Bridger Plant Materials Center

2010 Annual Technical Report

United States
Department
Of Agriculture

Natural Resources
Conservation Service

Bridger Plant
Materials
Center
Bridger, Montana

May 2011

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BRIDGER PLANT MATERIALS CENTER
2010 TECHNICAL REPORT

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This is a preliminary report of results from the Bridger Plant Materials Center activities; these results may change with continued investigations. Written authorization must be obtained from the authors before publishing data from this report. Contact the project leader or the plant materials center manager or plant materials specialist for more information.

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FOREWORD

The Bridger Plant Materials Center (PMC) is a federally operated facility under the administration of the Montana State Office of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). It operates under a cooperative agreement with the Soil and Water Conservation Districts of Montana, Inc. (SWCDMI) and the Wyoming Association of Conservation Districts (WACD). The purpose of the PMC is to assemble, test, and select plant materials to develop new technologies for use in conservation applications in Montana and Wyoming. The conservation plant research at the Bridger PMC is directed by a Long-Range Plant Materials Plan and administered by a five-member Board of Managers (appointed by Montana and Wyoming State Associations of Conservation Districts) and a State Conservationist Advisory Board (NRCS State Conservationists from Montana, Wyoming, and Colorado). The PMC has cooperative agreements for plant testing and development with the Agricultural Experiment Stations (Montana State University-Bozeman and University of Wyoming-Laramie); Montana Conservation Seedling Nursery-Missoula; the United States Department of Interior -National Park Service (USDI-NPS) (Yellowstone, Glacier, and Devil's Tower National Monument) and the USDI Wyoming Bureau of Land Management; and the Deer Lodge Valley Conservation District (DLVCD), which is funded through the State of Montana-Natural Resource Damages Program.

The Bridger PMC was established in 1959 to serve 104 Conservation Districts in Montana and Wyoming. It is located on a 140-acre, irrigated farm 3-1/2 miles southeast of Bridger, Montana, that is owned by the Conservation Districts and leased to NRCS. Initial and advanced evaluations of new plant materials, seed increase plantings of promising accessions, and foundation seed production are all conducted on site. Field Evaluation Plantings and Demonstration Plantings are established on off-Center locations throughout Montana and Wyoming at conservation problem sites in cooperation with federal, state, and municipal agencies, and private individuals.

BRIDGER PLANT MATERIALS CENTER
2010

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Xavier Montoya, State Conservationist, Wyoming

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Jerry Jasmer, State Resource Conservationist, Wyoming
Jim Jacobs, Plant Materials Specialist, Montana/Wyoming

Plant Materials Center Cooperators

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Jeff Tiberi, Executive Director, Montana Association of Conservation Districts
Dr. Ken Kephart, Director, Montana Agricultural Experiment Station
Dr. Bret Hess, Director, Wyoming Agricultural Experiment Station

Plant Materials Center Personnel

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Roger Hybner, Research Agronomist
Susan Winslow, Agronomist
Beth Graham, Project Leader DATR
Darren Zentner, Biological Technician
Ross Oyler, Biological Technician
Bob Fisher, Biological Technician BLM
Marlene Kinney, Experience Works Assistant
Andi Pierson, STEP Student

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TOURS, PRESENTATIONS, AND TRAINING

Fiscal Year 2010

Date presented: 10/7/2009
Title: Overview of the DATR Project in Cooperation with Deer Lodge Valley CD and the Bridger PMC
Presenter: Beth Graham **Location:** Camp Mak A Dream, Gold Creek, MT

Date presented: 11/18/2009
Title: NRCS Plant Materials Program
Presenter: Zentner, D. and R. Oyler **Location:** Billings, MT

Date presented: 11/18/2009
Title: Bridger Plant Materials Center 2009 Activities
Presenter: Scianna, J.D. **Location:** Cheyenne, WY

Date presented: 11/18/2009
Title: Bridger Plant Materials Center Activities for 2009
Presenter: Roger Hybner **Location:** Lewistown, MT

Date presented: 11/19/2009
Title: DATR Project Overview
Presenter Beth Graham **Location:** Yogo Hotel and Convention Center, Lewistown, MT

Date presented: 1/26/2010
Title: Horticulture Research at the Bridger PMC
Presenter: Scianna, J.D. **Location:** Bozeman, MT

Date presented: 1/26/2010
Title: MT silver buffaloberry release recommendation
Presenter: Beth Graham **Location:** MSU, Bozeman, MT

Date presented: 2/4/2010
Title: PMC Update to WCIA
Presenter: Winslow, S.R. **Location:** Powell, WY

Date presented: 2/4/2010
Title: Blanketflower Release Recommendation
Presenter: Winslow, S.R. **Location:** Powell, WY

Date presented: 2/4/2010
Title: Silver buffaloberry Release recommendation
Presenter: Beth Graham **Location:** Powell Experiment Station, Powell, WY

Date presented: 2/11/2010
Title: Forage Plants for Saline Soils
Presenter: Roger Hybner **Location:** Riverton, WY

Date presented: 2/12/2010
Title: Woody Species for Salinity Conditions
Presenter: Roger Hybner **Location:** Riverton, WY

Date presented: 2/17/2010
Title: DATR Update and Project History
Presenter: Beth Graham **Location:** Camp Mak-A-Dream, Gold Creek, MT

Date presented: 3/1/2010
Title: Xeriscape for Bridger Gardeners
Presenter Winslow, S.R. **Location** Bridger, MT

Date presented: 3/2/2010
Title: Yellowstone's Native Plant Project
Presenter: Winslow, S.R. **Location:** Red Lodge, MT

Date presented: 4/6/2010
Title: Partnering for Revegetation Success in the PRA
Presenter: Winslow, S.R. **Location:** Laramie, WY

Date presented: 4/13/2010
Title: WY PM Committee Update
Presenter: Winslow, S. R. **Location:** Casper, WY

Date presented: 5/11/2010
Title: Fifth grade field trip to the PMC facility- Mountainview Elem .School, Red Lodge, MT
Presenter: BPMC Staff **Location:** Bridger PMC

Date presented: 5/19/2010
Title: Herbicide Effects in Wildflower Seed Production Fields
Presenter: Winslow, S.R. **Location:** Snowbird, UT

Date presented: 5/24/2010
Title: Bridger PMC Program Overview
Presenter: BPMC Staff **Location:** Bridger, MT

Date presented: 6/2/2010
Title: Bridger Plant Materials Center Program
Presenter: Oyler, Ross & J.D. Scianna **Location:** Bridger PMC

Date presented: 6/16/2010
Title: Tree Planting, Maintenance, and Stress Monitoring
Presenter: Scianna, J.D. **Location:** Joliet, MT

Date presented: 6/16/2010
Title: 2010 Grant application presentation
Presenter: Beth Graham **Location:** Deer Lodge Community Center, MT

Date presented: 6/17/2010
Title: BPMC 2010 Field Day
Presenter: PMC Staff **Location:** BPMC

Date presented: 6/21/2010
Title: Conserving the Heritage of Native Plants--Intertribal Ag Council Ft Belknap
Presenter: Buck, T. & S.R. Winslow **Location:** Ft Belknap Indian Reservation, MT

Date presented: 6/29/2010
Title: Perennial Forage Grass and Legume Evaluations Under Dryland and Irrigated Conditions
Presenter: Roger Hybner **Location:** MSU-Northern Ag Research Center, near Havre, MT

Date presented: 6/29/2010
Title: Perennial Forage Grass and Legume Produciton in Northern MT
Presenter: Roger Hybner **Location:** Northern Ag Research Center near Havre, MT

Date presented: 6/29/2010
Title: Perennial Forage Grass and Legume Production in Northern MT
Presenter: Roger Hybner **Location:** Northern Ag Research Center near Havre, MT

Date presented: 6/29/2010
Title: Perennial Grass and Legume Forage Production in Northern Montana
Presenter: Roger Hybner **Location:** Northern Ag Research Center near Havre, MT

Date presented: 7/13/2010
Title: Nursery Management and Plant Propagation Training
Presenter: Scianna, J.D. **Location:** West Glacier, MT

Date presented: 7/14/2010
Title: Irrigation system design and operation training
Presenter: Oyler, Ross **Location:** West Glacier, MT

Date presented: 11/16/2010
Title: Salinity Research at the BPMC
Presenter: Roger Hybner **Location:** Billings, MT

Date presented: 11/18/2010
Title: WACD 2010 BPMC Update
Presenter: Roger Hybner **Location:** Worland, WY

Publications

Fiscal Year 2010

Winslow, S.R. 2010. Abstract--Herbicide Effects in Wildflower Seed Production Fields. National Native Seed Conference, Oregon. May 2010. 1p.

Winslow, S.R. 2010. IEP WY BLM 2010 Progress Report. Bridger PMC, Bridger, MT. FY 2010. 8p.

Winslow, S.R. 2010. Rosana Western Wheatgrass--A Conservation Plant for Montana and Wyoming. Bridger PMC, U.S. Printing Office. February 2010. 1p.

Winslow, S.R. 2010. Yellowstone National Park 2009 Annual Technical Report. Bridger PMC, Bozeman, MT. 2009. 147p.

Winslow, S.R. 2010. Yellowstone National Park 2009 Summary Reports. Bridger PMC, Bridger, MT. 2009. 2p.

Scianna, J.D., Robert Logar, Darren Zentner. 2010. Ekalaka Germplasm Selected Class Bur Oak - A Conservation Plant for MT and WY. Bridger PMC, Bozeman, MT. September 2009. 2p.

Scianna, J.D. and James S. Jacobs. 2010. Notice of Release of Ekalaka Germplasm Bur Oak. Native Plants Journal, Bloomington, Indiana. Vol. 11, No. 1. Spring 2010. 5p.

Scianna, J.D. 2010. Glacier National Park 2009 Annual Technical Report. Bridger PMC, Bridger, MT. 2009. 172p.

Scianna, J.D. 2010. Glacier National Park 2009 Summary Report. Bridger PMC, Bridger, MT. 2009. 1p.

Scheinost, P.L.; Scianna, J.D., and D.G. Ogle. 2010. Rubber Rabbitbrush *Ericameria nauseosa*. Pullman, Washington PMC via PLANTS.

Hybner, Roger and Jim Jacobs. 2010. Field Bindweed Control in Winterfat Seed Production Fields. Proceedings - Western Society of Weed Science, Las Cruces, NM. Vol. 63, 2010. 146p.

Hybner ,Roger. 2010. BPMC Field Day. MT Soil & Water Conservation Society Fall Newsletter, MT. November 2010. 1p.

PMC Staff, Jacobs, Pearce, Wiese 2010. Bridger Plant Materials Center 2009 Annual Technical Report. Bridger, Montana PMC, Bozeman, MT. 2009. 292p.

PMC Staff, Graham, Majerus, and Sable. 2010. Cultivating Conservation with Bridger Plant Materials Center. BPMC and Montana State University - VIDEO DVD., Bozeman, MT. 2009.

PMC Staff. 2010. Bridger PMC 2010 Tour Handout. Bridger PMC, Bridger, MT. 2010. 18p.

PMC Staff. 2010. Bridger PMC Year 2009 Progress Report of Activities. Bridger PMC, Bridger, MT. 2009.

PM Staff. 2009. Plant Materials Today - Fall 2009. Bridger PMC, Bridger, MT. Vol. 16, No. 4, October 2009. 3p.

PM Staff. 2010. Plant Materials Today - Spring 2010. Bridger PMC, Bridger, MT. Vol. 17, No. 2. 2p.

PM Staff. 2010. Plant Materials Today - Summer 2010. Bridger PMC, Bridger, MT. Vol. 17, No. 3, July 2010. 3p.

PM Staff. 2010. Plant Materials Today - Winter 2010. Bridger PMC, Bridger MT. Vol. 17, No. 1, January 2010. 3p.

Gransbery, Jim (Scianna interview). 2010. Plants That Thrive in Heavy Metals - Replace Invasive Species. Magic City Magazine, Billings, MT. September 2010 (planned publication). 2p.

Graham, E.C. 2010. Notice of Release of Mill Creek Germplasm Silver buffaloberry selected class of natural germplasm. Bridger PMC, Bridger, MT. September 2010. 13p.

Clause, K.J. & S.R. Winslow. 2010. Re-vegetation Trials in the High Desert. Wyoming Native Plant Society's newsletter, Castilleja. Laramie, WY. Vol. 29, No. 2, May 2010. 2p.

WEATHER

In August of 2002, the Bridger PMC weather station was upgraded with a Davis Vantage Pro™ weatherlink® data logger. The station records temperature, humidity, wind speed, wind direction, and precipitation; and sends data to a wireless data logger in the PMC office building. Data is downloaded into the PMC computers, where daily and monthly data reports can be printed. Soil moisture sensors have yet to be installed. Records are kept on file at the Bridger PMC, as well as forwarded to the NRCS Montana Snow Survey office in Bozeman.

2010

Precipitation	
Annual Total	8.50 inches
Long-Term Average	11.90 inches
High Monthly Total (June)	1.92 inches
Low Monthly Total (September)	0.10 inches
Temperature	
Highest Daily Temperature (July 25)	103.3°F
Lowest Daily Temperature (January 6)	-15.1°F
Highest Monthly Mean Temperature (July)	72.2°F
Lowest Monthly Mean Temperature (December)	24.4°F

Table 1. Weather Data, 2010. Mean monthly temperatures, mean monthly precipitation, and average wind speed at the Bridger Plant Materials Center†.

	Mean Monthly Temperature					Total Monthly Precipitation				
Month	°F Max.	°F Min.	°F Mean	Long-Term Mean	Dep. from Long-Term Mean	2010	Long-Term Mean	Departure from Mean	Number Days Ppt.	Avg. Wind Speed
						in.	*in.*	*in.*		*mph*
January	36.5	15.7	26.1	22.2	+3.9	0.28	0.50	-0.22	5	6.0
February	38.6	16.8	27.7	27.6	+0.1	0.16	0.33	-0.17	5	4.3
March	56.9	28.9	42.9	35.1	7.8	0.12	0.74	-0.62	2	6.0
April	59.7	32.3	46.0	43.8	+2.2	0.98	1.45	-0.47	8	3.7
May	64.6	39.4	52.0	53.4	-1.4	1.39	2.16	-0.77	10	3.3
June	78.3	50.3	64.3	62.1	+2.2	1.92	1.90	+0.02	10	2.1
July	89.6	54.8	72.2	69.9	+2.3	0.44	0.75	-0.31	8	2.0
August	87.7	54.1	70.9	67.6	+3.3	0.78	0.80	-0.02	11	1.7
September	76.3	43.8	60.1	57.9	+2.2	0.10	1.24	-1.14	5	2.2
October	67.9	36.2	52.0	46.3	+5.7	0.51	1.15	-0.64	4	‡
November	41.2	17.7	29.5	33.4	+3.9	1.53	0.48	+1.05	6	‡
December	34.3	14.5	24.4	24.5	-0.1	0.29	0.39	-0.10	3	‡
Yearly Total						8.50	11.90	-3.39	77	
Monthly Mean	61.0	33.7	47.3	46.5	+0.8					3.5

† Growing Season 28°F: 163 days, May 8 to October 18.
High Temperature: 103.3°F July 25 (Record High: 110°F).
Low Temperature: -15.1°F January 6 (Record Low: -38°F on December 24, 1983).
‡ Wind speed not recorded.

I. INITIAL EVALUATION PLANTINGS (IEPs)

Study Title: Initial Evaluation Planting—Plant Materials Collections

Study Number: NA

Objective:

Project Description: NRCS Field Offices assist with plant materials activities, which include initial seed and plant collecting for improved plant development (ref. 190-V-NPMM, Third Ed., June 2000). Species are chosen for collection based on conservation needs identified in the Bridger Plant Materials Center's long-range plan. The Bridger Plant Materials Center Long-Range Plan (LRP) was revised in 2001 to reflect phased-out, ongoing, and future demands on the program. A revised collection list was developed in 2004 and again in 2005 based on recommendations made by the Montana and Wyoming State Plant Materials Committees. The new list focused on species targeted to address priority conservation issues outlined in the LRP.

Results: In 2010, the Bridger PMC received 26 seed collections from offices in Montana totaling 552 grams (Table 1). Individuals from 12 counties contributed seed collections. There were 12 Wyoming seed collections received from eight counties totaling 0.068 kilograms (Table 2).

Table 1. Initial Evaluation Planting. The 2010 Montana Plant Materials Collections.

Accession	Genus & Species	Date Collected	County	Collector	Amount
					grams
Grasses					
9088237	*Andropogon hallii*	-	Wibaux, MT	Merriman, C. & R. Kilian	4
9088268	*Pseudoroegneria spicata* ssp. *spicata*	7/12/10	Custer, MT	Henning, M.	3
9088272	*P. spicata* ssp. *spicata*	7/20/10	Ravalli, MT	Jacobs, J.	14
9088277	*P. spicata* ssp. *spicata*	7/20/10	Ravalli, MT	Jacobs, J.	19
9088292	*P. spicata* ssp. *spicata*	8/11/10	Meagher, MT	Jacobs, J.	59
9090761	*Spartina gracilis*	11/13/10	Stillwater, MT	Majerus, M.	25
9088178	*Sporobolis cryptandrus*	9/20/10	Custer, MT	Woodward, J. & R. Kilian	25
9090762	*Sporobolis cryptandrus*	9/20/10	Custer, MT	Woodward, J. & R. Kilian	119
Subtotal:	4 species	5 days	5 counties	6 collectors	268 gr (0.59 lb)
Legumes					
9090764	*Oxytropis-Astragalus*	August 2010	Carbon, MT	Majerus, M.	38
9090765	*Pediomelum argophylla*	-	Fallon, MT	Wolenetz, R. & J. Dalzell	13
-	*P. argophylla*	8/10/10	Garfield, MT	Eddy, K. & R. Kilian	No fill
-	*P. argophylla*	8/26 & 8/27/10	Custer, MT	Henning, M.	No fill
9090766	*Pediomelum esculentum*	7/12 & 7/16/10	Custer, MT	Henning, M.	17
9090767	*P. esculentum*	7/22/10	Custer, MT	Kilian, R.	1
9090768	*P. esculentum*	7/22/10	Custer, MT	Kilian, R.	1
9090769	*P. esculentum*	8/02/10	Custer, MT	Hagemeister, P., J. Bogkins, 7 R. Kilian	1
9090770	*P. esculentum*	8/26/10	Custer, MT	Henning, M.	4
9090771	*P. esculentum*	-	Fallon, MT	Wolenetz, R. & J. Dalzell	11
9090772	*Thermopsis rhombifolia*	7/06, 7/12, 7/16/10	Custer, MT	Henning, M.	74
9090773	*T. rhombifolia*	7/13/10	Dawson, MT	Ragsdale, R., T. Decock, & B. Drummond	20
9090774	*T. rhombifolia*	7/14/10	Prairie, MT	Ragsdale, R., T. Decock, & B. Drummond	48
Subtotal:	4 species	10 days	6 counties	11 collectors	228 gr (0.50 lb)
Forbs					
9090777	*Calylophus (Oenothera) serrulatus*	8/05/10	Big Horn, MT	Ricketts, M. & E. Vanorder	4
9090778	*Heterotheca villosa*	8/05/10	Carbon, MT	Majerus, M.	5
9090781	*Polygala alba*	7/22/10	Custer, MT	Kilian, R.	1
9090782	*Tradescantia*	7/22/10	Custer, MT	Kilian, R.	1
9090783	*Tradescantia*	8/02/10	Custer, MT	Hagemeister, P., J. Boykins, & R. Kilian	1
9090784	*Tradescantia*	8/10/10	Garfield, MT	Eddy, K. & R. Kilian	trace
Subtotal:	4 species	5 days	4 counties	7 collectors	12 gr (0.03 lb)
Tree					
9090785	*Acer negundo*	9/29/10	Treasure	Kilian, R.	44 gr (0.10 lb)
2010 Totals: 26 collections	13 species	16 days	12 counties	collectors	552 gr (1.22 lb)

Table 2. Initial Evaluation Planting. The 2010 Wyoming Plant Materials Collections.

Accession	Genus & Species	Date Collected	County	Collector	Amount
					lb
Grass					
9088282	*Pseudoroegneria spicata* ssp. *spicata*	7/21/10	Big Horn	SOS-WY930-10	0.003
9088284	*P. spicata* ssp. *spicata*	7/21/210	Carbon	SOS-WY030-79	0.002
9088285	*P. spicata* ssp. *spicata*	7/29/10	Carbon	SOS-WY030-85	0.003
9088286	*P. spicata* ssp. *spicata*	7/30/10	Johnson	Murray, R., B. Rapp, & J. Lawrence	0.123
9088287	*P. spicata* ssp. *spicata*	7/30/10	Washakie	SOS-WY010-23	0.003
Subtotal:	1 species	3 days	4 counties	7 collectors	0.134 lb
Forbs					
9090775	*Agoseris glauca*	7/06/10	Carbon	SOS-WY030-63	0.003
9088186	*Astragalus bisulcatus*	7/30/09	Albany	SOS-WY930-09	0.003
9090776	*Eriogonum umbellatum* var. *umbellatum*	7/30/09	Sweetwater	SOS-WY040-11-09	0.002
-	*E. umbellatum*	7/26/10	Uinta	WY BLM	No fill
9090779	*Penstemon humilis*	8/13/10	Sublette	SOS-WY100-09	0.001
9090780	*P. humilis*	8/15/10	Sublette	SOS-WY040-50	0.001
9088195	*P. laricifolius* var. *laricifolia*	8/23/10	Sublette	SOS-WY100-11	0.002
9088198	*P. nitidus*	7/31/09	Sweetwater	SOS-WY040-12	0.003
Subtotal:	6 species	7 days	5 counties	8 collectors	0.015 lb
2010 Total:					
13 collections	7 species	9 days	8 counties	15 collectors	0.149 lb

Study Title: Initial Evaluation Planting of Native Forbs to Revegetate Disturbances

Study Number: MT-08-003

Objective: Evaluate the performance of native forbs to enhance species diversity in revegetating disturbed environments.

Project Description: The Bridger Plant Materials Center's (PMC) Long-Range Plan (LRP) consists of priority items that require testing a variety of plant life forms to help solve conservation problems. Bulletins are sent out to Montana and Wyoming NRCS Field Offices in the spring of each year with a list of appropriate species targeted for evaluation. Due to changes and/or modifications in the distributed target list, along with the need to have adequate geographic representation for a species, collections are accumulated until a large trial is feasible. Over that period of time (several years at the most), collections are received, processed, cleaned, accessioned, and eventually planted in an Initial Evaluation Planting (IEP) at the PMC. Furthermore, dedicated, interested supporters of the Plant Materials Program often send unsolicited material that appears (to their trained eye) to display superior performance in the field. These types of collections are also included in the IEPs.

