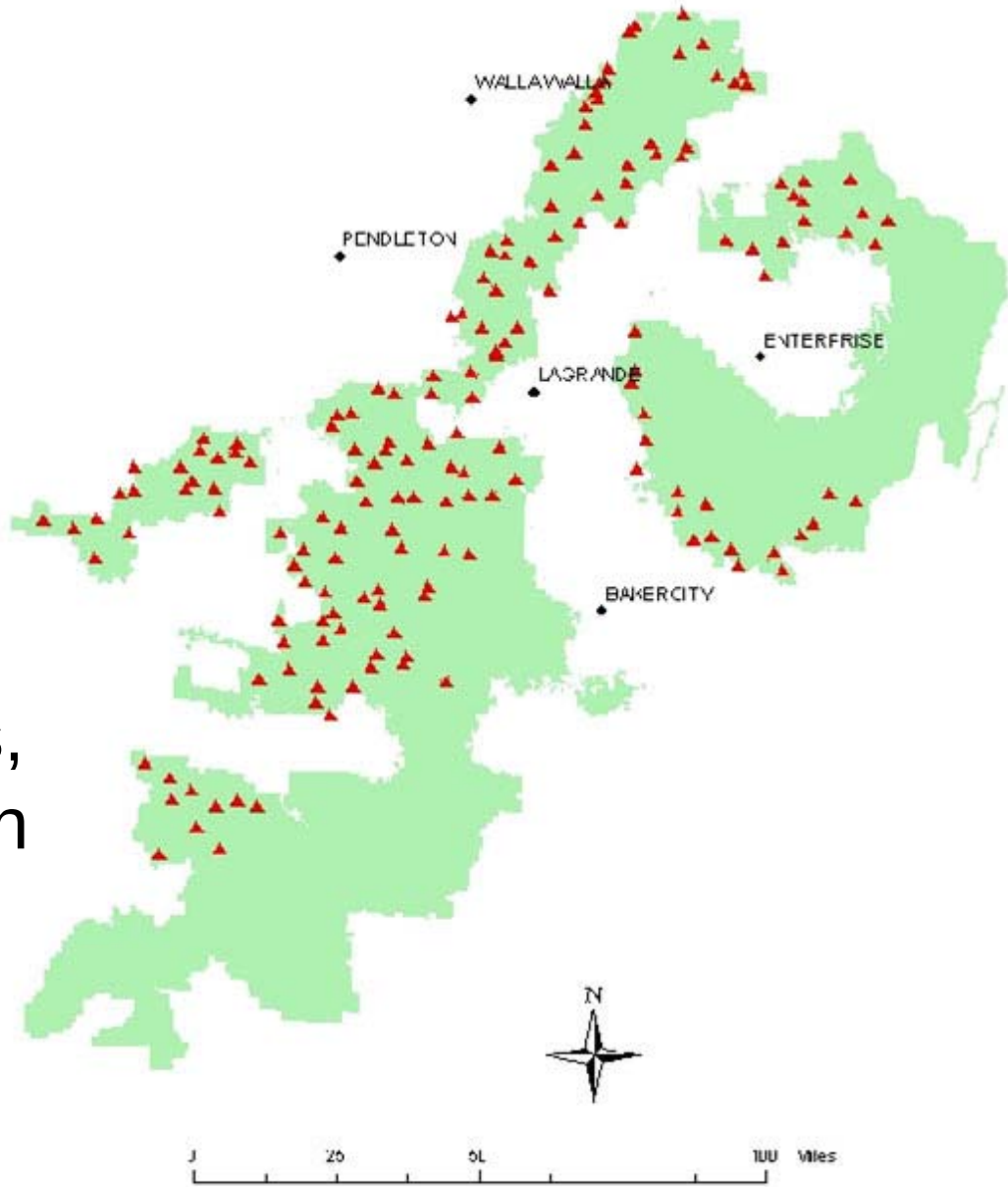
Bromus carinatus, Mountain Brome

Progress (USFS support):