Methods and Materials: Seed collections received from 2005 to 2008 were assembled, seeds per pound calculated, and the appropriate amount of each entry was weighed and packaged (Table 1). On November 17, 2008, seed of 79 accessions were hand-planted with a single-row belt seeder to a depth of approximately 13 mm (½ inch), at a rate of approximately 50 bulk seeds per meter (15 seeds per linear foot) of row. Standard plot length was 4.6 m (15 ft.), but length was variable depending on seed availability. Within each row, the distance between plots was 0.3 m (1 ft.), and between-row width spacing was 1.22 m (4 ft.). Shortly after planting, weed barrier was installed between the rows to reduce weed problems. Two additional plots were seeded on April 22, 2009, and March 10, 2010, at the end of the ninth row in plots 26 and 27, and seven plots in the first of the tenth row (Figure 1). The study area is approximately 0.41 acre.

Results: Eight-eight plots were evaluated for vigor, height, dates of emergence and floral phenology, and seed production. Seedling emergence was variable with the earliest growth recorded on March 24, in nearly 50% of the entries (Appendix Table 1). The latest emergence was recorded on April 28, for *Liatris punctata* from Phillips County, Montana. Twenty-nine entries did not emerge. The dates of floral initiation and development ranged from April 21 in *Penstemon nitidus* and *Thermopsis rhombifolia* (2 entries), through mid-November in *Liatris punctata*. The most vigorous performers were *Helianthella uniflora* (also the tallest), *Thermopsis montana*, *Vicia americana,* and several entries of *Penstemon* and *Phacelia.*

Seed was harvested from 33 entries (Table 2). The study is anticipated to remain active until 2012.

Table 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. Species seeded at the BPMC in Field 2 on November 17, 2008; April 22, 2009; and March 10, 2010.

Row-Position-Length†	Accession	Genus & Species	Date Collected	County	Collector	Seeded
						grams
East-West, Row 1	**Legume**					
1-1	9087816	*Astragalus*	7/10/07	Fallon	Kilian, R.	0.27
1-2-2.4 ft	9087817	*Astragalus agrestis*	8/1-5-21/07	Big Horn	Knoblach, K.	trace
1-3	9087741	*Astragalus pectinatus*	7/12/06	McCone	Holzworth/Harwood/Kirchner	0.95
1-4	9087818	*A. pectinatus*	7/10/07	Fallon	Kilian, R.	0.95
1-5	9087401	*Astragalus canadensis*	8/31/04	Sublette, WY	Clause, K.	0.35
1-6	9063357	*Astragalus crassicarpus*	1991	Choteau	Blair, D.R.	1.35
1-7	9081970	*A. crassicarpus*	8/09/02	Cascade	Siddoway, J.	1.35
1-8	9087505	*A. crassicarpus*	8/18/05	Madison	Ricketts, M.	1.35
1-9-2 ft	9087536	*A. crassicarpus*	9/20/05	Madison	Ricketts, M.	0.21
1-10	9087819	*A. crassicarpus*	8/19/07	Carbon	Winslow, S.R.	1.35
1-11	9087820	*Astragalus douglasii*	8/02/07	Big Horn	Knoblach, K.	0.75
1-12	9087821	*Astragalus flexuosus*	8/01/07	Big Horn	Knoblach, K.	0.45
1-13	9078644	*Thermopsis rhombifolia*	6/20/97	McCone	Lackner, H. & D. Wiedenheft	4.14
1-14	9082253	*T. rhombifolia*	7/22/02	Carbon	Winslow, S.R.	4.14
1-15	9082291	*T. rhombifolia*	7/06/03	Lewis&Clark	Majerus, M.	4.14
1-16	9082292	*T. rhombifolia*	7/04/03	Petroleum	Majerus, M.	4.14
1-17	9087509	*T. rhombifolia*	7/25/05	Judith Basin	Caquelin, R.	4.14
1-18	9087535	*T. montana*	8/17/05	Carbon, WY	Gullion, R. & C. Pompy	4.14
1-19	9087841	*T. rhombifolia*	7/02/07	Hot Springs, WY	Gullion, R. & C. Thomas	4.14
West-East, Row 2						
2-1	9087842	*T. rhombifolia*	7/10/07	Fallon	Kilian, R.	4.14
2-2	9087843	*T. rhombifolia*	7/05/07	Fallon	Kilian, R.	4.14
2-3	9087844	*T. rhombifolia*	7/03/07	Weston, WY	Kopp, G.	4.14
2-4	9087845	*T. rhombifolia*	7/10/07	Fergus	Waage, B., M. McClendon, M. Walker, L. Spokas, P. Creamer, & J. Siddoway	4.14
2-5	9087846	*T. rhombifolia*	7/12/07	Fergus	Walker, M., Waage, B., M. McClendon, L. Spokas, P. Creamer, & J. Siddoway	4.14
2-6-6.7 ft	9087847	*T. rhombifolia*	7/25/07	Carter	Wolenetz, R.	1.86
2-7-3.8 ft	9087848	*T. rhombifolia*	7/18/07	Campbell, WY	Woodward, J.	1.05
2-8-13.8 ft	9087849	*T. rhombifolia*	7/14/07	Campbell, WY	Woodward, J.	3.82
2-9	9087869	*T. rhombifolia*	2008		BLM (SOSWY-03008-09)	4.10
2-10	9087870	*T. rhombifolia*	2008		BLM (SOSWY-03008-10)	4.64
2-11	9087871	*T. rhombifolia*	7/16/08	Washakie, WY	Warren, Y.; BLM (SOSWY-01008-13)	4.82
2-12	9087523	*Trifolium gymnocarpum*	6/8/05	Carbon, WY	Hicks, L.	1.55
2-13-1 ft	9087525	*T. gymnocarpum*	6/14/05	Carbon, WY	Hicks, L.	0.08
2-14	9087397	*Vicia americana*	7/26/04	Blaine	Siddoway, J. & S. Brady	5.30
2-15	9087399	*V. americana*	7/26/04	Blaine	Siddoway, J. & S. Brady	5.30
2-16-10 ft	9087537	*V. americana*	9/16/05	Powder River	Swenson, C.	3.52
2-17	9087851	*V. americana*	7/10/07	Custer	Brady, S. & P. Hagemeister	5.30
2-18-7.5 ft	9087852	*V. americana*	7/19/07	Judith Basin	Caquelin, R. & L. Spokas	2.66
2-19	9087853	*V. americana*	6/21/07	Sheridan, WY	Gamblin, G.	5.30
2-20	9087854	*V. americana*	7/10/07	Fergus	Creamer, P., M. McClendon, M. Walker, L. Spokas, B. Waage , & J. Siddoway	5.30

† Length 15 ft. unless otherwise stated.

Table 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. Species seeded at the BPMC in Field 2 on November 17, 2008; April 22, 2009; and March 10, 2010—Continued.

Row-Position-Length†	Accession	Genus & Species	Date Collected	County	Collector	Seeded
						gr
East-West, Row 3	**Legumes**					
3-1	9087855	*Vicia americana*	7/03/07	Washakie, WY	Gullion, R.	5.30
3-2	9087856	*Vicia* spp.	6/21/07	Natrona, WY	Jensen, B.	1.26
3-3	9087857	*V. americana*	7/13/07	Custer	Ritter, V. & C. Swenson	5.30
3-4-1.6 ft	9087858	*V. americana*	7/25/07	Carter	Wolenetz, R.	0.27
3-5-10 ft	9087872	*V. americana*	7/17/08	Sweetgrass	Ricketts, M., C. Roloff, V. Reiter	3.58
Total Legumes	44 accessions	11 species				
Continue Row #3	**Forbs**					
3-6	9087527	*Agoseris glauca*	6/16/05	Carbon, WY	Warren, A.	0.45
3-7-6 ft	9087733	*A. glauca*	6/11/06	Sublette, WY	Clause, K.	0.18
3-8	9087734	*A. glauca*	6/13/06	Rich, UT	Clause, K.	0.45
3-9	9087416	*A. textile*	7/1/04	Blaine	Kilian, R. & B. Main.	0.86
3-10-9 ft	9087538	*Allium* spp.	9/30/05	Madison	Ricketts, M.	0.53
3-11	9087822	*Castilleja sessiliflora*	6/20 & 6/21/07	Fallon	Kilian, R.	0.05
3-12-12 ft	9087873	*Echinacea angustifolia*	7/24/08	Yellowstone	Ricketts, M.	0.63
3-13	9087874	*Helianthella uniflora*	8/6/08	Gallatin	Jacobs, J.	2.27
3-14	9058079	*Liatris punctata*	10/21/004	Phillips	Kindle, B., D.Hines, S.Messerly, & S.Winslow	0.73
3-15	9076006	*L. punctata*	10/26/05	Wibaux	Johnson, K. & R. Nelson	0.73
3-16	9082127	*L. punctata*	11/26/04	Fergus	Majerus, M.	0.73
3-17	9087575	*L. punctata*	11/7/05	Carbon	Winslow, S.R.	0.73
3-18	9087576	*L. punctata*	10/21/05	Fallon	Fischer, A.	0.73
3-19	9087577	*L. punctata*	11/02/05	Yellowstone	Robertson, V. & R. Kilian	0.73
West-East, Row 4						
4-1	9087823	*Lomatium macrocarpum*	5/31/07	Custer	Kilian, R.	1.00
4-2	9087824	*Lomatium dissectum*	5/31/07	Custer	Kilian, R.	1.00
4-3	9087831	*Penstemon* spp.	7/09/07	Fallon	Kilian, R.	0.29
4-4	9087510	*Penstemon eriantherus*	8/28/05	Silver Bow	Garverich, M.	0.29
4-5	9087511	*P. eriantherus*	8/19/05	Glacier	Luna, T.	0.29
4-6	9087529	*P. eriantherus*	7/29/05	Washakie, WY	Gullion, R. & C. Pompy	0.29
4-7	9087875	*P. eriantherus*	7/24/08	Washakie, WY	Galloway, L. & C. Thomas	0.29
4-8	9087876	*P. eriantherus*	7/24/08	Washakie, WY	Galloway, L. & C. Thomas	0.29
4-9	9087832	*Penstemon grandiflorus*	7/26/07	Toole	Vermulm, M., J. Lyseng, & J. Siddoway	0.32
4-10	9087512	*Penstemon nitidus*	8/19/05	Glacier	Luna, T.	0.41
4-11	9082252	*Perideridia gairdnerii*	9/17/02	Carbon	Winslow, S.R.	0.27
4-12	9087513	*Phacelia hastata*	8/6/05	Silver Bow	Garverich, M.	0.23
4-13	9087514	*P. hastata*	8/16/05	Madison	Ricketts, M.	0.23
4-14	9087530	*P. hastata*	7/21/05	Sublette, WY	Clause, K. & J. Hayward	0.23
4-15	9087531	*P. hastata*	8/5/05	Uinta, WY	Hunolt, A.	0.23
4-16	9087532	*P. hastata*	8/9/05	Lincoln, WY	Payne, W.	0.23
4-17	9087833	*P. hastata*	8/14/07	Lincoln, WY	Clause, K.	0.23
	9087515	*Platyschkuhria integrifolia*	8/2/05	Carbon	Majerus, M.	0.18

† Length 15 ft. unless otherwise stated.

Table 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. Species seeded at the BPMC in Field 2 on November 17, 2008; April 22, 2009; and March 10, 2010—Continued.

Row-Position-Length†	Accession	Genus & Species	Date Collected	County	Collector	Seeded
						gr
East-West, Row 5						
5-1	9087744	*Pulsatilla occidentalis*	6/12/06	Custer	Kilian, R. & M. Stoeber	0.36
5-2	9087850	*Tradescantia* spp.	-	Roosevelt	Kilian, R., K. Walstad, & T. Olsen	0.59
5-3-6 ft	9087570	*Sphaeralcea coccinea*	8/4/05	Golden Valley	Rouane, J.	0.22
East-West, Row 9						
R9P26	9087999	*Allium*	-	Carbon, WY	Little Snake River CD	0.70
R9P27	9088000	*Allium acuminatus*	-	Carbon, WY	Little Snake River CD	0.70
West-East, Row 10						
R10P1	9088001	*Allium textile*	7/7/08	Carbon, WY	Little Snake River CD	79.0
R10P2	9088003	*Lomatium foeniculaceum*	-	Carbon, WY	Little Snake River CD	1.00
R10P3	9088004	*Thelypodium*	-	Carbon, WY	Little Snake River CD	0.10
R10P4	9088144	*Agoseris glauca*	6/15/09	Carbon, WY	O'Leary, E. & S. Paavola, WY BLM	0.45
R10P5	9088005	*Penstemon*	7/31/09	Carbon, WY	Biasotti, V., WY BLM	0.27
R10P6	9088142	*Thermopsis rhombifolia*	8/12/09	Carbon, WY	O'Leary, E. & S. Paavola, WY BLM	4.23
R10P7	9088143	*T. rhombifolia*	8/5/09	Carbon, WY	O'Leary, E. & S. Paavola, WY BLM	4.25
Total Forbs	44 accessions	24 species				
Total Entries	88 accessions	35 species				

† Length 15 ft. unless otherwise stated.

IEP Row/Position/Species Code/Accession

R1P1 ASTRAG 9087816
R1P2 ASAG2 9087817
R1P3 ASPE5 9087741
R1P4 ASPE5 9087818
R1P5 ASCA11 9087401
R1P6 ASCR2 9063357
R1P7 ASCR2 9081970
R1P8 ASCR2 9087505
R1P9 ASCR2 9087536
R1P10 ASCR2 9087819
R1P11 ASDO 9087820
R1P12 ASFL2 9087821
R1P13 THRH 9078644
R1P14 THRH 9082253
R1P15 THRH 9082291
R1P16 THRH 9082292
R1P17 THRH 9087509
R1P18 THMO6 9087535
R1P19 THRH 9087841
R2P1 THRH 9087842
R2P2 THRH 9087843
R2P3 THRH 9087844
R2P4 THRH 9087845
R2P5 THRH 9087846
R2P6 THRH 9087847
R2P7 THRH 9087848
R2P8 THRH 9087849
R2P9 THRH 9087869
R2P10 THRH 9087870
R2P11 THRH 9087871
R2P12 TRGY 9087523
R2P13 TRGY 9087525
R2P14 VIAM 9087397
R2P15 VIAM 9087399
R2P16 VIAM 9087537
R2P17 VIAM 9087851
R2P18 VIAM 9087852
R2P19 VIAM 9087853
R2P20 VIAM 9087854
R3P1 VIAM 9087855
R3P2 VIAM 9087856
R3P3 VIAM 9087857
R3P4 VIAM 9087858
R3P5 VIAM 9087872
R3P6 AGGL 9087527
R3P7 AGGL 9087733
R3P8 AGGL 9087734
R3P9 ALTE 9087416
R3P10 ALLIUM 9087538
R3P11 CASE2 9087822
R3P12 ECAN 9087873
R3P13 HEUN 9087874
R3P14 LIPU 9058079
R3P15 LIPU 9076006
R3P16 LIPU 9082127
R3P17 LIPU 9087575
R3P18 LIPU 9087576
R3P19 LIPU 9087577
R4P1 LOMA3 9087823
R4P2 LODI 9087824
R4P3 PENST 9087831
R4P4 PEER 9087510
R4P5 PEER 9087511
R4P6 PEER 9087529
R4P7 PEER 9087875
R4P8 PEER 9087876
R4P9 PEGR7 9087832
R4P10 PENI 9087512
R4P11 PEGA 9082252
R4P12 PHHA 9087513
R4P13 PHHA 9087514
R4P14 PHHA 9087530
R4P15 PHHA 9087531
R4P15 PHHA 9087531
R4P16 PHHA 9087532
R4P17 PHHA 9087833
R4P18 PLINI 9087515
R5P1 PUOC 9087744
R5P2 TRADE 9087850
R5P3 SPCO 9087570
R5P4-R9P25 (SPCOCEP)
R9P26 ALLIU 9087999
R9P27 ALAC4 9088000
R10P1 ALTE 9088001
R10P2 LOFO 9088003
R10P3 THELY 9088004
R10P4 AGGL 9088144
R10P5 PENST 9088005
R10P6 THRH 9088142
R10P7 THRH 9088143

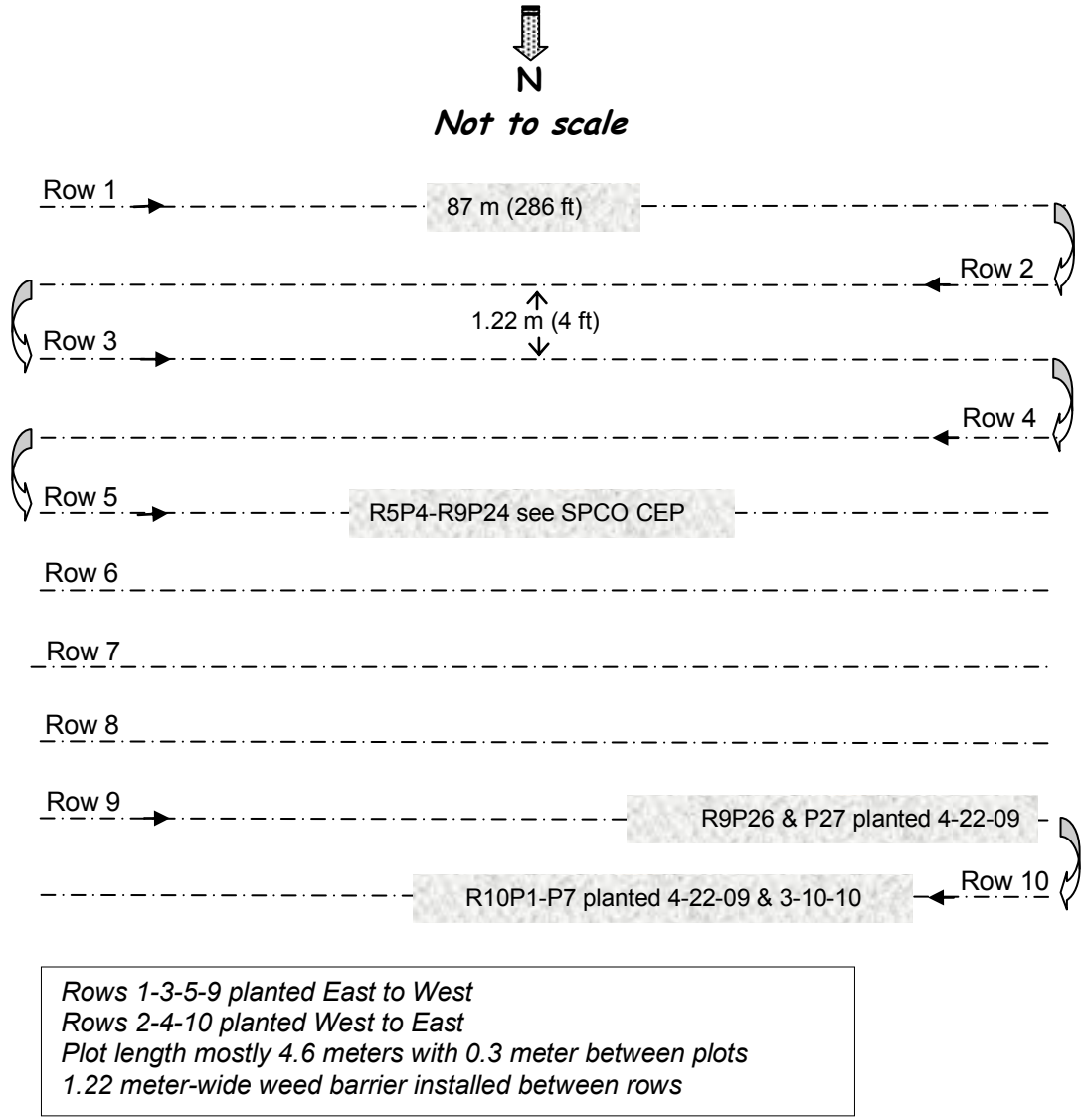


Figure 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2008-2010 establishment of 88 accessions of native forbs. Planted in Field 2 at the Bridger PMC. Planted Nov. 17, 2008; April 22, 2009; and March 10, 2010.

Table 2. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2010 evaluation of 88 accessions of native legumes and forbs. Planted in Field 2 at the Bridger PMC (see plot layout diagram for specific seeding dates).

Row/Plot	Accession	Genus & Species	Vigor†	Height	Seed Harvest
Plot length 15 ft. unless noted otherwise				*cm*	
Row 1					
East-West					
R1P1	9087816	*Astragalus*	-	0	
R1P-2 (2.4 ft.)	9087817	*Astragalus agrestis*	-	0	
R1P3	9087741	*Astragalus pectinatus*	4	29	4-Aug
R1P4	9087818	*A. pectinatus*	3	27	4-Aug
R1P5	9087401	*Astragalus canadensis*	-	0	
R1P6	9063357	*Astragalus crassicarpus*	6	13	21-Jul
R1P7	9081970	*A. crassicarpus*	3	11	21-Jul
R1P8	9087505	*A. crassicarpus*	7	8	21-Jul
R1P9 (2 ft.)	9087536	*A. crassicarpus*	6	8	
R1P10	9087819	*A. crassicarpus*	4	16	21-Jul
R1P11	9087820	*Astragalus douglasii*	6	25	21-Jul
R1P12	9087821	*Astragalus flexuosus*	2	19	21-Jul
R1P13	9078644	*Thermopsis rhombifolia*	2	53	
R1P14	9082253	*T. rhombifolia*	4	41	
R1P15	9082291	*T. rhombifolia*	-	0	
R1P16	9082292	*T. rhombifolia*	4	46	
R1P17	9087509	*T. rhombifolia*	3	47	
R1P18	9087535	*T. montana*	1	61	14-Jul
R1P19	9087841	*T. rhombifolia*	3	36	
Row 2					
West-East					
R2P1	9087842	*T. rhombifolia*	3	40	
R2P2	9087843	*T. rhombifolia*	3	43	
R2P3	9087844	*T. rhombifolia*	7	27	
R2P4	9087845	*T. rhombifolia*	4	43	
R2P5	9087846	*T. rhombifolia*	5	36	
R2P6 (6.7 ft.)	9087847	*T. rhombifolia*	6	31	
R2P7	9087848	*T. rhombifolia*	4	32	
R2P8 (13.8 ft.)	9087849	*T. rhombifolia*	5	24	
R2P9	9087869	*T. rhombifolia*	7	24	
R2P10	9087870	*T. rhombifolia*	7	26	
R2P11	9087871	*T. rhombifolia*	5	40	
R2P12	9087523	*Trifolium gymnocarpum*	-	0	
R2P13 (1 ft.)	9087525	*T. gymnocarpum*	-	0	
R2P14	9087397	*Vicia americana*	-	0	
R2P15	9087399	*V. americana*	5	19	27-Jul
R2P16 (10 ft.)	9087537	*V. americana*	-	0	
R2P17	9087851	*V. americana*	7	15	21-Jul
R2P18 (7.5 ft.)	9087852	*V. americana*	5	22	21-Jul
R2P19	9087853	*V. americana*	1	27	27-Jul
R2P20	9087854	*V. americana*	3	21	27-Jul

† Rated 1-9 with 1 best.

Table 2. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2010 evaluation of 88 accessions of native legumes and forbs. Planted in Field 2 at the Bridger PMC—Continued.

Row/Plot	Accession	Genus & Species	Vigor†	Height	Seed Harvest
				cm	
Plot length 15 ft. unless noted otherwise					
Row 3					
East-West					
R3P1	9087855	*Vicia americana*	5	18	21-Jul
R3P2	9087856	*Vicia spp.*	8	5	
R3P3	9087857	*V. americana*	3	18	21-Jul
R3P4 (1.6 ft.)	9087858	*V. americana*	-	0	
R3P5 (10 ft.)	9087872	*V. americana*	4	23	21-Jul
R3P6	9087527	*Agoseris glauca*	6	9	
R3P7 (6 ft.)	9087733	*A. glauca*	5	12	27-Jul
R3P8	9087734	*A. glauca*	-	0	
R4P9	9087416	*A. textile*	5	6	
R3P10 (9 ft.)	9087538	*Allium spp.*	5	6	
R3P11	9087822	*Castilleja sessiliflora*	-	0	
R3P12 (12 ft.)	9087873	*Echinacea angustifolia*	-	0	
R3P13	9087874	*Helianthella uniflora*	1	57	27-Jul
R3P14	9058079	*Liatris punctata*	6	12	
R3P15	9076006	*L. punctata*	5	31	
R3P16	9082127	*L. punctata*	-	0	
R3P17	9087575	*L. punctata*	9	2	
R3P18	9087576	*L. punctata*	8	5	
R3P19	9087577	*L. punctata*	-	0	
Row 4					
West-East					
R4P1	9087823	*Lomatium macrocarpum*	-	0	
R4P2	9087824	*Lomatium dissectum*	-	0	
R4P3	9087831	*Penstemon spp.*	1	33	4-Aug
R4P4	9087510	*Penstemon eriantherus*	3	32	27-Jul
R4P5	9087511	*P. eriantherus*	5	25	14-Aug
R4P6	9087529	*P. eriantherus*	4	32	27-Jul
R4P7	9087875	*P. eriantherus*	3	28	27-Jul
R4P8	9087876	*P. eriantherus*	6	22	4-Aug
R4P9	9087832	*Penstemon grandiflorus*	5	20	27-Jul
R4P10	9087512	*Penstemon nitidus*	1	36	27-Jul
R4P11	9082252	*Perideridia gairdnerii*	-	0	
R4P12	9087513	*Phacelia hastata*	5	27	27-Jul
R4P13	9087514	*P. hastata*	1	53	27-Jul
R4P14	9087530	*P. hastata*	1	23	4-Aug
R4P15	9087531	*P. hastata*	4	19	4-Aug
R4P16	9087532	*P. hastata*	4	26	4-Aug
R4P17	9087833	*P. hastata*	3	34	4-Aug
R4P18	9087515	*Platyschkuhria integrifolia*	-	0	

† Rated 1-9 with 1 best.

Table 2. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2010 evaluation of 88 accessions of native legumes and forbs. Planted in Field 2 at the Bridger PMC—Continued.

Row/Plot	Accession	Genus & Species	Vigor†	Height	Seed Harvest
				cm	
Plot length 15 ft. unless noted otherwise					
East-West, Row 5					
R5P1	9087744	Pulsatilla occidentalis	-	0	
R5P2	9087850	Tradescantia spp.	-	0	
R5P3 (6 ft.)	9087570	Sphaeralcea coccinea	-	0	
Row 9					
East-West					
R9P26	9087999	*Allium spp.*	-	0	
R9P27	9088000	*Allium acuminatus*	-	0	
Row 10					
West-East					
R10P1	9088001	*Allium textile*	6	7	
R10P2	9088003	*Lomatium foeniculaceum*	-	0	
R10P3	9088004	*Thelypodium spp.*	-	0	
R10P4	9088144	*Agoseris glauca*	-	0	
R10P5	9088005	*Penstemon*	-	0	
R10P6	9088142	*Thermopsis rhombifolia*	-	0	
R10P7	9088143	*T. rhombifolia*	-	0	

† Rated 1-9 with 1 best.

Appendix Table 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2010 phenology dates of 88 native forbs in Field 2 at the Bridger PMC.

Row/Plot	Accession	Genus & Species	3-3	3-30	4-12	4-21	4-28	5-5	6-9	6-18	7-1	7-14	7-21	7-27l	8-4	8-11	11-3	11-9
Plot length 15 ft. unless noted otherwise																		
Row 1 East-West																		
R1P1	9087816	*Astragalus*	none															
R1P-2 (2.4 ft.)	9087817	*Astragalus agrestis*	none															
R1P3	9087741	*Astragalus pectinatus*			E.G./U.L.				O.F									
R1P4	9087818	*A. pectinatus*	E.G.	U.L.			O.F.	O.F.	O.F	O.F.	O.F				R.F			
R1P5	9087401	*Astragalus canadensis*	none															
R1P6	9063357	*Astragalus crassicarpus*	E.G./U.L.					O.F.	O.F									
R1P7	9081970	*A. crassicarpus*	E.G./U.L.					O.F.										
R1P8	9087505	*A. crassicarpus*	E.G.	U.L.			O.F.	O.F.	O.F									
R1P9 (2 ft.)	9087536	*A. crassicarpus*	none															
R1P10	9087819	*A. crassicarpus*	E.G.				O.F.	O.F.	O.F									
R1P11	9087820	*Astragalus douglasii*				E.G./U.L.			O.F				R.F.	R.F.				
R1P12	9087821	*Astragalus flexuosus*	E.G.	U.L.					O.F	O.F.			R.F.	R.F.	R.F			
R1P13	9078644	*Thermopsis rhombifolia*	E.G.		U.L.		O.F.	O.F.										
R1P14	9082253	*T. rhombifolia*	E.G.		U.L.													
R1P15	9082291	*T. rhombifolia*			E.G.		U.L.											
R1P16	9082292	*T. rhombifolia*	E.G.		U.L.													
R1P17	9087509	*T. rhombifolia*	E.G.		U.L.													
R1P18	9087535	*T. montana*	E.G.		U.L.			O.F.	O.F	O.F.	O.F	R.F.	R.F.					
R1P19	9087841	*T. rhombifolia*	E.G.		U.L.			O.F.										
Row 2 West-East																		
R2P1	9087842	*Thermopsis rhombifolia*	E.G.		U.L.			O.F.										
R2P2	9087843	*T. rhombifolia*	E.G.		U.L.	O.F.	O.F.	O.F.										
R2P3	9087844	*T. rhombifolia*			E.G.													
R2P4	9087845	*T. rhombifolia*	E.G.		U.L.													
R2P5	9087846	*T. rhombifolia*		E.G.	U.L.													
R2P6 (6.7 ft.)	9087847	*T. rhombifolia*		E.G.	U.L.													
R2P7	9087848	*T. rhombifolia*	E.G.		U.L.													
R2P8 (13.8 ft.)	9087849	*T. rhombifolia*	E.G.		U.L.	O.F.	O.F.	O.F.										
R2P9	9087869	*T. rhombifolia*		E.G.	U.L.													
R2P10	9087870	*T. rhombifolia*	E.G.	U.L.														
R2P11	9087871	*T. rhombifolia*	E.G.	U.L.														

E.G. emerging growth
U.L. unfolded leaves
O.F. open flowers
R.F. ripe fruit

Appendix Table 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2010 phenology dates of 88 native forbs in Field 2 at the Bridger PMC—Continued.

Row/Plot	Accession	Genus & Species	3-3	3-30	4-12	4-21	4-28	5-5	6-9	6-18	7-1	7-14	7-21	7-27l	8-4	8-11	11-3	11-9
Plot length 15 ft. unless noted otherwise																		
R2P12	9087523	*Trifolium gymnocarpum*	none															
R2P13 (1 ft.)	9087525	*T. gymnocarpum*	none															
R2P14	9087397	*Vicia americana*	none															
R2P15	9087399	*V. americana*			E.G./U.L.					O.F.	O.F	O.F.	O.F.	R.F.				
R2P16 (10 ft.)	9087537	*V. americana*	none															
R2P17	9087851	*V. americana*			E.G./U.L.				O.F	O.F.	O.F	O.F.	R.F.					
R2P18 (7.5 ft.)	9087852	*V. americana*	E.G.	U.L.				O.F.	O.F	O.F.	O.F		R.F.					
R2P19	9087853	*V. americana*	E.G.	U.L.					O.F	O.F.	O.F			R.F.				
R2P20	9087854	*V. americana*	E.G.	U.L.					O.F	O.F.	O.F			R.F.				
Row 3 East-West																		
R3P1	9087855	*Vicia americana*	E.G./U.L.						O.F	O.F.			R.F.					
R3P2	9087856	*Vicia* spp.	E.G.						O.F									
R3P3	9087857	*V. americana*	E.G./U.L.				O.F.	O.F.	O.F	O.F.	O.F		R.F.					
R3P4 (1.6 ft.)	9087858	*V. americana*	none															
R3P5 (10 ft.)	9087872	*V. americana*	E.G.	U.L.					O.F	O.F.	O.F		R.F.					
R3P6	9087527	*Agoseris glauca*	E.G./U.L.							O.F.	R.F							
R3P7 (6 ft.)	9087733	*A. glauca*	E.G./U.L.							O.F.	O.F			R.F.				
R3P8	9087734	*A. glauca*	none															
R3P9	9087416	*Allium textile*	E.G./U.L.						O.F	O.F.								
R3P10 (9 ft.)	9087538	*Allium* spp.	none															
R3P11	9087822	*Castilleja sessiliflora*	none															
R3P12 (12 ft.)	9087873	*Echinacea angustifolia*	none															
R3P13	9087874	*Helianthella uniflora*			E.G./U.L.				O.F	O.F.	O.F			R.F.	R.F			
R3P14	9058079	*Liatris punctata*					E.G./U.L.								O.F	O.F.	O.F.	
R3P15	9076006	*L. punctata*			E.G.	U.L.									O.F	O.F.	O.F.	O.F.
R3P16	9082127	*L. punctata*	none															
R3P17	9087575	*L. punctata*				E.G.	U.L.											
R3P18	9087576	*L. punctata*				E.G.	U.L.											
R3P19	9087577	*L. punctata*	none															

E.G. emerging growth
U.L. unfolded leaves
O.F. open flowers
R.F. ripe fruit

Appendix Table 1. Initial Evaluation Planting of Native Forbs to Revegetate Disturbances. The 2010 phenology dates of 88 native forbs in Field 2 at the Bridger PMC—Continued.

Row/Plot	Accession	Genus & Species	3-3	3-30	4-12	4-21	4-28	5-5	6-9	6-18	7-1	7-14	7-21	7-27l	8-4	8-11	11-3	11-9
Plot length 15 ft unless noted otherwise																		
Row 4 West-East																		
R4P1	9087823	*Lomatium macrocarpum*	E.G.	U.L.														
R4P2	9087824	*Lomatium dissectum*	E.G./U.L.															
R4P3	9087831	*Penstemon* spp.	E.G./U.L.						O.F	O.F.	O.F	O.F.		R.F.	R.F	R.F.		
R4P4	9087510	*Penstemon eriantherus*	E.G./U.L.						O.F	O.F.	O.F			R.F.	R.F			
R4P5	9087511	*P. eriantherus*	E.G./U.L.						O.F	O.F.	O.F	O.F.			R.F	R.F.		
R4P6	9087529	*P. eriantherus*	E.G./U.L.						O.F	O.F.	O.F			R.F.	R.F			
R4P7	9087875	*P. eriantherus*	E.G./U.L.						O.F	O.F.	O.F			R.F.				
R4P8	9087876	*P. eriantherus*	E.G./U.L.						O.F	O.F.	O.F				R.F			
R4P10	9087512	*Penstemon nitidus*	E.G./U.L.			O.F.	O.F.	O.F.	O.F					R.F.				
R4P11	9082252	*Perideridia gairdnerii*	none															
R4P13	9087514	*Phacelia hastata*	E.G./U.L.						O.F	O.F.		R.F.	R.F.	R.F.				
R4P14	9087530	*P. hastata*	E.G./U.L.						O.F	O.F.	O.F	O.F.	O.F.	O.F.	R.F	R.F.		
R4P15	9087531	*P. hastata*	E.G./U.L.						O.F	O.F.	O.F	O.F.	O.F.	O.F.	R.F	R.F.		
R4P16	9087532	*Phacelia hastata*		E.G.					O.F	O.F.	O.F	O.F.	O.F.	O.F.	R.F	R.F.		
R4P17	9087833	*P. hastata*	E.G./U.L.						O.F	O.F.	O.F	O.F.	O.F.	O.F.	R.F	R.F.		
R4P18	9087515	*Platyschkuhria integrifolia*	none															
Row 5 East-West																		
R5P1	9087744	*Pulsatilla occidentalis*	none															
R5P2	9087850	*Tradescantia* spp.	none															
R5P3 (6 ft.)	9087570	*Sphaeralcea coccinea*	none															
Row 9 East-West																		
R9P26	9087999	*Allium* spp.	none															
R9P27	9088000	*Allium acuminatus*	none															
R10P1	9088001	*Allium textile*	E.G./U.L.					O.F.	O.F	O.F.	R.F							
R10P2	9088003	*Lomatium foeniculaceum*	none															
R10P3	9088004	*Thelypodium spp.*	none															
R10P4	9088144	*Agoseris glauca*	none															
R10P5	9088005	*Penstemon*	none															
R10P6	9088142	*Thermopsis rhombifolia*	none															
R10P7	9088143	*T. rhombifolia*	none															

E.G. emerging growth
U.L. unfolded leaves
O.F. open flowers
R.F. ripe fruit

II. INITIAL SEED INCREASE

Study Title: Initial Seed Increase

Study Number: NA

Objective: Increase seed supply of desirable species.

Project Description: Initial seed increase is the first step in increasing the seed supply of any accession. Through this project, small quantities of seed are made available for advanced testing, secondary increase, exchange with other researchers, and, in some cases, the replenishing of old seed having poor viability. There are three categories of Initial Seed Increase:

1. Seed Harvest from IEP/CEP Rows or Plots. Superior accessions in various Initial Evaluation Plantings (IEPs) and Comparative Evaluation Plantings (CEPs) are harvested to acquire as much seed as possible to establish larger seed-increase blocks. This is sometimes supplemented with seed from the original collection or additional seed harvested from the original collection site. Also, some collections are received as vegetative material and must be grown to create a seed supply.

2. Initial Seed Increase (ISI). This is larger-scale increase, usually seeded in 50 to 400 meters of row. Enough seed is produced for the establishment of Comparative Evaluation Plantings (CEPs), small-scale field testing, and establishment of secondary seed increase.

3. Breeder Seed. The Bridger PMC is responsible for maintaining breeder-quality seed of the cultivars it releases, as well as those maintained for Montana State University and the Agricultural Research Service, Logan, Utah. The seed from breeder blocks is used for the establishment of foundation seed fields only. Breeder blocks of the rhizomatous species are established by sprigging to maintain the original clonal material.

Methods and Materials: All ISI rows or blocks are fertilized in September of each year with 112 kilograms nitrogen per hectare (100 pounds per acre) and 45 kilograms phosphorus per hectare (40 pounds per acre). Supplemental water is applied as needed, either by sprinkler or furrow irrigation. Seed is harvested in a variety of ways, e.g., hand stripping, flail-vac, swathing seed heads onto a canvas, or swathing and combining with one of three different combines.

Results: In 2010, breeder blocks of two grass species and one shrub produced approximately 3.1 kg (7 lb) of clean seed (Table 1). There was no initial seed increase from NRCS plant materials projects.

Seed harvested from reimbursable projects totaled approximately 130 kg (286 lb), including approximately 92.1 kg (203 lb) from five grass species for Yellowstone National Park; approximately 25.8 kg (57 lb) from one grass and two forbs for Glacier National Park; and 15.3 kg (7 lb) from two grass/grass-like species, two forbs, and two shrubs for the DATR project.

Table 1. Initial Seed Increase. Seed harvested in 2010 from Breeder Blocks, Initial Evaluation Plantings, and Initial Seed Increase at the Bridger PMC.

Genus & Species	Accession	Field	Harvest Date	Clean Seed	
				lb	*kg*
Breeder Blocks (B.B.)					
Elymus lanceolatus	Critana	22	8/18	1.500	0.680
Krascheninnikovia lanata	Open Range	7W	10/22	2.328	1.056
Pascopyrum smithii	Rosana	2	9/14	2.000	0.908
P. smithii	Rosana	21	10/15	1.100	0.499
			B.B. Subtotal	6.928	3.143
Initial Evaluation Planting (IEP)					
Miscellaneous forbs	31 plots	2	June-September	3.721	1.688

Table 1. Initial Seed Increase. Seed harvested in 2010 from Breeder Blocks, Initial Evaluation Plantings, and Initial Seed Increase at the Bridger PMC--Continued.

Genus & Species	Accession	Field	Harvest Date	Clean Seed	
				lb	*kg*
Initial Seed Increase, Yellowstone Park (YNP)					
Agrostis scabra	9081342	21	7/26	65.633	29.771
Bromus marginatus	9076165	1	7/09	93.700	42.502
Elymus trachycaulus	9076211	1	7/27	12.216	5.541
E. trachycaulus	9081729	2	7/16	13.757	6.240
Hesperostipa comata	9081502	1	7/06-7/12	7.000	3.175
Pseudoroegneria spicata	9063432	1	7/20	0.139	0.063
P. spicata	9087860	2	7/21	9.458	4.290
P. spicata	9087860	21	8/06	1.312	0.595
			YNP Subtotal	203.215	92.177
Initial Seed Increase, Glacier Park (GNP)					
Eurybia conspicua	9087433	4S	unknown	0.840	0.381
Elymus glaucus	9087348	15	7/26	56.000	25.402
Symphyotrichum laevis	9081447	4N	unknown	0.110	0.050
			GNP Subtotal	56.950	25.833
ISI Development of Acid-Heavy Metal Tolerant Releases (DATR)					
Juncus balticus	9087653	4S	7/13	0.055	0.025
Juniperus horizontalis	9081968	23	9/20-10/01	2.205	1.000
Phacelia hastata	9081832	4S	8/09	0.123	0.056
P. hastata	9081832	15	7/30	3.800	1.723
Potentilla hippiana	9076274	4S	8/23-8/25	0.721	0.327
Prunus virginiana	9081326	19	8/12	0.434	0.197
Pseudoroegneria spicata	9081636	20SE	7/16	8.000	3.629
			DATR Subtotal	15.338	6.957
16 species	19 accessions	-	2010 Grand Total	286.15	129.798

III. SEED AND PLANT INCREASE

Study Title: Seed and Plant Increase—Seed Production of Foundation Seed Stocks

Objective:

Project Description: All seed increase activities take place at the USDA-NRCS Plant Materials Center near Bridger, Montana. The 140-acre research farm is set up for irrigated seed production of conservation plants for use in Montana and Wyoming. Breeders and Foundation seed of released plant materials are produced at the Bridger PMC for distribution to commercial seed growers throughout the Pacific Northwest and Northern Great Plains. The PMC is set up to utilize both sprinkler and furrow irrigation. Seed increase blocks or fields are established by direct seeding, transplanting of container-grown stock, and transplanting/establishment of seed production orchards (woody plant material). Special consideration must be given to properly isolate DATC project material from other releases or test material of the same species. Cross-pollinated species are isolated at least 900 feet apart, while self-fertilized species are isolated at least 100 feet apart.

Cultural Practices:

Seeding**.** All seeding is done with a two-row, double-disk planter equipped with depth bands to get a uniform 0.25- to 0.5-inch seeding depth. Seed is planted in rows spaced 30 inches apart to accommodate the gated pipe irrigation water delivery system. Depending on the species, planting is done either as a dormant-fall planting (Oct. 15 to Dec. 15) or as an early spring planting (April 1 to May 15). Seed that have a dormancy or after-ripening problem are dormant-fall seeded to get natural stratification.

Transplanting. For small lots of seed that need seed increase, the limited seed supply is planted into Cone-tainers™ and transplanted into fields following 6 months of growth under greenhouse conditions. A mechanical transplanter is used, resulting in uniform 14-inch within-row spacing. This method has been used on alpine bluegrass *Poa alpina*, western wheatgrass *Pascopyrum smithii*, bluebunch wheatgrass *Pseudoroegneria spicata*, fuzzy-tongue penstemon *Penstemon eriantherus*, silverleaf phacelia *Phacelia hastata*, wooly cinquefoil *Potentilla hippiana*, and tufted hairgrass *Deschampsia cespitosa*.

Woody Transplants. All woody material is container grown and transplanted as 2-0 stock into seed production orchards. In some cases, weed-barrier is used to reduce weed establishment within the rows; while in others, cultivation is used to keep the between-row spaces weed-free. Most shrubs will not initiate seed production until the plants are 5 to 6 years old.

Production Fields. Table 1 shows the species grown for foundation seed production in 2010. Some of the woody increase orchards have yet to reach the maturity level necessary for seed production, but seed will be harvested once these stands are productive. The seed will then be made available to other researchers and potentially released to the commercial plant production industry.

Weed Control. Mechanical weed control, either by cultivation or hand roguing, is the preferred method, but chemical weed control is often necessary. With everything established in rows, between-row cultivation can be easily accomplished with standard cultivators. All chemical applications need to be done prior to flowering or late in the season when plants are going dormant.

Fertilization. No fertilizers are added to field increase plots until fall of the first growing season and then every fall for the life of the stand. A standard mix of 80 lb N/acre and 40 lb P_2O_5/acre is used on most species. Fall applications are usually applied in granular form from Sept 15 to Oct. 15.

Irrigation. The Bridger area receives an average of only 11.3 inches of annual precipitation, making it necessary to provide supplemental water to improve seed production. Hand-moved sprinklers are available for plant establishment if natural precipitation is inadequate. Once established, furrow irrigation is generally used. Critical irrigation times are early summer prior to flowering, after pollination as seeds are maturing, and during the fall when seed head primordia are developing for the following year.

Table 1. Foundation and Breeders Seed Production, Bridger, Montana, 2010.