- ✓Germplasm collection
- ✓Common gardens established
- ✓Evaluation of morphological and phenological diversity
- ✓Analysis of genetic diversity
- ❖Determine seed adaptation zones
- ❑Manuscript (2008)



Distribution of Mt. Brome collections, ca. 120 Blue Mountain locations studied in common gardens



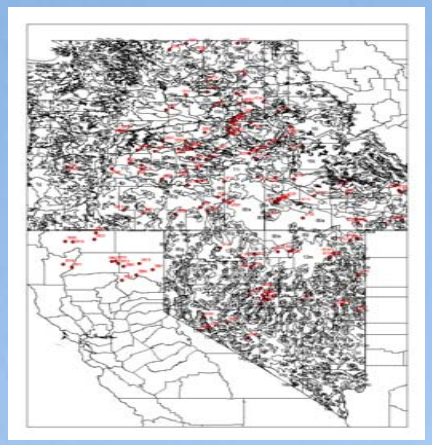
Phenotypic factors measured on Mountain Brome and their descriptions taken in the spring and summer of 2004 and 2005 at Central Ferry and Pullman WA

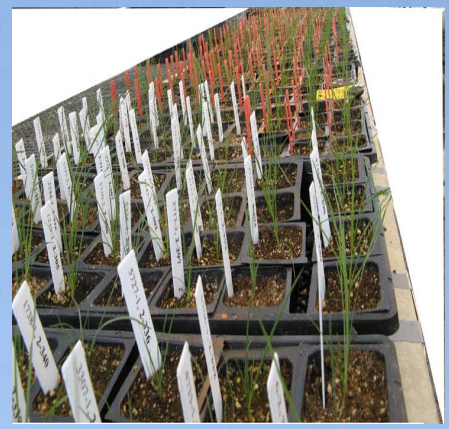
Factor	Description
Winter survival	Measured in early spring
Heading day	Day of year when first inflorescence extends from sheath
Plant habit	Rated from 1 = prostate to 9 = upright after heading
Leaf width	Width of an upper, fully emerged leaf (cm)
Leaf length	Length of an upper, fully emerged leaf (cm)
Leaf color	On an upper, emerged leaf rated from 1 = light green to 9 = dark green
Leaf pubescence	Rated from 1 = no pubescence to 9 = heavily pubescence
Leaf texture	Rated from 1= coarse to 9= fine on the entire plant before anthesis
Leaf abundance	Leafiness at heading rated from 1 = low to 9 = high before anthesis
Head abundance	Density of inflorescences per plant rated from 1 = no heads to 9 = high
Plant height	From soil surface to upper plant after anthesis (cm)
Aerial dry matter	Above ground plant dry weight cut at about 5 cm above ground
Crown diameter	Measured plants were cut for dry matter (cm)

Mt. Brome Summary

- There was wide variation in geographic and climatic factors across the Blue Mountain sampling area; the elevation range was 1531 m (5036 ft).
- Even though collection location effects were generally significant, the within location variance component was quite large also.
- The best regression model between plant traits and environmental factors explained 29% of the collection location variation.
- To a certain extent location variation was adaptive, but to a greater extent it appeared random. The preliminary conclusion is that one seed zone may be most logical for the Blue Mountains.
- The variation among locations should be maintained *ex situ* in the National Germplasm System and *in situ* reserves considered

Poa secunda, Sandberg bluegrass





Progress (BLM support but not GBNPSIP):

- ✓Germplasm collection (~140 locations)
- ❖Common gardens established (Spring 2008)
- ❑Evaluation of morphological and phenological diversity
- ❑Analysis of genetic diversity
- ❑Determine seed adaptation zones
- ❑Manuscript for publication

Plans, 2008

- **Finish Mountain brome manuscript**
- **Finish genecology analysis of Tapertip onion and draft manuscript**
- **Finish Indian ricegrass evaluation of germplasm from the Southern and Eastern Great Basin**
- **Finish collection of Indian ricegrass for study of Northern and Central Great Basin germplasm**
- **Establish common gardens of Sandberg bluegrass**
- **Finish data collection for Bluebunch wheatgrass common gardens**