Genus & Species	Release Name	Harvest Date	Field Number	Field Size	Bulk Seed
				acres	*kg*
Achnatherum hymenoides	Rimrock	9/13	11	1.00	16.330
Alopecurus arundinaceus	Garrison	7/01	16	2.10	38.556
Calamovilfa longifolia	Goshen	-	12	0.75	-
Elymus lanceolatus	Critana	hayed	5/6	6.64	-
Elymus trachycaulus	Copperhead	7/22	15	0.78	45.360
Elymus trachycaulus ssp. trachycaulus	Pryor	7/23	18	2.50	81.648
Hierochloe odorata	Spirit Germplasm	-	4	0.06	-
Juniperus scopulorum	Bridger Select	2/14	14	2.77	1.030
Krascheninnikovia lanata	Open Range	2011	12	0.10	0.91-1.81
Leymus cinereus	Washoe	9/08	2	0.25	0.360
Leymus cinereus	Trailhead	8/26	17	3.80	18.144
Leymus multicaulis	Shoshone	9/07	20N	0.96	27.216
Leymus multicaulus	Shoshone	-	20SE	1.28	-
Onobrychis viciifolia	Delaney	-	16	1.85	-
Onobrychis viciifolia	Delaney	8/24	20SE	1.40	272.160
Onobrychis viciifolia	Delaney	11/02	18	1.40	13.154
Pascopyrum smithii	Rosana	9/14	27	0.41	6.804
Penstemon eriantherus	Old Works	8/2	15	0.22	4.990
Penstemon eriantherus	Old Works	7/21	4	0.10	0.116
Pinus ponderosa	Hunter Germplasm	-	19	1.71	-
Poa secunda	Opportunity	7/07	15	0.78	26.309
Poa secunda	Opportunity	7/02	20SE	0.24	9.979
Poa secunda	Opportunity	7/07	21	0.50	27.216
Psathyrostachys juncea	Bozoisky-Select	7/15	7E	2.25	14.515
Quercus macrocarpa	Ekalaka Germplasm	9/1-11/1	23	3.02	19.05
Shepherdia argentea	Mill Creek Germplasm	-	30/31	0.06	-
Symphoricarpos albus	Prospectors	8/16-9/15	19	0.44	0.180
Symphoricarpos occidentalis	Trapper Germplasm	-	3	0.25	-

Seed Harvest. Depending on the species, size of stand, and amount of seed, harvesting may be accomplished in a variety of ways. Seed can be hand stripped, direct combined, swathed/combined, or head harvested/dried/combined. Seed is harvested at a 20-30% moisture level and dried to <12% for cleaning and storage. Seed that is officially released and made available to commercial growers must meet standards established by the Montana Seed Growers Association and be analyzed for purity and germination by the Montana Seed Testing Laboratory at Montana State University.

Post-harvest Maintenance. Following harvest, seed production stands are mowed to remove excess biomass and stimulate tillering. The stands are also cultivated prior to fall fertilization and irrigation.

Seed Cleaning. A variety of standard seed cleaning equipment is utilized to clean all the seed, both wildland collections and field seed increase. A hammermill is used to further thresh seed or remove appendages. Three different sizes of screen-fanning mills are available for cleaning seed based on size, shape, and weight. An indent cylinder is used to remove round weed seed from elongated grass seed and a small gravity table is used to make separations based on specific gravity.

Seed Storage. All smaller lots of cleaned seed are stored in cloth-mesh bags on shelves in the basement of the office building and in the seed barn at the Bridger PMC. The ambient conditions at Bridger are quite good for seed storage, as there is consistently low relative humidity and uniform cool temperatures in the basement environment. Under these conditions most native seeds will remain viable for up to 10 years. Large lots are stored in metal bins in the seed barn.

Seed Accessioning and Inventory. The USDA-NRCS Plant Materials nation-wide network utilizes POMS (Plant Materials Operation and Management System) for the accessioning, inventory, and distribution of all lots of seed and plants handled through the Plant Materials network. All seed in small lots is inventoried to the nearest gram, and large lots are inventoried to the nearest pound.

Study Title: Seed and Plant Increase—Seed Distribution of Foundation Seed Stocks

Objective:

Project Description: Several classes of seed were distributed from the Bridger PMC including foundation, field plant, and common, along with packets of seed for research and demonstration plantings. Additional information on the miscellaneous seed orders is available upon request.

In 2010, the PMC assembled and distributed 40 foundation seed orders. There were 103 lots of 24 releases, representing 22 species, sent throughout the western United States. There were an additional four seed orders of a variety of species distributed to miscellaneous cooperators for conservation applications (Table 1).

Table 1. Seed Distribution. Species and amounts of foundation seed distributed from the Bridger PMC during 2010 (40 D&Ds).

Accession	Release Name	Genus & Species	Lot Number	D&D Number	Shipped To	Amt. Shipped	
66515	Lutana	Astragalus cicer (ASCI4) / cicer milkvetch	SFD-01-FLD16	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	91.04 g	99 g
66515	Lutana	Astragalus cicer (ASCI4) / cicer milkvetch	SFD-01-FLD16	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT	156.10 g	161 g
66515	Lutana	Astragalus cicer (ASCI4) / cicer milkvetch	SFD-01-FLD16	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	1.05 lb	1.08 lb
109452	Largo	Thinopyrum ponticum (THPO7) / rush wheatgrass	SFD-04-F12	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	1 lb	1.06 lb
150123	Jose	Thinopyrum ponticum (THPO7) / rush wheatgrass	SFD-02-F16	MTPMC-10-060 / 12/8/2010	Robert Dunn / Bozeman,MT	116.22g	129.3 g
346419	Wytana	Atriplex aptera (ATAP) / moundscale	SFD-03-FLD011	MTPMC-10-060 / 12/8/2010	Robert Dunn / Bozeman,MT	196.82 g	556 g
346419	Wytana	Atriplex aptera (ATAP) / moundscale	SFD-87-FLD101	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	0.79 lb	2.28 lb
346419	Wytana	Atriplex aptera (ATAP) / moundscale	SFD-87-FLD101	mTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	4 g	11.49 g
346419	Wytana	Atriplex aptera (ATAP) / moundscale	SFD-87-FLD101	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	113.48 g	326 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-06-	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	2 g	2.11g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-09-FLD18	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	113.67g	124 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-09-FLD18	MTPMC-10-039 / 6/22/2010	Mike Moore / Powell,WY	110 lb	119.99 lb
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-09-FLD18	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	1.2 lb	1.316 lb
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-09-FLD18	MTPMC-10-057 / 10/19/2010	Upper Colorado EPC, Meeker,CO /	0.5 lb	0.55 lb
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-07-FLD18	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	2.25 lb	2.33 lb
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-06-	MTPMC-10-036 / 6/2/2010	Bob Sandlund / Grangeville,ID	0.5 lb	0.53 lb
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-06-	MTPMC-10-010 / 5/24/2010	Tracy Cumber / Glasgow,MT	0.5 g	0.53 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-05-FLD251	MTPMC-10-060 / 12/8/2010	Robert Dunn / Bozeman,MT	68.735 g	71.8 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus (ELTRT) / slender wheatgrass	SFD-07-FLD18	MTPMC-10-011 / 4/7/2010	Mark / Pullman,WA	6 lb	6.21lb
433949	Goshen	Calamovilfa longifolia (CALO) / prairie sandreed	SFD-00-Fld131	MTPMC-10-002 / 3/26/2010	Brett Allen / Sidney,MT	10 lb	10.81 lb
433949	Goshen	Calamovilfa longifolia (CALO) / prairie sandreed	SFD-02-FLD132	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT /	113.07 g	142 g
434040	Shoshone	Leymus multicaulis (LEMU11) / manystem wildrye	SFD-09-FLD20N	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.6 lb	0.62 lb
434040	Shoshone	Leymus multicaulis (LEMU11) / manystem wildrye	SFD-09-FLD20N	MTPMC-10-060 / 12/8/2010	Robert Dunn / Bozeman,MT	36.43 g	37.5 g

Table 1. Seed Distribution. Species and amounts of foundation seed distributed from the Bridger PMC during 2010 (40 D&Ds)—Continued.

Accession	Release Name	Genus & Species	Lot Number	D&D Number	Shipped To	Amt. Shipped	
434444	Salado	Sporobolus airoides (SPAI) / alkali sacaton	SFD-06-F11&19	MTPMC-10-060 / 12/8/2010	Robert Dunn / Bozeman,MT	225.19 g	254.01 g
436704	Garrison	Alopecurus arundinaceus (ALAR) / creeping meadow foxtail	SFD-07-FLD16	MTPMC-10-030 / 5/12/2010	USDA-NRCS Gillette FO / Gillette,WY	6 lb	6.56 lb
436704	Garrison	Alopecurus arundinaceus (ALAR) / creeping meadow foxtail	SFD-07-FLD16	MTPMC-10-011 / 4/7/2010	Mark / Pullman,WA	3 lb	3.28 lb
436704	Garrison	Alopecurus arundinaceus (ALAR) / creeping meadow foxtail	SFD-06-FLD16	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.3 lb	0.32 lb
436704	Garrison	Alopecurus arundinaceus (ALAR) / creeping meadow foxtail	SFD-05--FLD161	MTPMC-10-016 / 5/10/2010	USDA-NRCS Gillette FO / Gillette,WY	30.57 lb	32.04 lb
436704	Garrison	Alopecurus arundinaceus (ALAR) / creeping meadow foxtail	SFD-07-FLD16	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT /	63.08 g	69 g
445972	Appar	Linum lewisii (LILE3) / prairie flax	SFD-01-8LOT2	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	0.63 lb	0.68 lb
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-06-FLD5-6E	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.6 lb	0.64 lb
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-09-FLD5/6E	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	1.2 lb	1.26 lb
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-09-FLD5/6E	MTPMC-10-004 / 3/1/2010	Mike Foreman / Powell,WY	100 lb	105.15 lb
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-09-FLD5/6E	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	113.18 g	119 g
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-09-FLD5/6E	MTPMC-10-005 / 3/1/2010	Dwight Gilbert / Powell,WY	120 lb	126.17 lb
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-09-FLD5/6E	MTPMC-10-042 / 8/10/2010	Gord / Townsend,MT	125.94 lb	132.42 lb
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	3 g	3.33 g
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-09-FLD27	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	113.33 g	122 g
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-10-057 / 10/19/2010	Upper Colorado Environmental Plant Center / Meeker,CO	0.5 lb	0.55 lb
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-10-036 / 6/2/2010	Bob Sandlund / Grangeville,ID	0.5 lb	0.55 lb
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.8 lb	0.89 lb
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	2 g	2.12 g
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-06-	MTPMC-10-019 / 4/27/2010	Bridger PMC Bridger,MT /	142.77 g	161 g
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-06-	MTPMC-10-028 / 5/10/2010	Ken Borcher / Powell,WY	80 lb	90.21 lb
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-06-	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	1.4 lb	1.58 lb

Table 1. Seed Distribution. Species and amounts of foundation seed distributed from the Bridger PMC during 2010 (40 D&Ds)—Continued.

Accession	Release Name	Genus & Species	Lot Number	D&D Number	Shipped To	Amt. Shipped	
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-04-FLD171	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT	72.97 g	85 g
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	113.20 g	120 g
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-10-057 / 10/19/2010	Upper Colorado Environmental Plant Center / Meeker,CO	0.5 lb	0.53 lb
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-10-010 / 5/24/2010	Tracy Cumber / Glasgow,MT	0.5 g	0.53g
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-08-065 / 5/26/2010	Larry Holzworth / Bozeman,MT	0.28 lb	0.3 lb
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-06-	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.6 lb	0.68 lb
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian ricegrass	SFD-04-FLD181	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT	134.67 g	193 g
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian ricegrass	SFD-03-FLD181	MTPMC-10-003 / 2/19/2010	John Larson / Watertown,SD	0.95 lb	1 lb
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian ricegrass	SFD-03-FLD201	MTPMC-10-010 / 5/24/2010	Tracy Cumber / Glasgow,MT	0.5 g	0.51 g
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian ricegrass	SFD-03-FLD201	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	2 lb	2.02 lb
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian ricegrass	SFD-04-FLD201	MTPMC-10-032 / 5/17/2010	M. Dean Stacy / Price,UT	7 lb	7.08 lb
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian ricegrass	SFD-03-FLD201	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	1.5 g	1.52 g
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-05-FLD021	MTPMC-10-046 / 8/19/2010	Bridger PMC Bridger,MT	2.34 lb	2.37 lb
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.18 lb	0.19 lb
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	1.4 lb	1.46 lb
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	2.2 lb	2.25 lb
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-002 / 3/26/2010	Brett Allen / Sidney,MT	5 lb	5.21 lb
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-049 / 9/2/2010	Stacey Plummer / Connell,WA	12 lb	12.38 lb
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-034 / 5/17/2010	Rory Karhu / Powell,WY	57.13 g	59.54 g
478834	Antelope	Dalea candida (DACA7) / white prairie clover	SFD-06-FLD131	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	91.13 g	94 g
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian wildrye	SFD-07-FLD7E	MTPMC-10-012 / 4/12/2010	Evan Van Order / Hardin,MT	0.5 lb	0.57 lb
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian wildrye	SFD-08-FLD7E	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	1.5 g	1.62 g
9057902	Great	Achillea millefolium var. occidentalis (ACMIO) / western yarrow	SFD-05-FLD011	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT	67.15 g	73 g
9057902	Great	Achillea millefolium var. occidentalis (ACMIO) / western yarrow	SFD-06-FLD241	MTPMC-10-034 / 5/17/2010	Rory Karhu / Powell,WY	3.44 g	4.01 g
9057902	Great	Achillea millefolium var. occidentalis (ACMIO) / western yarrow	SFD-06-FLD241	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	0.2 lb	0.23 lb
9057902	Great	Achillea millefolium var. occidentalis (ACMIO) / western yarrow	SFD-06-FLD241	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	0.1 g	0.12 g

Table 1. Seed Distribution. Species and amounts of foundation seed distributed from the Bridger PMC during 2010 (40 D&Ds)—Continued.

Accession	Release Name	Genus & Species	Lot Number	D&D Number	Shipped To	Amt. Shipped	
9057902	Great	Achillea millefolium var. occidentalis (ACMIO) / western yarrow	SFD-05-FLD011	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	90.78 g	104 g
9057902	Great	Achillea millefolium var. occidentalis (ACMIO) / western yarrow	SFD-06-FLD221	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	0.5 lb	0.52 lb
9063535	Open Range	Krascheninnikovia lanata (KRLA2) /	SFD-09-FLD12	MTPMC-10-061 / 11/15/2010	Robert Dunn / Bozeman,MT	0 g	7 g
9063535	Open Range	Krascheninnikovia lanata (KRLA2) /	SFD-09-FLD12	MTPMC-10-060 / 12/8/2010	Robert Dunn / Bozeman,MT	0 g	42.5 g
9063535	Open Range	Krascheninnikovia lanata (KRLA2) /	SFD-09-FLD12	MTPMC-10-062 / 12/8/2010	Bridger PMC Bridger,MT	0 g	100 g
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT	91.62 g	100 g
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-05-FLD161	MTPMC-10-010 / 5/24/2010	Tracy Cumber / Glasgow,MT	0.5 g	0.61 g
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-05-FLD161	MTPMC-10-019 / 4/27/2010	Bridger PMC Bridger,MT	52.78 g	64 g
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-10-023 / 4/30/2010	Brian Mealor / Laramie,WY	0.25 g	0.27 g
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	0.5 lb	0.55 lb
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-10-053 / 9/20/2010	Nancy Shaw / Boise,ID	1.01 g	1.1 g
9078631	Bridger	Juniperus scopulorum (JUSC2) / Rocky Mountain juniper	SFD-09-FLD14	MTPMC-10-021 / 4/30/2010	John Justin / Missoula,MT	3 lb	3.57 lb
9078631	Bridger	Juniperus scopulorum (JUSC2) / Rocky Mountain juniper	SFD-09-FLD14	MTPMC-10-022 / 4/30/2010	Don Regan / Moscow,ID	1.5 lb	1.79 lb
9078666	Foot Hills	Poa compressa (POCO) / Canada bluegrass	SFD-07-FLD6	MTPMC-10-046 / 8/19/2010	Bridger PMC Bridger,MT	0.26 lb	0.27 lb
9081620	Copperhead	Elymus trachycaulus (ELTR7) / slender wheatgrass	SFD-07-	MTPMC-09-032 / 4/28/2010	Ken Borcher / Powell,WY	24 lb	24.64 lb
9081627	Washoe	Leymus cinereus (LECI4) / basin wildrye	SFD-03-DATC-	MTPMC-10-020 / 4/28/2010	Beth Graham / Bridger,MT	0.8 lb	0.88 lb
9081627	Washoe	Leymus cinereus (LECI4) / basin wildrye	SFD-04-DATC-	MTPMC-09-032 / 4/28/2010	Ken Borcher / Powell,WY	8.56 lb	9 lb
9081627	Washoe	Leymus cinereus (LECI4) / basin wildrye	SFD-04-DATC-	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	113.87 g	121 g
9081631	Old Works	Penstemon eriantherus (PEER) / fuzzytongue penstemon	SFD-06-DATC-	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	0.27 lb	0.37 lb
9081631	Old Works	Penstemon eriantherus (PEER) / fuzzytongue penstemon	SFD-06-DATC-	MTPMC-10-059 / 11/3/2010	Bill Kayser and Kathy Allen / Upper Black Eddy,PA	0.5 lb	0.68 lb
9081633	Opportunity	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-DATC-	MTPMC-10-053 / 9/20/2010	Nancy Shaw / Boise,ID	0.99 g	1.1 g
9081633	Opportunity	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-DATC-	MTPMC-09-032 / 4/28/2010	Ken Borcher / Powell,WY	4 lb	4.41 lb
9081633	Opportunity	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-DATC-	MTPMC-10-009 / 4/2/2010	Derek Tilley / Aberdeen,ID	120 g	132.18 g
9081843	Hunter	Pinus ponderosa (PIPO) / ponderosa pine	SFD-06-FLD19	MTPMC-10-068 / 12/29/2010	Joe Scianna / Bridger,MT	28.72 g	48 g
9081843	Hunter	Pinus ponderosa (PIPO) / ponderosa pine	SFD-09-FLD19	MTPMC-10-013 / 4/9/2010	John Justin / Missoula,MT	0.68 lb	1 lb
9081843	Hunter	Pinus ponderosa (PIPO) / ponderosa pine	SFD-06-FLD19	MTPMC-10-018 / 4/27/2010	Bridger PMC Bridger,MT	16.76 g	28 g
9081843	Hunter	Pinus ponderosa (PIPO) / ponderosa pine	SFD-09-FLD19	MTPMC-10-014 / 4/30/2010	Dwight Walton / Florence,MT	0.68 lb	1 lb
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-03-FLD06W1	MTPMC-10-010 / 5/24/2010	Tracy Cumber / Glasgow,MT	0.5 g	0.53 g
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-03-FLD06W1	MTPMC-10-046 / 8/19/2010	Bridger PMC Bridger,MT	1.17 lb	1.24 lb

Table 1. Seed Distribution. Species and amounts of foundation seed distributed from the Bridger PMC during 2010 (40 D&Ds)—Continued.

Accession	Release Name	Genus & Species	Lot Number	D&D Number	Shipped To	Amt. Shipped	
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-03-FLD06W1	MTPMC-10-007 / 3/29/2010	Steve Ferschweiler / Hubbard,OR	5 lb	5.29 lb
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-06-FLD131	MTPMC-10-029 / 5/10/2010	USDA-NRCS Buffalo FO / Buffalo,WY	0.8 lb	0.81 lb
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-06-FLD131	MTPMC-10-043 / 8/18/2010	Ed Galazzo / Bend,OR	5 lb	5.07 lb
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-06-FLD131	MTPMC-10-034 / 5/17/2010	Rory Karhu / Powell,WY	32 g	32.47 g
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-06-FLD131	MTPMC-10-048 / 8/31/2010	Derek Tilley / Aberdeen,ID	90.68 g	92 g
9081988	Stillwater	Ratibida columnifera (RACO3) / upright prairie coneflower	SFD-07-FLD13	MTPMC-10-056 / 10/18/2010	Jim Jacobs / Bozeman,MT	0.7 lb	0.77 lb
9087640	Delaney	Onobrychis viciifolia (ONVI) / sainfoin	SFD-08-	MTPMC-10-035 / 6/1/2010	Steve Parr / Meeker,CO	199.82 g	254 g
9087732	Ekalaka	Quercus macrocarpa (QUMA2) / bur oak	VFD-10-CF	MTPMC-10-010 / 5/24/2010	Tracy Cumber / Glasgow,MT	5 ea	
9087732	Ekalaka	Quercus macrocarpa (QUMA2) / bur oak	SFD-09-FLD23	MTPMC-10-022 / 4/30/2010	Don Regan / Moscow,ID	0 lb	10 lb
9087732	Ekalaka	Quercus macrocarpa (QUMA2) / bur oak	SFD-09-FLD23	MTPMC-10-021 / 4/30/2010	John Justin / Missoula,MT	0 lb	43.5 lb

IV. COMPARATIVE EVALUATION PLANTINGS (CEPs)

Study Title: Woody Comparative Evaluation Planting – Mill Creek Study (Development of Acid and Heavy Metal Tolerant Releases (DATR) Project)

Study Number: MT-00-0006

Study Objective: To compare the performance of local seed sources of woody plants to non-local seed sources at a non-amended site in Anaconda, Montana.

Introduction: This report summarizes the plant performance of the Woody Comparative Evaluation Planting (CEP) installed in the fall of 2000 at the Anaconda Smelter Superfund Site. One of the most impacted areas is the approximately 18 square miles of uplands within the Anaconda Smelter Superfund Site. The uplands are commonly derived from the weathering of bedrock and are typically thin, clay-rich alfisols. Due to the susceptibility of these soils to erosion by wind and water, the soil surface in many areas has eroded away and the subsoil, which is now exposed at the surface, continues to erode. Original vegetation in the uplands consisted primarily of shrub lands with coniferous forests above approximately 5,800 feet (Keammerer, 1995). In an effort to stem the transport of contaminants and restore these injured areas, state and federal regulatory agencies have developed several reclamation alternatives, many of which include the planting of shrubs and trees in the uplands.

History: The low pH soils at the Anaconda Smelter Superfund Site are routinely ameliorated by incorporating lime; however, non-uniform lime incorporation, as well as the upward migration of acid-producing compounds, results in pockets of acidity. Additionally, many steeply sloped areas are not accessible to heavy equipment making them difficult to amend. Research has demonstrated that metal-tolerant plants can be used to stabilize and immobilize contaminants in the soil (Smith and Bradshaw, 1972; Bradshaw et al., 1978). Metals are absorbed and accumulated by roots, adsorbed onto roots, or precipitated within the rhizosphere, thereby trapping contaminants in the soil and breaking the soil-plant-animal cycle.

Numerous demonstration projects over the last 50 years at the Anaconda Smelter Superfund Site have tested the performance of several woody plant species in diverse edaphic conditions (Dutton, 1992; Eliason, 1959; Gordon, 1984; Reclamation Research Unit and Schafer and Associates, 1993; Reclamation Research Unit, 1997). The study builds on previous research findings by testing accessions (ecotypes) of woody plant species that have shown adaptations to low pH and heavy-metal contaminated soils. The study's objective is to identify acid and heavy-metal-tolerant native plant ecotypes that provide erosion control and wildlife habitat.

Study entries include "local" germplasm originated from seed collected on nearby mine-affected soils in Deer Lodge County, Montana, as well as "non-local" germplasm originated from seed collected on non-impacted lands in various counties of Montana, Colorado, South Dakota, Utah, and Wyoming. Seedlings of 19 accessions of 7 woody species including *Pinus contorta* lodgepole pine (PICO), *Pinus ponderosa* ponderosa pine (PIPO), *Shepherdia argentea* silver buffaloberry (SHAR), *Rosa woodsii* Woods' rose (ROWO), *Symphoricarpos albus* common snowberry (SYAL), *Symphoricarpos occidentalis* western snowberry(SYOC), and *Ribes cereum* wax currant (RICE) were transplanted into a common garden in a randomized complete block design.

Study Site: The 0.4-acre study site, located approximately four miles southeast of Anaconda, Montana, has been impacted by emission fallout from the Upper and Lower Works as well as the Washoe smelter. From 1884 to 1902 the Upper and Lower Works smelters operated, after which the Washoe smelter operated until 1980. The study site lies about 200 yards east of Mill Creek at an elevation of 5,140 feet in USDA Plant Hardiness Zone 4a. Soils at the site are in the Haploboroll's Family and consist of deep, well-drained soils formed in mixed alluvium composed of granitic, meta-sedimentary, and volcanic rocks. The alluvium is derived from the Mill Creek drainage. Cobbles and stones commonly occur on the soil surface.

In 1999, the site was plowed to a depth of 6 inches, rototilled, and packed. Laboratory analysis of four (0- to 6-inch) composite soil samples taken after tilling to 6 inches indicated an average pH of 4.53.

Average arsenic, cadmium, copper, lead, and zinc concentrations in the four soil samples were 423 mg/kg, 6 mg/kg, 510 mg/kg, 233 mg/kg, and 308 mg/kg, respectively (Table 1).

Table 1. Acid extractable heavy-metal levels (EPA method 3050) and pH of 0- to 6-inch composite samples.

Sample No.	pH *s.u.*	As *mg/kg*	Cd *mg/kg*	Cu *mg/kg*	Pb *mg/kg*	Zn *mg/kg*
A.T. 0-6" NE	4.0	610	7	620	320	370
A.T. 0-6" NW	4.9	360	5	340	120	222
A.T. 0-6" SE	4.6	530	5	340	150	200
A.T. 0-6" SW	4.6	190	7	740	340	440
x Mean	4.53	422.5	6	510	232.5	308
Phytotoxic Criteria†	< 5.0	136-315	5.1-20	236-750	94-250	196-240

† EPA phytotoxicity standards (CDM Federal 1997).

Methods and Materials: The study tested 19 accessions consisting of two or three accessions of each of the seven shrub/tree species (Table 2). The 1-0 and 2-0 (6- to 12-inch) seedlings were transplanted in a Randomized Complete Block Design replicated 20 times on October 18, 2000. An individual plant of each accession is represented in each replication. The seedlings are spaced 4.5 feet apart within rows and 9 feet apart between rows. The plot receives no supplemental irrigation. Vispore™ (3-ft x 3-ft) tree mats were installed the spring following planting on all entries to suppress weeds and retard soil moisture evaporation.

Plant survival, height, and vigor were evaluated in 2001 (May 21 and August 14), 2002 (May 20 and August 20), 2003 (May 28 and August 26), 2004 (June 30), 2005 (August 29), 2006 (August 28), 2007 (August 21) 2008 (August 24), 2009 (September 7) and in 2010 (September 13). Plant height is measured in centimeters to the top of live foliage. Vigor rating is measured on a scale of 1 to 9, with 1 representing excellent vigor and 9 representing near plant mortality.

Anaconda's 30-year average annual precipitation is 13.93 inches. The site was quite dry the year of establishment (2000—9.57 inches), but subsequent years were near or above normal, as shown below, and reported at the National Oceanic and Atmospheric Administration's climatological station in Anaconda:

2001—13.99 inches
2002—16.23 inches
2003—15.42 inches
2004—13.37 inches
2005---15.75 inches
2006—19.03 inches
2007---16.47 inches
2008---16.89 inches
2009---18.79 inches
2010---18.65 inches

Table 2. Seed origin ([1]) and elevation of entries in the Woody Comparative Evaluation Planting.

Family/Species	Seed Origin	Elevation
		feet
Caprifoliaceae:		
Symphoricarpos albus (L.) Blake	**Deer Lodge Co., MT**	**6000**
S. albus (L.) Blake	Ravalli Co., MT	3500
***S. occidentalis* Hook.**	**Deer Lodge Co., MT**	**5559**
S. occidentalis Hook	CO Seed Source	unknown
S. occidentalis Hook	Weston Co., WY	5000
Elaeagnaceae:		
***Shepherdia argentea* (Pursh) Nutt.**	**Deer Lodge Co., MT**	**6000**
S. argentea (Pursh) Nutt.	UT Seed Source	unknown
S. argentea (Pursh) Nutt.	Sweetwater Co., WY	6000
Grossulariaceae:		
***Ribes cereum* Dougl.**	**Deer Lodge Co., MT**	**5700**
R. cereum Dougl.	Chaffee Co., CO	8000
Pinaceae:		
***Pinus contorta* Dougl. ex Loud.**	**Deer Lodge Co., MT**	**6400**
P. contorta Dougl. ex Loud.	Albany Co., WY	9500
P. contorta Dougl. ex Loud.	Custer Co., ID	6300
***P. ponderosa* P. & C. Lawson**	**Deer Lodge Co., MT**	**5850**
P. ponderosa P. & C. Lawson	Lawrence Co., SD	5500
P. ponderosa P. & C. Lawson	San Juan Co., CO	8000
Rosaceae:		
Rosa woodsii	**Deer Lodge Co., MT**	**5168**
R. woodsii	Ravalli Co., MT	3400
R. woodsii	Pueblo Co., CO	6000

[1] Local seed source entries are indicated in **bold** in Table 2.

Results:

Survival - Overall mean percent survival of the entries in the Mill Creek Woody CEP has decreased over time (Table 3) as the edaphic conditions have likely affected the tree and shrub health. The site has received no maintenance since early establishment, and has received only natural precipitation for plant survival. It must be emphasized that the results of this CEP provide valuable information regarding plant adaptation to the presence of low pH and heavy metals in soil, as site prep included only tilling, with no fertilizer or pH amendment.

There are instances where mean percent survival had increased from 2009 to 2010. In cases of increasing percentage survival over time, seedlings appearing dead at evaluation time produced a sucker or latent bud the following year. If only one tree or shrub in a species entry appears dead in 2009, but has growth in 2010, the percentage survival increases by 5 percent. Environmental stresses from edaphic and climatic conditions resulted in decreasing survival for all species and seed sources tested over the course of the study. An increase was evident in the mean percent survival of local and non-local accessions of ponderosa pine, silver buffaloberry, and common snowberry. It should be noted the test site was exceptionally dry the year of establishment (9.57 inches), but subsequent years were near or above the long-term average (13.93 inches). Fluctuating annual precipitation did not appear to be a major factor in seedling survival.

In all species except *Symphoricarpos occidentalis* (western snowberry) the "local" source (bolded line entries in Table 3) had equal or better survival than the "nonlocal" sources. The superior accessions included *Pinus ponderosa* (Deer Lodge County, MT), *P. ponderosa* (Lawrence County, SD), *Ribes cereum* (wax currant from Deer Lodge County, MT), *Symphoricarpos albus* (common snowberry from Deer Lodge County, MT), and *Shepherdia argentea* (siver buffaloberry Deer Lodge County, MT). The common snowberry is Prospector's Germplasm common snowberry, a pre-varietal release in 2003. In 2010, the 9081334 accession was released as Mill Creek Germplasm silver buffaloberry based upon its superior performance in the Mill Creek CEP, as well as in a seed orchard at the PMC in Bridger, Montana.

In 2010, the percentage survival of the local accessions of all species averaged 54.3 percent, in comparison to 26.3 percent among the non-local species.

Height - Mean height data appears in Table 4. In all entries except for a non-local western snowberry, the mean height increased from 2009 to 2010, indicating continued growth. In 2009, a beetle infestation of many snowberry plants was noted during the field evaluation and may be the cause of the decreased growth between the two years. In 2010, the plants looked much healthier at the time of evaluation.

Generally, the local source materials outgrew the nonlocal materials except for the two snowberry species, *Symphoricarpos albus* and *Symphoricarpos occidentalis,* and the ponderosa pine. The accessions with the greatest sustained growth were *Shepherdia argentea* silver buffaloberry (Deer Lodge County), *Rosa woodsii* Wood's rose (Deer Lodge County), *Symphoricarpos albus* common snowberry (Ravalli County) and *Ribes cereum* wax currant (Deer Lodge County). The local accession of silver buffaloberry, the Mill Creek Germplasm release, exhibited the greatest overall height and growth, with a mean height of 105.25 cm, and growth of 19.89 cm between 2009 and 2010.

Based on survival and growth, the best overall performing species have been *Pinus ponderosa, Symphoricarpos albus, Shepherdia argentea, Ribes cereum, and Rosa woodsii.* All accessions of *Pinus contorta* have performed poorly, despite a greater height in 2009 of the local accession over the non-local accession.

Vigor Rating - Mean vigor rating results are reported in Table 5. Vigor rating was evaluated on a scale from 1 to 9 (1=best vigor) based on a visual assessment of live plant vigor or robustness. Dead plants were entered as missing values. The vigor rating for local source materials was somewhat better among some species than the nonlocal source materials, but not significantly so, as demonstrated by the lodgepole pine (5.33 vs. 6.00) and wax currant (3.83 vs. 4.71). The Mill Creek Germplasm silver

buffaloberry had significantly better mean vigor (4.25) than a Wyoming source (7.00) but did little better in vigor rating than a Utah source (4.50). The top-ranking accession for vigor was locally-collected wax currant (RICE 9081329 Deer Lodge County), followed by the local Mill Creek Germplasm silver buffaloberry (SHAR 9081334). These two local accessions have consistently out-performed non-local sources since establishment.

Table 3. DATR Woody CEP,: percentage survival, 2002 through 2010.

	2002 Surv.	2003 Surv.	2004 Surv.	2005 Surv.	2006 Surv.	2007 Surv.	2008 Surv.	2009 Surv.	2010 Surv.
	%	%	%	%	%	%	%	%	%
PICO 9078320	**85**	**40**	**25**	**25**	**25**	**20**	**10**	**15**	**15**
PICO m039ID0002	30	15	10	10	10	0	0	0	0
PICO m038WY0002	20	15	5	10	10	10	10	10	10
PIPO 9081318	**100**	**100**	**95**	**95**	**95**	**80**	**80**	**75**	**85**
PIPO m04CO0002	85	85	85	75	50	30	25	20	20
PIPO m020SD9903	100	100	95	95	95	90	75	70	75
RICE 9081329	**75**	**65**	**70**	**60**	**60**	**60**	**60**	**65**	**60**
RICE m024CO0003	65	50	50	40	40	45	40	40	35
ROWO 9081638	**75**	**65**	**65**	**55**	**50**	**50**	**50**	**50**	**50**
ROWO m076CO0003	15	5	5	0	0	0	0	0	5
ROWO m07MT0003	20	10	15	10	10	10	10	10	15
SHAR 9081334	**80**	**80**	**80**	**75**	**75**	**70**	**65**	**55**	**60**
SHAR m022WY0005	60	35	30	35	20	15	15	10	15
SHAR m015UT9901	25	20	10	10	10	10	10	10	10
SYAL 9078388	**90**	**85**	**95**	**90**	**85**	**90**	**90**	**75**	**90**
SYAL m045MT003	30	30	30	30	30	25	25	25	20
SYOC 9081639	**85**	**80**	**65**	**30**	**20**	**20**	**20**	**25**	**20**
SYOC m021WY0004	90	75	70	65	55	50	55	50	55
SYOC m018CO9904	90	85	75	70	65	65	55	50	55

Table 4. DATR Woody Comparative Evaluation Planting, mean height, 2002 to 2010

Replication	2002 Mean Height *cm*	2003 Mean Height *cm*	2004 Mean Height *cm*	2005 Mean Height *cm*	2006 Mean Height *cm*	2007 Mean Height *cm*	2008 Mean Height *cm*	2009 Mean. Height *cm*	2010 Mean. Height *cm*
PICO 9078320	**10.06**	**10.19**	**11.83**	**14.00**	**17.40**	**20.93**	**25.00**	**26.33**	**37.67**
PICO m039ID0002	12.83	16.33	16.00	16.50	16.00	0.0	0.0	0.0	0.0
PICO m038WY0002	14.50	15.67	18.00	20.50	20.00	19.05	21.50	23.00	24.50
PIPO 9081318	**24.68**	**27.38**	**25.79**	**31.26**	**32.32**	**30.65**	**31.69**	**34.50**	**47.69**
PIPO m04CO0002	14.29	14.74	13.65	14.13	11.90	16.92	13.60	11.00	17.75
PIPO m020SD9903	26.80	32.10	31.47	38.32	41.63	46.99	61.00	65.07	80.07
RICE 9081329	**25.50**	**47.15**	**52.00**	**78.67**	**93.92**	**89.33**	**114.25**	**111.46**	**117.77**
RICE m024CO0003	12.31	24.00	25.60	46.88	56.75	57.02	78.14	71.63	81.38
ROWO 9081638	**26.07**	**35.85**	**39.39**	**57.27**	**57.50**	**58.68**	**65.00**	**64.60**	**70.00**
ROWO m076CO0003	9.00	5.00	4.00	0.0	0.0	0.0	0.0	0.0	0.0
ROWO m07MT0003	12.00	28.50	21.67	50.50	46.00	53.35	50.50	49.00	63.00
SHAR 9081334	**29.88**	**37.94**	**41.69**	**73.93**	**79.93**	**84.18**	**98.30**	**85.36**	**105.25**
SHAR m022WY0005	5.58	7.79	12.67	20.14	33.25	44.00	46.00	40.00	54.00
SHAR m015UT9901	9.20	13.25	15.00	31.50	24.00	38.10	57.50	67.00	98.5
SYAL 9078388	**18.67**	**25.06**	**28.53**	**30.50**	**29.00**	**27.09**	**30.56**	**28.73**	**30.33**
SYAL m045MT003	18.33	30.33	33.67	40.50	45.67	49.78	54.60	57.20	63.00
SYOC 9081639	**18.06**	**16.09**	**18.62**	**26.50**	**27.25**	**29.88**	**31.75**	**28.00**	**39.67**
SYOC m021WY0004	24.79	40.57	37.53	55.69	59.55	59.69	67.90	76.73	73.91
SYOC m018CO9904	16.61	22.79	23.71	35.93	36.39	41.42	39.55	44.60	50.45

Table 5. DATR Woody Comparative Evaluation Planting, mean vigor rating, 2002 through 2010

Replication	2002 Mean Vigor Rating (1-9)*	2003 Mean Vigor Rating (1-9)*	2004 Mean Vigor Rating (1-9)*	2005 Mean Vigor Rating (1-9)*	2006 Mean Vigor Rating (1-9)*	2007 Mean Vigor Rating (1-9)*	2008 Mean Vigor Rating (1-9)*	2009 Mean Vigor Rating (1-9)*	2010 Mean Vigor Rating (1-9)*
PICO 9078320	**5.80**	**5.10**	**6.50**	**7.60**	**7.40**	**7.25**	**5.50**	**5.67**	**5.33**
PICO m039ID0002	5.00	5.00	7.00	8.00	8.00	0	0	0	0.00
PICO m038WY0002	4.00	4.50	5.50	6.00	6.50	7.50	7.00	7.00	6.00
PIPO 9081318	**2.10**	**3.40**	**5.63**	**5.74**	**5.84**	**5.94**	**5.63**	**5.47**	**5.71**
PIPO m04CO0002	4.20	4.80	7.29	8.00	7.90	8.67	7.40	7.00	7.75
PIPO m020SD9903	3.20	2.70	4.84	5.26	5.37	4.67	4.53	4.14	4.67
RICE 9081329	**4.80**	**2.80**	**3.86**	**3.25**	**3.42**	**3.58**	**3.25**	**4.08**	**3.83**
RICE m024CO0003	5.40	5.10	5.90	5.38	5.13	5.78	4.50	5.00	4.71
ROWO 9081638	**4.20**	**4.50**	**4.54**	**4.36**	**5.00**	**5.00**	**5.10**	**5.00**	**5.10**
ROWO m076CO0003	7.00	7.00	8.00	0	0	0	0	0	0.00
ROWO m07MT0003	5.00	4.00	6.00	4.00	7.00	7.00	5.50	6.50	4.67
SHAR 9081334	**2.50**	**2.50**	**3.94**	**4.00**	**3.67**	**3.57**	**4.39**	**4.91**	**4.25**
SHAR m022WY0005	6.60	5.20	6.67	7.29	6.25	6.33	5.33	6.50	7.00
SHAR m015UT9901	5.80	5.00	5.50	6.00	5.50	5.00	4.50	4.00	4.50
SYAL 9078388	**3.60**	**4.00**	**4.53**	**5.67**	**6.24**	**6.28**	**6.33**	**7.13**	**5.83**
SYAL m045MT003	3.60	3.00	4.17	4.83	4.83	3.60	3.80	4.80	4.25
SYOC 9081639	**4.60**	**5.20**	**6.85**	**6.50**	**6.00**	**4.75**	**5.00**	**6.20**	**5.00**
SYOC m021WY0004	3.80	2.80	4.57	4.39	4.09	4.00	4.18	3.90	4.00
SYOC m018CO9904	4.00	4.50	4.80	5.36	5.39	4.85	5.38	5.60	5.27

*Vigor rating: 1+best vigor; 4=average vigor; 9=near or at mortality

Study Title: Comparative Evaluation of Scarlet Globemallow

Study Number: MT-08-004

Objective: Evaluate phonological development of multiple populations of scarlet globemallow to identify superior performing material for use in revegetating disturbances.

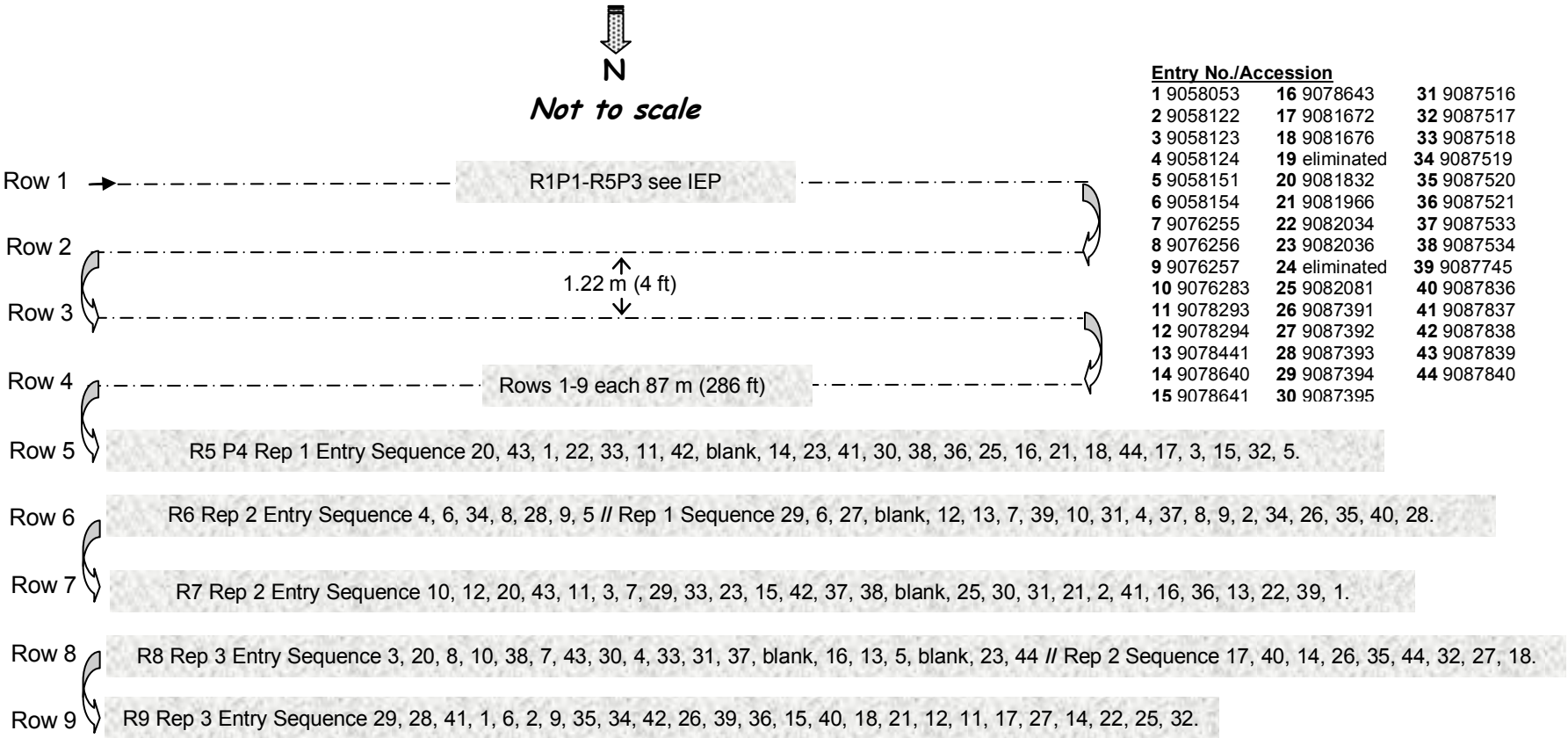
Project Description: Scarlet globemallow *Sphaeralcea coccinea* (Nutt.) Rydb. is a spreading perennial wildflower that is found throughout Great Plains grasslands and occurs naturally from southern British Columbia to western Iowa, south to Texas, and across the western U.S. to eastern Oregon. The generic name comes from the Greek language: *sphaera* meaning globe-like, referring to the round fruit comprised of pie-shaped carpels; and *alcea* meaning mallow. It is an extremely drought-tolerant plant and common at low- to occasionally mid-elevations of mixed grass prairie, sagebrush steppe, and open pine woodlands. It thrives in disturbed areas such as roadsides, railway grades, prairie dog colonies, and marginally productive rangelands. Scarlet globemallow growth is erect or semi-erect, 10 to 30 cm (4 to 12 in.) tall from extensively creeping rootstocks with vegetative surfaces densely covered in branched, star-shaped (stellate) silvery-white hairs. Leaves are alternate along the stem, grey green in color, and palmately divided in 3 to 5 deeply lobed clefts. Flowers are in short terminal racemes, orange to brick-red in color, and initiated from June to August with seed maturity approximately 6 to 8 weeks after blooming. The button-shaped fruit is fused of 8 to 12, single-seeded carpel segments.

Scarlet globemallow is considered an increaser under conditions of drought and overgrazing. Forage value is excellent for antelope and deer, and palatability ranges from poor to fair for livestock. Scarlet globemallow is a valuable source of nectar, nesting, and shelter to a wide variety of beneficial pollinator species. It is susceptible to seed feeding straight-snouted weevils and is an occasional host to hollyhock fungal rust. Scarlet globemallow historically played an important cultural and medicinal role in the lives of Native Americans.

The 2001 Bridger PMC Long Range Plan identified several high priority environmental needs associated with improving native species diversity in seed mixes to revegetate rangeland and disturbed areas, and to enhance wildlife habitat and residential landscapes. The PMC installed Initial Evaluation Plantings (IEP) in 1994, 1997, 2004, and 2008 to assess adaptation and performance of nearly 400 entries of native grasses, legumes, and forbs, including 36 individual sources of scarlet globemallow. A total of 57 seed collections of scarlet globemallow have been processed at the PMC since 1981. The Plant Materials program does not presently have a release of scarlet globemallow available to the commercial seed industry.

Methods and Materials: In the fall of 2008, scarlet globemallow seed was assembled from 30 of the best performing entries as identified in the two previous IEPs, along with seed of 14 new collections received from 2005-2008 (Figure 1). The proper amount of seed at a rate of 33 seeds/m (10 seeds/ft.) per 3.1 m (10 ft.) long plot was calculated and each entry was weighed and packaged (Table 1). On November 17 and 18, seed of 44 accessions were hand-planted with a single-row belt seeder to a depth of approximately 13 mm (½ in.). Within each row, the distance between plots was 0.3 m (1 ft.) and between-row width spacing was 1.22 m (4 ft.) with weed barrier installed between rows (Figure 1). The study is a Randomized Complete Block design with four replications planted in an approximate area of 0.06 ha (0.14 acre). This study was over-seeded atop the original rows on November 9, 2009.

Results: All plots were evaluated with no emergence. The study may be reseeded in the fall of 2011.



Entry No./Accession

1 9058053	**16** 9078643	**31** 9087516
2 9058122	**17** 9081672	**32** 9087517
3 9058123	**18** 9081676	**33** 9087518
4 9058124	**19** eliminated	**34** 9087519
5 9058151	**20** 9081832	**35** 9087520
6 9058154	**21** 9081966	**36** 9087521
7 9076255	**22** 9082034	**37** 9087533
8 9076256	**23** 9082036	**38** 9087534
9 9076257	**24** eliminated	**39** 9087745
10 9076283	**25** 9082081	**40** 9087836
11 9078293	**26** 9087391	**41** 9087837
12 9078294	**27** 9087392	**42** 9087838
13 9078441	**28** 9087393	**43** 9087839
14 9078640	**29** 9087394	**44** 9087840
15 9078641	**30** 9087395	

♦*Rows 5-7-9 planted East to West; Rows 6 & 8 planted West to East; Plot length 3.05 meters with 0.3 meter between plots; 1.22 meter-wide weed barrier installed between rows*

Figure 1. Comparative Evaluation Planting. The 2009 re-seeding of *Sphaeralcea coccinea* scarlet globemallow. Planted in Field 2 at the Bridger PMC on November 9, 2009 (originally seeded Nov. 17-18, 2008).

Table 1. Comparative Evaluation Planting—Scarlet Globemallow *Sphaeralcea coccinea*. Entries of 44 accessions seeded at the Bridger PMC in Field 2 on November 17-18, 2008.

Accession	Entry No.	Date Collected	County	Collector
9081832	20	July & Sept. '99	Weston , WY	Brazee, B.
9087839	43	8/01/07	Big Horn	Knoblach, K.
9058053	1	8/11/89	Sweetwater	-
9082034	22	7/25/03	Big Horn, WY	Gullion, R.
9087518	33	8/2/05	Carbon	Majerus, M.
9078293	11	8/11/95	Albany, WY	Covington, K.
9087838	42	-	Washakie, WY	Gullion, R.
9081831	19	10/1999	Petroleum	Brady, K.
9078640	14	7/23/97	Laramie, WY	Gullion, R.
9082036	23	7/18/03	Washakie, WY	Gullion, R. & C. Agee
9087837	41	6/26/07	Platte, WY	Gamblin, G.
9087395	30	8/06/04	Pondera	Brady, S., M. McLendon, P. Philipps, J. Carleton, M. Johnson, J. Burkehart, M. Delperdang, & B. Bledsoe
9087534	38	8/25/05	Sublette	Vasquez, R.
9087521	36	8/11/05	Carbon	Winslow, S.
9082081	25	7/7/03	Campbell, WY	White, M.
9078643	16	8/27/97	McCone	Meissner, J.
9081966	21	7/15 & 7/31/01	Carbon, WY	Brazee, B. & C.Louthan
9081676	18	8/24/98	Uinta, WY	Jons, L. & L. Burrough
9087840	44	7/25/07	Cascade	Petersen, G.
9081672	17	7/28/98	Powder River	O'Doherty, B.J.
9058123	3	8/22/89	Liberty	Sibley, C.R.
9078641	15	8/11/97	Park	Fuson, R.
9087517	32	8/29/05	Glacier	Johnson, M. & J.
9058151	5	7/25/89	Park	Majerus-Scheetz-Holzworth
9087393	28	7/19/04	Blaine	Kilian, R. & B. Main
9087836	40	7/29/07	Sublette, WY	Clause, K.
9087520	35	8/25/05	Yellowstone	Reinhart, L. & Ricketts, M.
9087391	26	7/31/04	Cascade	J. Siddoway
9087519	34	8/4/05	Jefferson	Malucelli, A.
9058122	2	9/1/89	Golden Valley	Krouse, R. & K. Striby
9076257	9	8/23/94	Park	Fuson, R.
9076256	8	8/12/94	Park	-
9087533	37	7/26/05	Washakie, WY	Gullion, R., C. Pompy, & L. Galloway
9058124	4	7/18/89	Toole	Short, S.
9087516	31	7/25/05	Judith Basin	Caquelin, R.
9076283	10	8/5/03	Deer Lodge	Marty, L.
9087745	39	7/12/06	McCone	Holzworth/Harwood/Kirchner
9076255	7	8/8/94	Park	Fuson, R.
9078441	13	8/22/96	Garfield	Monahan, J. & S. Fitzgerald
9078294	12	8/17/95	Uinta, WY	Jons, L. & L. Burroughs
9082040	24	7/7/03	Campbell, WY	White, M.
9087392	27	7/21/04	Teton	Gunderson, P. & J. Carleton
9058154	6	7/31/89	Sheridan	Johnson, J.
9087394	29	8/06/04	Pondera	Brady, S., M. McLendon, P. Philipps, J. Carleton, M. Johnson, J. Burkehart, M. Delperdang, & B. Bledsoe

Study Title: Comparative Evaluations of Native and Introduced Cool-Season Grasses for Forage Production

Study Numbers: MT-09-037 and MT-09-040

Objective: To compare the forage production of 32 accessions of cool-season grasses under dryland conditions at two sites in Montana.

Project Description: The project consists of two Comparative Evaluation Plantings (CEPs) testing the forage yield of cool-season grasses at two Montana Agricultural Experiment Stations. Assisting with the study are David Wichman, MSU Central Agricultural Research Center (CARC) near Moccasin, and Julia Dafoe and Dr. Darrin Boss, MSU Northern Agricultural Research Center (NARC) near Havre. The goal of the study is to determine the forage yield of "new" versus "old" accessions of 17 grass species under dryland conditions.

Methods and Materials: Seed for the trial was obtained from BPMC inventory or other PMCs in the western USA. PLS seeding rates for each species were taken from Tech Note MT-46 (Rev. 2). A Randomized Complete Block Design with four replications was no-till planted into wheat stubble using a Kincaid double disc plot planter at CARC on May 7 and into barley stubble at NARC on May 8, 2009. There were four rows per plot, spaced 14 inches apart, and plots were 20 feet long. At NARC, fertilizer (36-43-21 blend at 70 lb/acre) was top dressed after planting for a predicted one ton/acre grass hay yield according to Montana Fertilizer guidelines and spring soil samples. Weeds were controlled with one application of Aim (TMC) herbicide following stand establishment at NARC. Stand percentages were taken via ocular measurement at NARC on August 10 and at CARC on September 30. Plots with stand percentages less than 50% were replanted under dormant conditions at CARC and NARC on November 25 and 27, respectively, according to the same MT-46 seeding rates used previously.

At CARC, fertilizer (20-20-20-10 NPKS) was applied in March 2010. The plots were rated for percentage downy brome on June 18 and infestations ranged from 0% to 43.75%. Forage yield harvest occurred on June 19 and September 16. Plots were trimmed to 15 ft. in length and an Almaco forage harvester was then used to harvest all four rows of each plot. Wet samples were collected from each species, weighed and then air dried at 125°F for 7 days to determine moisture content. Yields were adjusted downward for percentage downy brome and are reported on a dry matter basis.

In the spring of 2010 at NARC, a single treatment of bromoxynil (Buctril®) was applied for weed control. The plots were fertilized for a predicted 2 ton/acre yield with a fertilizer blend (60-20-20). Three of the four reps were harvested June 24 with a self-propelled Almaco forage harvester. Rep 1 was used for demonstration purposes during Field Day 2010, but was harvested shortly afterwards so the second cutting could take place with the other reps. Grab samples were taken off each plot to determine dry matter. All reps had a second harvest on October 8, 2010. Total yield for each cutting and the total for the year were calculated for each species.

Conclusions: Individual stand percentages significantly varied among several accessions of the same species at CARC. Although these differences were not observed at NARC, there were some interesting variances for the same accessions between the two test sites. Both planting sites have similar sandy loam soils. Mean stand percentage in 2009 ranged from 6.25 to 90.0 percent at CARC and from 3.75 to 88.75 percent at NARC. The overall mean stand percentage at CARC and NARC were 58.8 and 62.9 percent, respectively. At CARC, „AC Saltlander' hybrid wheatgrass had significantly higher stand percentage than „NewHy'. „Wapiti' bottlebrush squirreltail had significantly higher stand percentage than „Fish Creek'. „Mustang' altai wildrye had significantly higher stand percentage than „Prairieland'. „Trailhead' basin wildrye had significantly higher stand percentage than Washoe. There were no significant differences for stand percentage between accessions of the same species at NARC.

At CARC in 2010, there were significant differences among the slender wheatgrass cultivars for forage yield, which may be attributed to Copperhead's adaptation to the acid pH soils near Anaconda where it

was originally collected. There were no significant differences between cultivars of the same species for percentage downy brome at CARC.

At NARC in 2010, the forage cropping environment was categorized as above average with higher than normal precipitation and lower than normal temperatures. At Havre, total annual growing season precipitation (9/1/09 through 8/31/10) was 14.61 inches, 22.5 percent more than the average for all years since 1916. April 1 through July 31 precipitation was 9.69 inches or 144 percent of the 95-year average. With the outstanding growing conditions, the dryland forage yields were excessively high and not very different than irrigated plots nearby and *should not be expected every year*. Several of the wheatgrass varieties were the highest yielding species. With the poor stand establishment and replanting in the fall, the bluegrasses as a whole were severely impacted in yield the first year of production. Tall wheatgrass, Altai wildrye, green needlegrass, hybrid wheatgrass, and big bluegrass showed a trend for having the most regrowth in response to additional precipitation after first harvest. Additional years of yield data are necessary for accurate comparisons between varieties and species.

Results: The two studies' forage yield results appear in Table 1. Analyzed results will be forwarded to the cooperating scientists and Montana NRCS Field Offices.

Table 1. Comparative Evaluations. Cool-season forage yields at MSU-CARC and NARC in 2010.

Common Name	Genus & Species	Accession	Stand 2009		DB†	Plant Height		Yield	
			CARC	NARC	CARC	CARC	NARC	CARC	NARC
			%	%	%	inches	inches	lb/acre‡	lb/acre‡
Altai wildrye	*Leymus angustus*	Mustang	65.00	69.75	32.5	14.0	57.25	768	8540
Altai wildrye	*Leymus angustus*	Prairieland	48.75	63.00	32.5	16.5	46.50	718	7220
many-stemmed wildrye	*Leymus triticoides*	Shoshone	25.00	27.00	43.75	20.7	37.50	§	4831
basin wildrye	*Leymus cinereus*	Trailhead	63.75	65.00	35.00	19.8	60.00	732	7505
basin wildrye	*Leymus cinereus*	Washoe	43.75	59.50	36.25	18.9	59.25	683	5696
Russian wildrye	*Psathyrostachys juncea*	Bozoisky-Select	68.75	81.25	18.75	16.5	52.75	754	8504
Russian wildrye	*Psathyrostachys juncea*	Mankota	61.25	74.25	18.75	16.7	57.50	597	9082
tall wheatgrass	*Thinopyrum elongatum*	Jose	75.00	75.50	17.50	15.5	43.50	1294	9720
tall wheatgrass	*Thinopyrum elongatum*	Largo	83.75	78.90	28.75	18.2	55.50	1312	13428
slender wheatgrass	*Elymus trachycaulus*	Pryor	86.25	76.25	0.00	20.6	51.00	2298	7336
slender wheatgrass	*Elymus trachycaulus*	Copperhead	76.25	59.50	13.75	19.7	39.25	1003	8666
thickspike wheatgrass	*Elymus lanceolatus*	Critana	72.50	72.75	30.00	14.4	47.00	763	10135
thickspike wheatgrass	*Elymus lanceolatus*	Bannock	75.00	72.50	3.75	15.6	48.25	1012	9481
pubescent wheatgrass	*Thinopyrum intermedium*	Manska	90.00	75.75	22.50	14.3	50.00	1218	9278
pubescent wheatgrass	*Thinopyrum intermedium*	Luna	90.00	88.75	1.25	15.7	48.25	1761	8876
western wheatgrass	*Pascopyrum smithii*	Rosana	76.25	78.75	12.50	12.0	47.50	836	10314
western wheatgrass	*Pascopyrum smithii*	Rodan	70.00	71.25	13.75	15.5	44.00	873	7778
hybrid wheatgrass	*Elymus hoffmanii*	NewHy	61.25	73.75	15.00	15.9	48.00	1247	9630
green wheatgrass	*Elymus hoffmanii*	AC Saltlander	80.00	77.50	10.00	14.6	55.50	1319	8143
Siberian wheatgrass	*Agropyron fragile*	Vavilov	77.50	72.50	26.25	16.2	35.00	1047	10684
Siberian wheatgrass	*Agropyron fragile*	Vavilov II	67.25	75.75	25.00	16.1	40.50	1385	11088
Indian ricegrass	*Achnatherum hymenoides*	Rimrock	13.75	48.75	42.50	12.4	32.50	556	4653
Indian ricegrass	*Achnatherum hymenoides*	Nezpar	22.50	65.00	45.00	15.7	35.25	589	4348
bottlebrush squirreltail	*Elymus elymoides*	Fish Creek	58.75	67.50	20.00	14.0	26.50	707	6185
bottlebrush squirreltail	*Elymus elymoides*	Wapiti	75.00	57.50	31.25	11.9	34.50	900	6817
green needlegrass	*Nassella viridula*	Lodorm	32.50	53.75	42.50	19.4	49.75	714	7353
Nevada bluegrass	*Poa secunda*	Opportunity	7.50	3.75	28.75	16.5	36.00	478	2279
Sandberg bluegrass	*Poa secunda*	Sherman	11.25	17.50	26.25	14.6	43.00	911	7777
Sandberg bluegrass	*Poa secunda*	High Plains	6.25	20.50	41.25	10.8	28.25	§	2910
bluebunch wheatgrass	*Pseudoroegneria spicata*	Goldar	63.75	64.25	26.25	14.8	40.00	1314	8303
bluebunch wheatgrass	*Pseudoroegneria spicata*	Anatone	76.25	68.25	3.75	14.2	37.50	1430	6112
tall fescue	*Lolium arundinaceus*	Bridgestone	56.25	62.50	2.50	16.8	34.75	1432	5571

† % DB = Downy Brome 2010

‡ Yields are reported on a dry matter basis and as the total of the first and second harvests.

§ Not harvested due to poor stands.

Study Title: Comparative Evaluation of Cool-Season Grasses for Forage Production under Irrigated Conditions

Study Numbers: MT-10-002

Objective: To compare the forage production of eight species of cool-season grasses, composed of 11 accessions under irrigated conditions near Bridger, Montana.

Project Description: The project consists of a Comparative Evaluation Planting (CEP) testing the forage yield of cool-season grasses and two grass/legume mixes at the Bridger Plant Materials Center. The goal of the study is to compare newer vs. older grass accessions when grown under irrigated conditions and compare them to species commonly used for irrigated pastures in Montana and Wyoming.

Methods and Materials: Seed for the trial was obtained from BPMC inventory. PLS seeding rates for each species were taken from Tech Note MT-46 (Rev. 2). A Randomized Complete Block Design with three replications was planted into fallow ground using a Kincaid double disc plot planter on March 18, 2010. There were four rows per plot, spaced 14 inches apart, and plots were 20 feet long. Plots were hand weeded due to the close proximity of a forb demonstration area. Stand percentages were taken via ocular measurement on August 10.

Two harvests occurred on August 10 and November 3, 2010. Plots were trimmed to 15 feet and the two center rows of each plot were then harvested using a REM flail harvester. Grab samples were taken for each cultivar to determine percentage dry matter, and yields are reported on a dry matter basis. No fertilizer was applied during the establishment year.

Results: The study's stand percentages and forage yield results appear in Table 1. Analyzed results will be forwarded to the cooperating scientists and Montana NRCS Field Offices.

Table 1. Irrigated Cool-Season Grass Stand Percentages and Forage Yield, BPMC 2010.

Common Name	Accession	Stand	Yield Aug. 10	Yield Nov. 3	Total†
		%	*T/Acre*	*T/Acre*	*T/Acre*
basin wildrye	Trailhead	75	2.41	*	2.41
basin wildrye	Continental	80	2.08	0.23	2.31
tall wheatgrass	Largo	85	3.57	0.37	3.94
orchardgrass	Potomac	80	2.83	1.24	4.07
western wheatgrass	Rosana	95	2.73	0.49	3.22
green wheatgrass	AC Saltlander	90	2.91	0.98	3.89
hybrid wheatgrass	NewHy	90	2.29	0.83	3.12
Nevada bluegrass	Opportunity	10	‡	‡	‡
big bluegrass	Sherman	5	‡	‡	‡
meadow brome	McBeth	85	2.76	1.06	3.82
intermediate wheatgrass	Manifest	90	3.15	1.48	4.63
intermediate wheatgrass	Oahe	90	2.48	1.01	3.49
timothy	Climax	75	2.19	‡	2.19
creeping foxtail	Garrison	25	‡	‡	‡

† Yield is a total of the August 10 and November 3 harvests.
‡ Yields were not taken due to poor stands or inadequate regrowth for the 2nd harvest.

Conclusions: Mean stand percentages in 2010 ranged from 5 to 95 percent within the evaluation. There were no significant differences among accessions of the same species for stand percentage. Harvested forage yield ranged from 2.19 to 4.63 tons/acre. There were no significant differences for yield among accessions of the same species. Even though 'Trailhead' basin wildrye did not have any regrowth

for a second harvest, it still out-yielded ‘Continental’ by a very small margin during the first year of establishment.

Study Title: Comparative Evaluation of Cool-Season Grasses and Two Grass/Legume Mixes for Forage Production under Irrigated Conditions

Study Numbers: MT-09-039

Objective: To compare the forage production of 12 species of cool-season grasses, composed of 17 accessions, and two grass/legume mixes under irrigated conditions near Havre, Montana.

Project Description: The project consists of a Comparative Evaluation Planting (CEP) testing the forage yield of cool-season grasses and two grass/legume mixes at a Montana Agricultural Experiment Station near Havre, Montana. Assisting with the study are Julia Dafoe and Dr. Darrin Boss, MSU Northern Agricultural Research Center (NARC). The goal of the study is to compare newer vs. older grass accessions when grown under irrigated conditions and to also compare a four grass-one legume mix with a two grass-three legume mix.

Methods and Materials: Seed for the trial was obtained from BPMC inventory or other PMCs in the western USA. PLS seeding rates for each species were taken from Tech Note MT-46 (Rev. 2). A Randomized Complete Block Design with four replications was no-till planted into barley stubble using a Kincaid double disc plot planter at NARC on May 8, 2009. There were four rows per plot, spaced 14 inches apart, and plots were 20 feet long. Stand percentages were taken via ocular measurement on August 10. Grass rows within plots having stand percentages less than 50% were replanted under dormant conditions at NARC on November 27, according to the same MT-46 seeding rates used previously.

In the spring of 2010, a single treatment of bromoxynil (Buctril®) was applied for weed control. The plots were fertilized for a predicted 4 ton/acre yield with a fertilizer blend (70-15-15). The first harvest occurred on June 24 with a self-propelled Almaco forage harvester. Rep 1 was used for demonstration during Field Day 2010, but was harvested shortly after Field Day so the second cutting could take place with the other reps. Grab samples were taken off each plot in Rep 2 to calculate dry matter. All reps had a second harvest on October 8, 2010.

Conclusions: Mean stand percentages in 2009 ranged from 4.25 to 70.0 percent within the evaluation. The overall mean stand percentage was 51.43. There were significant differences among accessions of the same species. 'AC Saltlander' green wheatgrass was significantly higher in stand percentage than 'NewHy'. 'Manifest' intermediate wheatgrass was significantly higher in stand percentage than 'Oahe'.

In 2010, forage yield means ranged from 1.14 to 6.11 tons/acre. The overall mean yield was 3.59 tons/acre. There were no significant differences among cultivars of the same species. The forage cropping environment at the Research Center was categorized as above average with higher than normal precipitation and lower than normal temperatures. At Havre, total annual growing season precipitation (9/1/09 through 8/31/10) was 14.61 inches, 22.5 percent more than the average for all years since 1916. April 1 through July 31 precipitation was 9.69 inches or 144 percent of the 95-year average.

Several of the wheatgrass varieties, the meadow brome, and Mix 2 (alfalfa, intermediate wheatgrass, orchardgrass, and tall fescue) were the highest yielding species. With the poor stand establishment and replanting in the fall, the bluegrasses as a whole were severely impacted in yield this first year of production. Additional years of yield data are necessary for accurate comparisons between varieties and species.

Results: The study's stand percentages and yield results appear in Table 1. Analyzed results will be forwarded to the cooperating scientists and Montana NRCS Field Offices.

Table 1. Comparative Evaluations. Irrigated Cool-Season Grass Forage Yields at NARC 2010.

Common Name	Genus & Species	Accession	Stand 2009	Yield†
			%	*tons/acre*
birdsfoot trefoil, alfalfa, sainfoin, meadow brome, orchardgrass		Cooper Mix	76.00	4.29
orchardgrass, meadow brome, intermediate wheatgrass, creeping foxtail, alfalfa		Mix 2	59.50	5.08
basin wildrye	*Leymus cinereus*	Trailhead	27.50	3.84
basin wildrye	*Leymus cinereus*	Continental	29.50	3.50
tall wheatgrass	*Thinopyrum ponticum*	Jose	63.75	5.19
tall wheatgrass	*Thinopyrum ponticum*	Largo	68.00	6.11
western wheatgrass	*Pascopyrum smithii*	Rosana	62.50	4.13
green wheatgrass	*Elymus hoffmanii*	AC Saltlander	65.00	4.07
hybrid wheatgrass	*Elymus hoffmanii*	NewHy	41.25	5.24
Nevada bluegrass	*Poa secunda*	Opportunity	6.00	1.14
big bluegrass	*Poa secunda*	Sherman	4.25	2.71
meadow brome	*Bromus biebersteinii*	McBeth	67.25	4.93
pubescent wheatgrass	*Thinopyrum intermedium*	Manska	70.00	4.29
intermediate wheatgrass	*Thinopyrum intermedium*	Manifest	70.75	4.97
intermediate wheatgrass	*Thinopyrum intermedium*	Oahe	48.75	3.79
orchardgrass	*Dactylis glomerata*	Potomac	53.25	2.64
timothy	*Phleum pratense*	Climax	70.00	3.60
creeping foxtail	*Alopecurus arundinaceus*	Garrison	25.25	3.68
tall fescue	*Lolium arundinaceus*	Bridgestone	68.75	4.38

† Yield is a total of the two harvests in 2010 and is reported on a dry matter basis.

Study Title: CEAP/Almanac

Study Number: MT-10-001

Objective: Measure and quantify plant growth parameters for input into various ARS computer models to improve accuracy and predictability of conservation effects applied through Farm Bill programs.

Project Description: In cooperation with the National Plant Materials Program and the ARS's Grassland Soil and Water Research Laboratory in Temple, Texas, the pilot project utilizes the nationwide network of PMCs to directly contribute to improving NRCS technical vegetative recommendations and support the effects of conservation activities. The Plant Materials Centers located within the arid west will: 1) obtain data from existing plots where feasible, and 2) install new 3-5 year studies as required to collect accurate plant data. Plant growth parameter data will be provided to ARS staff for inclusion in the ALMANAC model. PMCs located in Arizona, New Mexico, Nevada, Washington, Idaho, California, Colorado, and Montana will be expected to participate. Plant Materials Centers and Specialists will: coordinate annually with the regional plant materials specialist to determine appropriate species to evaluate; incorporate appropriate plant characteristic data into FOTG; and develop regional or national technical notes with other NTSC discipline specialists.

Methods and Materials: The foundation seed production fields of 'Critana' thickspike wheatgrass, 'Rosana' western wheatgrass, 'Trailhead' basin wildrye, and 'Rimrock' Indian ricegrass were evaluated every 2 weeks during the 2010 growing season using a Decagon ceptometer with an external sensor to take simultaneous measurements of photosynthetic active radiation (PAR) above and below the plant canopy to calculate the fraction of intercepted PAR (fiPAR). The measurements were taken at 10-cm intervals in 1-m^2 plots (20 readings per plot) of four replications. Additional observations at each plot included plant life cycle (determined by Moore et al., 1991), crop uniformity, height in cm, vigor, insect and disease pressure, cold and heat injury, and pesticide or fertilizer damage. A minimum of two digital images were taken of each crop on every evaluation date. Plant biomass was harvested in ½ m^2 plots at mid- and mature growth stages. Wet, biomass subsamples were sent to ARS to determine leaf area index (LAI) and dried samples were sent to the AZ PMC for processing to forward to the NY PMC for nutrient analysis. Three-year, crop field histories were documented along with current-year cultural applications, such as site preparation technique, planting date, row spacing, irrigation treatments, weed control and tillage methods, and fertilizer rates.

Results: The ceptometer was used to measure incident radiation seven times in the 5-year-old field of Critana thickspike wheatgrass, beginning on April 21 and ending on July 20; eight times in the 3-year-old field of Rosana western wheatgrass, beginning on April 21 and ending on September 7; seven times in the 15-year-old field of Trailhead basin wildrye, beginning on April 21 and ending on August 4; and six times in the first-year field of Rimrock Indian ricegrass, beginning on June 23 and ending on September 7 (Appendix Table 2). Data means reported in the tables below were furnished by the cooperating ARS research lab in Temple, Texas. The light extinction coefficients (k value) were determined from fiPAR measurements and destructive LAI measurements. Rosana, Rimrock, and Trailhead had intermediate k-values while Critana had a low k-value (Table 1). The mean LAI (a one-sided leaf area per ground unit area) is reported in Table 1. Leaf area index influences how light moves through a plant canopy and is related to photosynthesis and biomass production. The mineral content of nitrogen and phosphorus at specific growth stages, and an estimate of crude protein, are reported in Table 2. Individual plot harvest data is reported in Appendix Table 1.

Discussion: The four grasses sampled under agronomic conditions at the Bridger PMC are key species of numerous ecological sites in Montana and Wyoming. They characterize the backbone of fundamental revegetation seed mixes that have been used successfully to stabilize tens of thousands of acres in the Northern Great Plains and the Intermountain West. While the historic conservation benefits on the ground are undisputed, there is a need to predict the effects of current practices on agricultural land with computer models such as Almanac. There are, however, cautionary shortcomings with interpreting the preliminary values generated in the analysis.

Table 1. CEAP/Almanac Project. The 2010 leaf area index and mean k-values for four grasses at the Bridger PMC.

Species/Date	Mean LAI	Mean k	Species/Date	Mean LAI	Mean k
Critana thickspike wheatgrass			**Rosana western wheatgrass**		
April 21	0.62	-0.77	April 21	0.16	-1.18
June 9	0.70	-0.15	July 7	3.99	-0.16
July 20	1.29	-0.27	September 7	1.78	-0.40
	mean	-0.40		mean	-0.58
Trailhead basin wildrye			**Rimrock Indian ricegrass**		
April 21	3.12	-0.14	June 23	Na	Na
June 23	2.37	-0.64	July 20	0.66	-0.61
August 4	1.58	-0.62	September 7	0.79	-0.49
	mean	-0.47		mean	-0.55

Table 2. CEAP/Almanac Project. The 2010 plant growth stage and nutrient composition of three grasses at the Bridger PMC.

Species	Harv. Date	Rep	Growth Stage†	Phosphorus	Nitrogen	C.P.‡
				%	%	%
Critana thickspike wheatgrass	June 30	1	R4 anther emergence	0.22	1.8	11.3
		2		0.22	2.0	12.5
		3		0.22	2.1	13.1
		4		0.24	2.3	14.4
	July 19	1	S4 endosperm hard	0.18	1.3	8.1
		2		0.18	1.3	8.1
		3		0.18	1.2	7.5
		4		0.19	1.3	8.1
Trailhead basin wildrye	June 30	1	R4 anther emergence	0.23	1.3	8.1
		2		0.21	1.1	6.9
		3		0.17	0.9	5.6
		4		0.24	1.4	8.8
	August 4	1	S4 endosperm hard	0.13	1.0	6.3
		2		0.13	1.0	6.3
		3		0.12	0.7	4.4
		4		0.11	0.8	5.0
Rosana western wheatgrass	June 30	1	R4 anther emergence	0.21	2.3	14.4
		2		0.22	2.3	14.4
		3		0.22	2.0	12.5
		4		0.19	1.9	11.9
	Sept. 7	-	S4 endosperm hard	0.12	1.5	9.4
				0.12	1.8	11.3
				0.13	1.9	11.9
				0.12	1.8	11.3

† Growth stage (Moore et al., 1991).
‡ Approx. crude protein (Murray et al., 1978).

For example, the mean k-value may be interpreted for Critana thickspike wheatgrass as having fewer horizontal leaves that are not very efficient at intercepting light and perhaps affording fewer benefits associated with protecting soil and water resources. In reality, the sample area was confined to short lengths of cultivated rows that poorly reflect the potential of its true growth form in a natural environment. Targeted sampling in well-established fields tends to ignore the important effects of first-year establishment on overall site stabilization. Despite the low primary production of Rimrock Indian ricegrass, the mean k-values indicate adequate numbers of horizontal leaves moderately efficient in intercepting light through a canopy, thus supplying a fair degree of resource protection. The percentage mineral content and estimated crude protein fall within normal parameters for healthy plant production and support a continuation of existing fertilizer application rates. A decline of nutrient levels in cool weather grasses as the season advanced is typical, in part because of reallocation during

phenological maturity and changes in stem-to-leaf ratios (Cook and Harris, 1968). Additional analysis of mineral concentrations and digestibility components would provide information needed to effectively manage dietary requirements of wildlife and domestic livestock. In harsh climatic environments, the Almanac model would be more robust with data gathered over multiple years per species to reliably predict trends in plant productivity, species dominance, drought and nutrient stress impacts, water infiltration and runoff, and soil erosion.

The cooperating ARS scientists are very satisfied with the preliminary results and are interested in receiving plant attribute data collected by participating PMCs over a second season to populate their models. In the next phase of the project, it may be advisable to increase biomass sample size to better simulate ground cover in a desired plant community. The Bridger PMC tentatively plans to sample established seed production fields of Antelope slender white prairieclover, Old Works fuzzytongue penstemon, blanketflower, and silverleaf phacelia. The CEAP/Almanac project is anticipated to remain active until further notice.

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Appendix Table 1. CEAP/Almanac Project. The 2010 measurements of light interception, biomass, leaf area index, and k-values for four grass species at the Bridger PMC.

Species/Date	Rep	Ave ABV PAR	Ave BLW PAR	Correction factor	FIPAR	Total fresh wt	Subsample fresh wt	Leaf area		LAI	k
Trailhead basin wildrye	1	1499	722	1.05	0.493	187	38.1	1324.08		2.60	-0.26
April 21	2	1944	1164	1.05	0.370	177	41.0	1396.03		2.41	-0.19
	3	1879	1238	1.05	0.306	191	25.0	1482.91		4.53	-0.08
	4	1997	1390	1.05	0.267	223	38.6	1264.69		2.92	-0.11
				MEAN	0.360				**MEAN**	3.12	-0.14
June 23	1	1814	432	1.00	0.762	792	41.8	475.57	15.89	3.72	-0.39
	2	1860	303	1.00	0.837	798	27.0	475.41	8.23	5.72	-0.32
	3	1860	531	1.00	0.715	705	20.5	390.56	34.12	5.84	-0.21
	4	1883	339	1.00	0.820	646	43.2	618.48		3.70	-0.46
				MEAN	0.780				**MEAN**	4.75	-0.32
August 4	1	1599	542	1.00	0.661	802	24.3	245.54	7.45	3.34	-0.32
	2	1655	681	1.00	0.589	639	24.7	229.45	19.49	2.58	-0.34
	3	1722	738	1.00	0.571	588	25.8	239.03	7.14	2.24	-0.38
	4	1752	576	1.00	0.671	966	24.6	275.23	8.40	4.46	-0.25
				MEAN	0.620				**MEAN**	3.15	-0.31
Rosana western wheatgrass	1	1697	1113	1.05	0.309	87	16.7	108.65		0.23	-1.64
April 21	2	1883	1453	1.05	0.188	54	15.2	76.18		0.11	-1.92
	3	2158	1795	1.05	0.124	83	14.3	60.68		0.14	-0.94
	4	2228	1983	1.05	0.063	63	13.1	84.02		0.16	-0.40
				MEAN	0.170				**MEAN**	0.16	-1.18
July 7	1	1790	1669	0.61	0.433	510	15.7	275.25		3.58	-0.16
	2	1823	1547	0.61	0.484	540	17.0	331.62		4.21	-0.16
	3	1853	1558	0.61	0.489	506	10.0	213.85		4.33	-0.16
	4	1881	1579	0.61	0.490	535	11.1	199.69		3.85	-0.17
				MEAN	0.470				**MEAN**	3.99	-0.16
September 7	1	1179	744	0.62	0.611	257	6.1	107.26		1.81	-0.52
	2	1396	1026	0.62	0.547	217	6.8	109.69		1.40	-0.57
	3	1460	1385	0.62	0.416	266	9.3	205.10		2.35	-0.23
	4	1498	1315	0.62	0.460	188	7.7	161.56		1.58	-0.39
				MEAN	0.510				**MEAN**	1.78	-0.40

Appendix Table 1. CEAP/Almanac Project. The 2010 measurements of light interception, biomass, leaf area index, and k-values for four grass species at the Bridger PMC --Continued.

Species/Date		Rep	Ave ABV PAR	Ave BLW PAR	Correction factor	FIPAR	Total fresh wt	Subsample fresh wt	Leaf area		LAI	k
Critana thickspike wheatgrass												
April 21	Calibr w/lvs	1	1421	872	1.05	0.354	131	15.7	158.69		0.53	-0.82
		2	1498	765	1.05	0.462	141	17.7	234.22		0.75	-0.83
		3	1514	838	1.05	0.417	102	12.5	188.67		0.62	-0.88
		4	1933	1313	1.05	0.285	103	11.1	160.78		0.60	-0.56
					MEAN	0.380				**MEAN**	0.62	-0.77
June 9	Calibr w/lvs	1	729	684	1.00	0.062	124	11.6	214.19		0.92	-0.07
		2	775	727	1.00	0.062	80	10.1	191.90		0.61	-0.11
		3	867	745	1.00	0.141	91	10.8	207.77		0.70	-0.22
		4	797	704	1.00	0.117	78	8.6	158.09		0.57	-0.22
					MEAN	0.100				**MEAN**	0.70	-0.15
July 20	Calibr w/lvs	1	1774	1760	0.62	0.384	242	180.19	88.88		2.10	-0.23
		2	1889	1781	0.62	0.414	154	113.76	80.71		1.60	-0.33
		3	1798	1752	0.62	0.395	217	139.77	51.71		2.31	-0.22
		4	1818	1667	0.62	0.430	183	196.24	149.90		2.00	-0.28
					MEAN	0.410				**MEAN**	2.00	-0.27
Rimrock Indian ricegrass**												
June 23	Calibr w/lvs	1	3001	1891	1.00	0.370	3.26	3.26	59.32		0.02	-19.46
		2	3080	1905	1.00	0.381	4.16	4.16	75.86		0.03	-15.83
		3	3105	1917	1.00	0.383	5.24	5.24	93.81		0.04	-12.85
		4	2993	1867	1.00	0.376	7.56	7.56	137.29		0.05	-8.59
					MEAN	0.380				**MEAN**	0.037	-14.19
July 20	Calibr w/lvs	1	2859	1799	1.00	0.371	44	7.7	116.61		0.27	-1.74
		2	2925	1811	1.00	0.381	35	13.2	170.98		0.19	-2.55
		3	2672	1823	1.00	0.318	111	15.8	225.81		0.70	-0.54
		4	2780	1834	1.00	0.340	103	8.5	117.05		0.61	-0.68
					MEAN	0.350				**MEAN**	0.68	-0.61

** Very small amounts.

Appendix Table 1. CEAP/Almanac Project. The 2010 measurements of light interception, biomass, leaf area index, and k-values for four grass species at the Bridger PMC--Continued.

Species/Date		Rep	Ave ABV PAR	Ave BLW PAR	Correction factor	FIPAR	Total fresh wt	Subsample fresh wt	Leaf area		LAI	k
Rimrock Indian ricegrass** (Cont.)												
September 7	Calibr w/lvs	1	1889	1551	1.00	0.179	175	11.6	210.37		1.27	-0.16
		2	1792	1538	1.00	0.142	100	8.9	143.08		0.64	-0.24
		3	2324	1592	1.00	0.315	38	14.3	236.09		0.25	-1.51
		4	1664	1579	1.00	0.051	283	12.2	107.10		0.99	-0.05
					MEAN	0.170				**MEAN**	0.79	-0.49

** Very small amounts.

V. Management – Cultural – Establishment Trials

Study Title: Management Trial of Alternate-Row Plantings of Cool-Season Grasses and Alfalfa for Forage Production

Study Number: MT-10-003

Objective: To compare the forage production of 14 species of cool-season grasses with alfalfa under irrigated conditions at Bridger, Montana.

Project Description: The project consists of a Comparative Evaluation Plantings (CEP) testing the forage yield of cool-season grasses in alternate rows with alfalfa at the Bridger Plant Materials Center (BPMC). The goal of the study is to identify the higher yielding grasses when planted in alternate rows with a legume, such as alfalfa.

Methods and Materials: Seed for the trial was obtained from BPMC inventory or other PMCs in the western USA. PLS seeding rates for each species were taken from Tech Note MT-46 (Rev. 2). The variety 'Shaw' was used for all alfalfa rows. A Randomized Complete Block Design with three replications was no-till planted into fallow ground using a Kincaid double disc plot planter at the BPMC on May 14, 2010. There were four rows per plot, spaced 14 inches apart, and plots were 20 feet long. Stand percentages were taken via ocular measurement on September 21, 2010.

The grasses to be tested are:

Bridger Plant Materials Center – Alternate Row Grass/Alfalfa CEP		
Garrison creeping foxtail	Manifest	Rosana
McBeth meadow brome	Largo	Oahe
Montana meadow brome	Trailhead	Sherman
Sherman big bluegrass	Continental	Garrison
Opportunity Nevada bluegrass	AC Saltlander	NewHy
Newhy hybrid wheatgrass	McBeth	Bozoisky-Select
AC Saltlander green wheatgrass	Bozoiksy-Select	Trailhead
Continental basin wildrye	Sherman	Largo
Trailhead basin wildrye	Newhy	Opportunity
Rosana western wheatgrass	Oahe	Montana
Manifest intermediate wheatgrass	Garrison	Continental
Oahe intermediate wheatgrass	Rosana	AC Saltlander
Largo tall wheatgrass	Opportunity	McBeth
Bozoisky-Select	Montana	Manifest

Results: Due to very poor emergence of the cool-season grasses in two out of the three replications, the trial will be abandoned and replanted in mid-August 2011.

Study Title: Management Trials of Alternate-Row Plantings of Cool-Season Grasses and Alfalfa for Forage Production

Study Numbers: MT-09-038

Objective: To compare the forage production of 13 species of cool-season grasses with alfalfa under dryland conditions at Moccasin, Montana.

Project Description: The project consists of a Comparative Evaluation Planting (CEP) testing the forage yield of cool-season grasses in alternate rows with alfalfa at a Montana Agricultural Experiment Station. Assisting with the study is David Wichman, MSU Central Agricultural Research Center (CARC). The goal of the study is to identify the higher yielding grasses when planted in alternate rows with a legume, such as alfalfa.

Methods and Materials: Seed for the trial was obtained from BPMC inventory or other PMCs in the western United States. PLS seeding rates for each species were taken from Tech Note MT-46 (Rev. 2). The variety 'Shaw' was used for all alfalfa rows. A Randomized Complete Block Design with four replications was no-till planted into wheat stubble using a Kincaid double-disc plot planter at CARC on May 7, 2009. There were four rows per plot, spaced 14 inches apart, and plots were 20 feet long. Stand percentages were taken via ocular measurement on August 9, 2009. Grass rows within plots having stand percentages less than 50% were replanted under dormant conditions on November 25, according to the same Tech Note MT-46 seeding rates used previously.

The plots were harvested for forage yield on June 14, 2010. Plots were trimmed to 15 feet in length and a Wintersteiger forage harvester was then used to harvest all four rows of each plot. Wet samples were collected from each species, weighed, and then air dried at 80°C for 48 hours to determine moisture content. Yields are reported on a dry matter basis.

Table 1. Comparative Evaluation Planting. Cool-season grass forage yields at CARC, 2010.

Common Name	Genus & Species	Accession	Stand 2009	Yield
			%	*lb/acre*
Altai wildrye	*Leymus angustus*	Mustang	31.75	2579
Basin wildrye	*Leymus cinereus*	Trailhead	50.00	1771
Russian wildrye	*Psathyrostachys juncea*	Mankota	50.50	1836
Tall wheatgrass	*Thinopyrum ponticum*	Jose	53.00	4175
Thickspike wheatgrass	*Elymus lanceolatus*	Critana	62.50	3823
Pubescent wheatgrass	*Thinopyrum intermedium*	Manska	51.25	2929
Western wheatgrass	*Pascopyrum smithii*	Rosana	53.25	1823
Green wheatgrass	*Elymus hoffmanii*	AC Saltlander	74.25	6849
Indian ricegrass	*Achnatherum hymenoides*	Rimrock	30.00	2659
Nevada bluegrass	*Poa secunda*	Opportunity	27.75	3437
Bluebunch wheatgrass	*Pseudoroegneria spicata*	Goldar	40.25	3051
Siberian wheatgrass	*Agropyron fragile*	Vavilov	54.00	4732
Tall fescue	*Lolium arundinaceus*	Bridgestone	43.00	3166

Conclusions: Mean stand percentages in 2009 ranged from 27.75 to 74.25 percent within the evaluation. The overall mean stand percentage was 47.8. There were significant differences among species with a trend showing the rhizomatous species having higher stand percentages. However, the rhizomatous altai wildrye was not part of this trend. The trend may be in part due to a spreading growth habit enabling them to fill in open spots in the plot rows when compared to the bunch grass species.

Mean forage yield in 2010 ranged from 1,771 to 6,849 lb/acre within the evaluation. The overall mean yield was 3,295 lb/acre. There were significant differences for forage yield among species, however; no

discernible trend was established when comparing rhizomatous and bunchgrass species, nor were 2010 forage yields dependent on stand percentages from 2009.

Study Title: Cultural and Establishment Trial of Grasses in a Xeriscape Demonstration

Study Number: MT-98-0002

Objective: Evaluate native or non-native grasses in monoculture and mixture plots for potential use in low-maintenance landscapes.

Project Description: The use of native or non-native dryland grasses in landscaping can reduce the water and nutrient requirements, as well as add a variety of color, texture, and size to the landscape. These nontraditional species can be used instead of the standard, manicured Kentucky bluegrass or perennial ryegrass lawns. A demonstration was set up in a dryland situation at the Bridger PMC to evaluate 10 grass species for their potential use in xeriscapes.

Methods and Materials: On a dryland site (Field 19), a series of single, 6.1-meter by 7.6-meter (20-ft. by 25-ft.) plots were established to evaluate 10 grasses for potential use for manicured lawns or low maintenance areas (Figure 1). The seedbed preparation on this fallow site consisted of rototilling, cultipacking, and leveling. On April 10, 1998, seed of each species was broadcast-seeded at a rate of approximately 5,400 PLS seeds/meter^2 (500 PLS seeds/ft.^{2}). The site was drug with a harrow section behind a four-wheel ATV to incorporate the seed and firm the seedbed. The site has been maintained in dryland conditions, with the exception of occasional drift from the sprinkler irrigation of an adjacent ponderosa pine orchard. For the past 12 years, the west half of each of the original 10 plots has been periodically mowed to an approximate height of 8 cm (3 inches), while the east half of each plot were allowed to grow to full mature height. This was done to have a visual comparison of how each of these species looked in mowed and unmowed condition. Since these plots are not replicated, they have been used primarily for demonstration purposes.

In May 2005, a series of single, 6.1-meter by 7.6-meter (20-ft. by 25-ft.) plots were established adjacent to the existing xeriscape demonstration plots to evaluate five native grass mixtures for potential use as manicured lawns or low maintenance areas (Figure 2). The seedbed preparation on this fallow site consisted of the same aforementioned treatments. On May 5, seed was broadcasted in four, two-species mixtures (50% each) at a total rate of approximately 5,400 PLS seeds/meter^2 (500 PLS seeds/ft.^{2}). The four plots were drug with a harrow section behind a four-wheel ATV to incorporate the seed and firm the seedbed. On May 10, a final plot was seeded with two species, each 50% of the mixture. This plot was hand-raked after seeding, but the earlier dragging of the area with the ATV resulted in a hard seedbed, so a layer of straw was placed on the surface to cover the seed.

These plots were maintained from the establishment year through 2003 under dryland conditions. The average annual precipitation was extremely variable and ranged from well-below to well-above the long-term average of 28.7 cm (11.3 inches): 2002--23.5 cm (9.24 inches); 2003--16.9 cm (6.65 inches); 2004--21.5 cm (8.46 inches); 2005--36.1 cm (14.22 inches); 2006--30.8 cm (12.12 inches); 2007--16.9 cm (6.65 inches); and 2010--21.6 cm (8.5 inches). Supplemental irrigation was applied in July 2004-2010 to prevent complete deterioration of the plots.

All plots were evaluated on June 29, 2010. The percentage basal cover in the mowed and unmowed areas was estimated in three, randomly located 0.14 m^2 (1.6 ft^2) frames. Height in the unmowed areas was randomly measured in centimeters three times, to the top of the seedhead. The mowed treatment areas were clipped to a height of approximately 3 inches (7.6 cm).

Results: The 2010 evaluation data of the monoculture and mixture plots are reported in Appendix Table 1. The percentage basal cover over time for each plot is shown in Figure 3 to Figure 17. To date, mowing negatively impacted percentage basal cover in six of the 10 monoculture plots and all five of the mixture plots. The rhizomatous entries best resisted weed invasion and tended to be dominant when mixed with a bunch-type grass. The two warm-season grasses rated highest in turf suitability. The best overall performance in the monoculture plots were blue grama, buffalo grass, and sheep fescue. In the mixture plots, the best performers were the combinations of thickspike and western wheatgrass, and blue grama and buffalo grass.

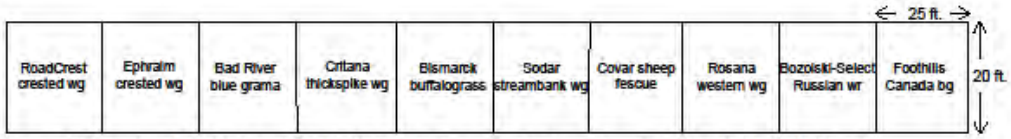

Figure 1. Cultural and Establishment Trial of Xeriscape Demonstration Area Grass Plots. Seeded in Field 19 at the Bridger PMC on April 10, 1998.

Figure 2. Cultural and Establishment Trial of Xeriscape Demonstration Area Grass Mixture Plots. Seeded in Field 19 at the Bridger PMC on May 5 and May 10, 2005.

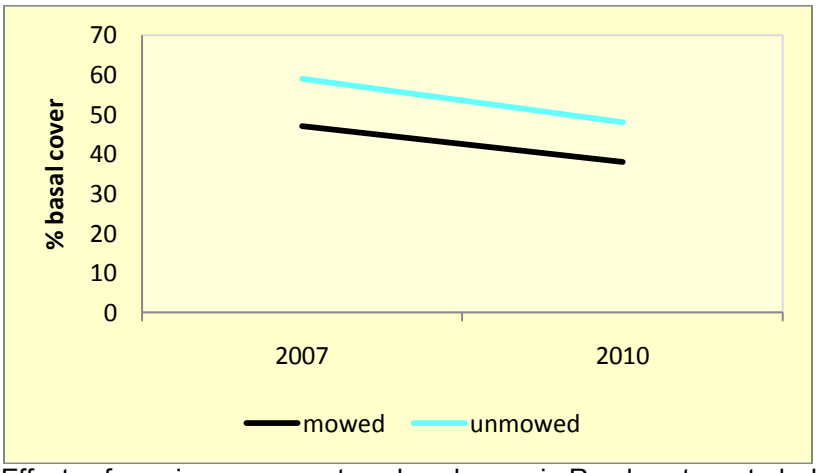

Figure 3. Effects of mowing on percentage basal cover in Roadcrest crested wheatgrass.

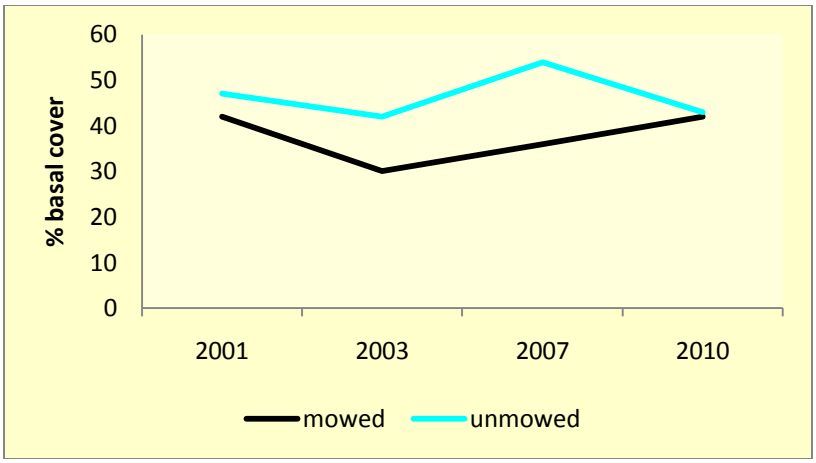

Figure 4. Effects of mowing on percentage basal cover in Ephraim crested wheatgrass.

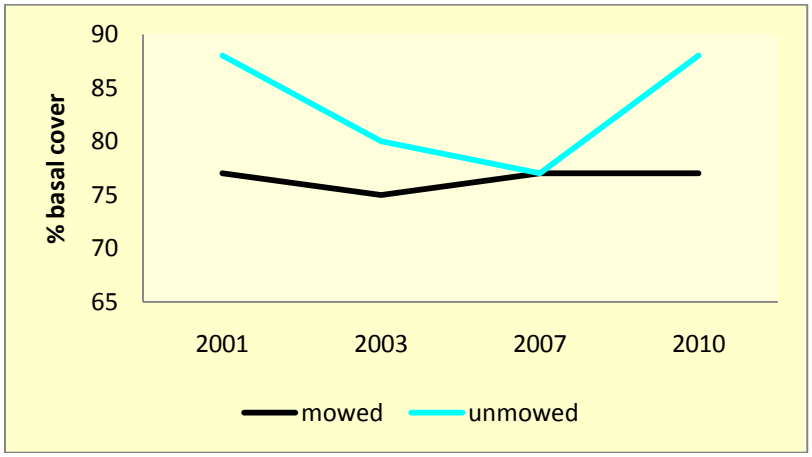

Figure 5. Effects of mowing on percentage basal cover in Bad River blue grama.

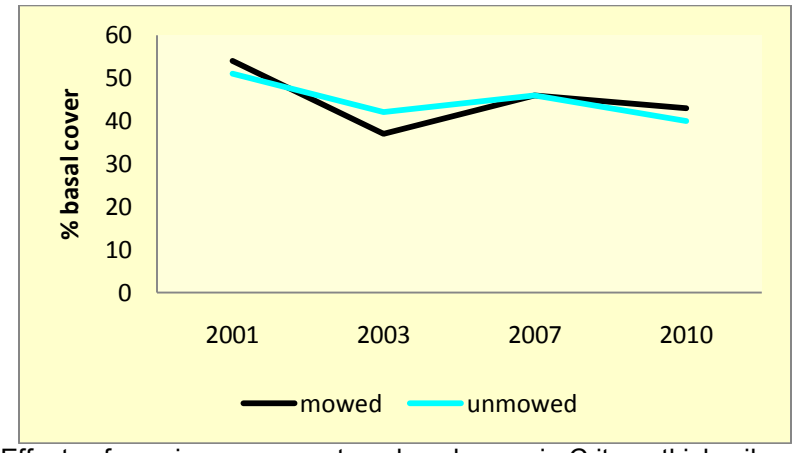

Figure 6. Effects of mowing on percentage basal cover in Critana thickspike wheatgrass.

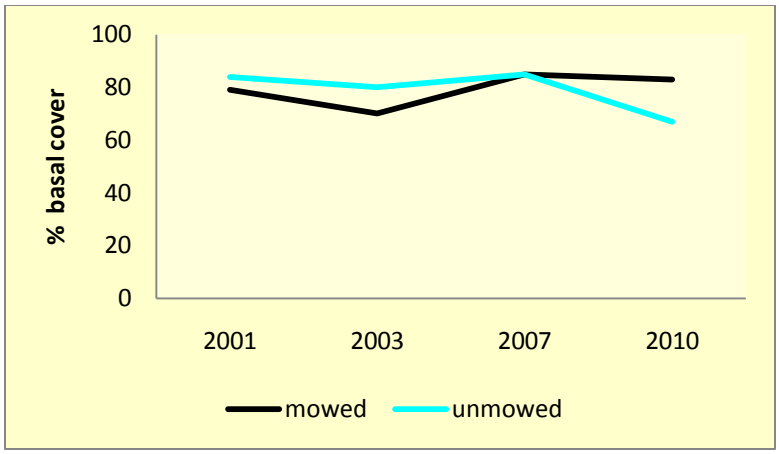

Figure 7. Effects of mowing on percentage basal cover in Bismarck buffalograss.

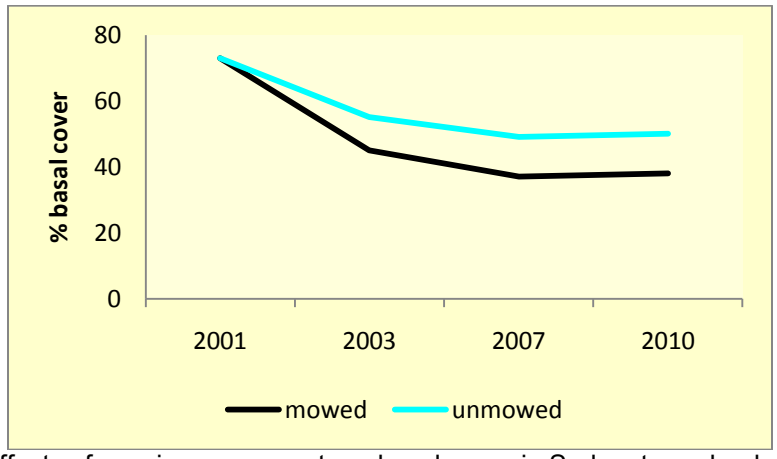

Figure 8. Effects of mowing on percentage basal cover in Sodar streambank wheatgrass.

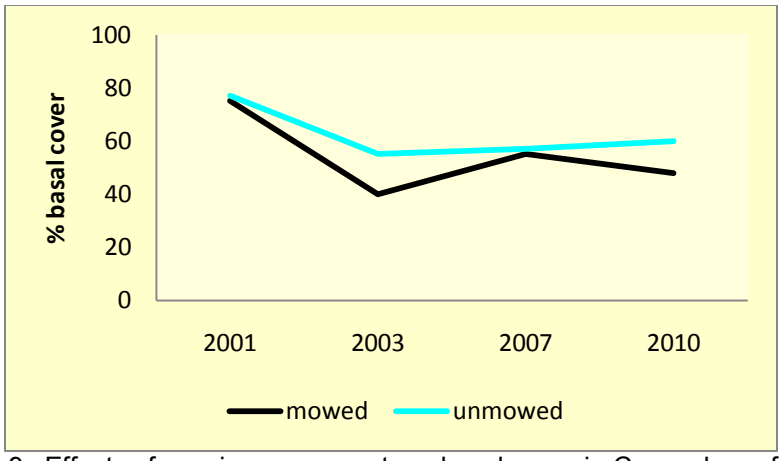

Figure 9. Effects of mowing on percentage basal cover in Covar sheep fescue.

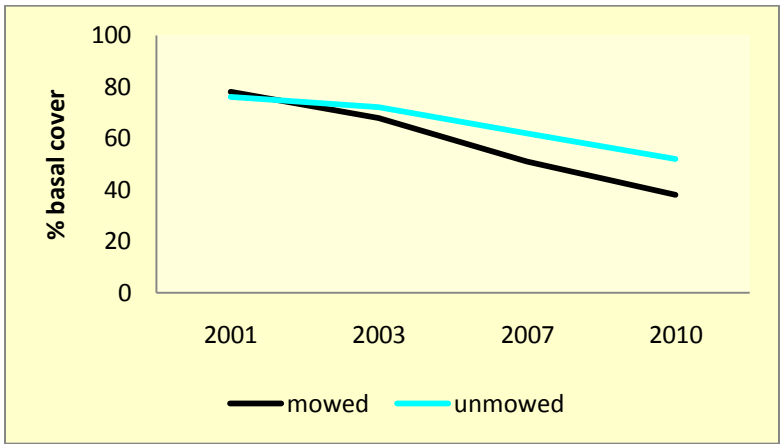

Figure 10. Effects of mowing on percentage basal cover in Rosana western wheatgrass.

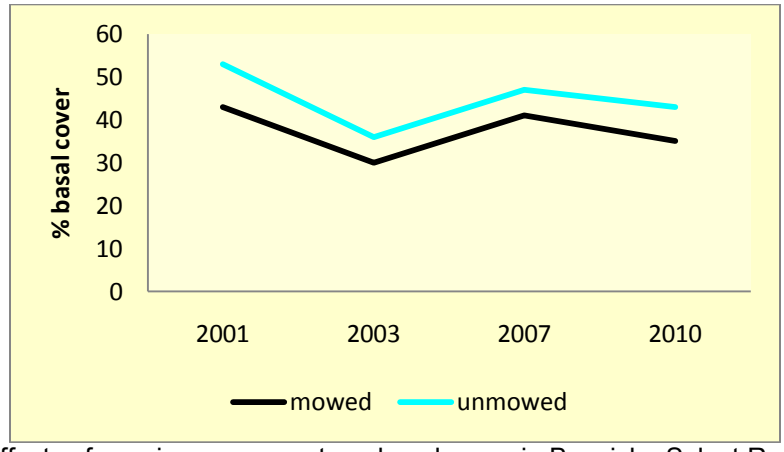

Figure 11. Effects of mowing on percentage basal cover in Bozoisky-Select Russian wildrye.

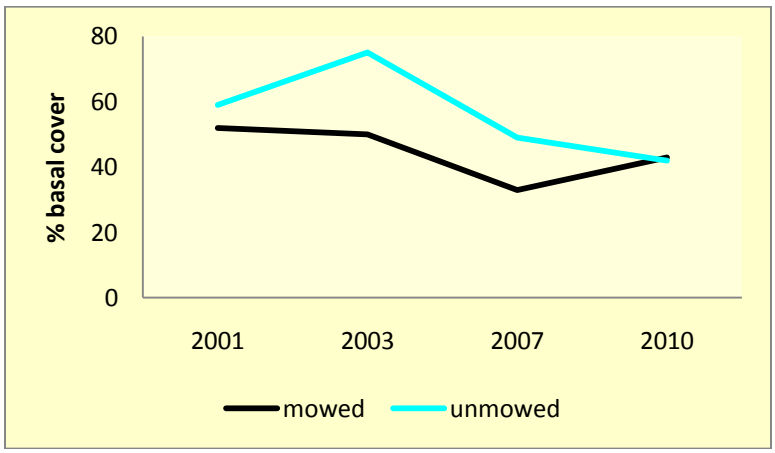

Figure 12. Effects of mowing on percentage basal cover in Foothills Canada bluegrass.

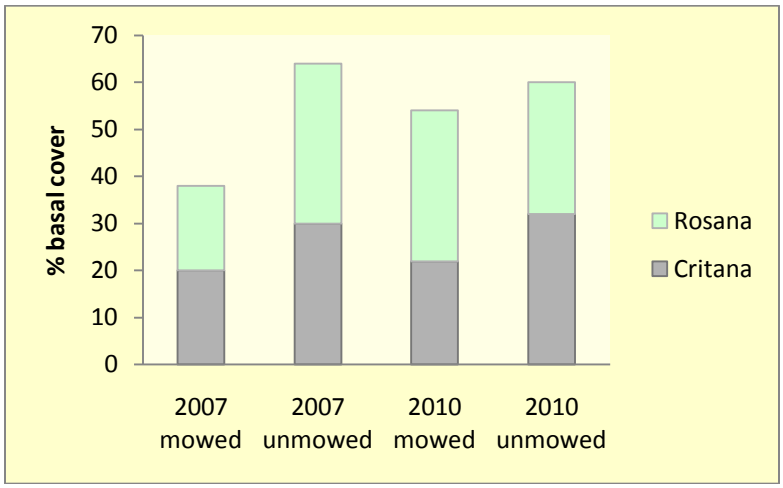

Figure 13. Effects of mowing on percentage basal cover in a mixture of Critana thickspike wheatgrass and Rosana western wheatgrass.

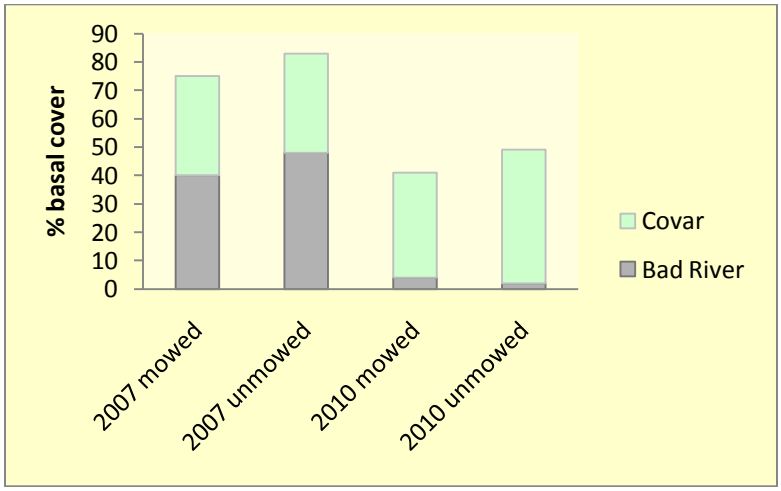

Figure 14. Effects of mowing on percentage basal cover in a mixture of Covar sheep fescue and Bad River blue grama.

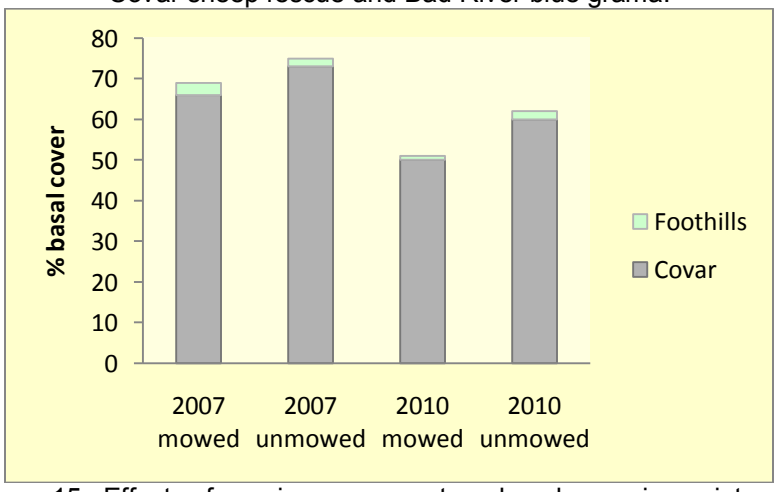

Figure 15. Effects of mowing on percentage basal cover in a mixture of Foothills Canada bluegrass and Covar sheep fescue.

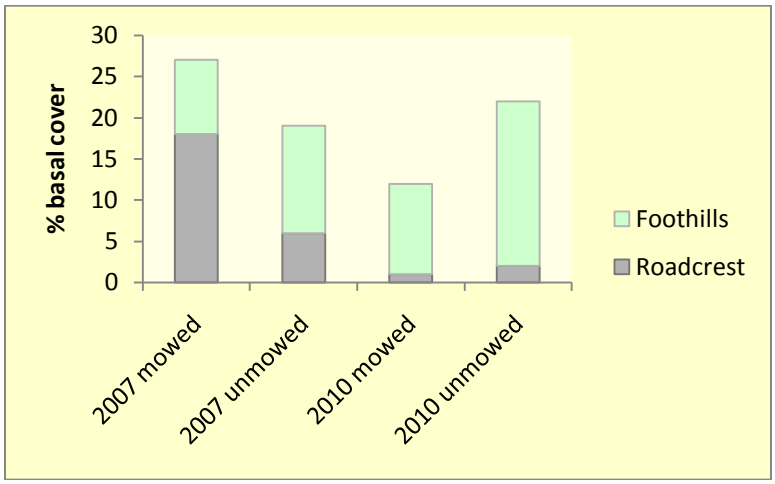

Figure 16. Effects of mowing on percentage basal cover in a mixture of Foothills Canada bluegrass and Roadcrest crested wheatgrass.

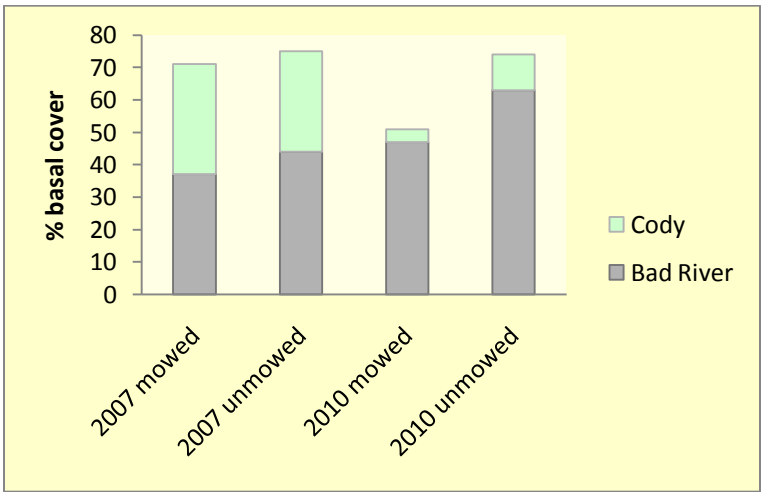

Figure 17. Effects of mowing on percentage basal cover in a mixture of Bad River blue grama and Bismarck buffalograss.

Summary: Based on previous years' data, some general statements can be made concerning the use of these grass species for low maintenance landscaping:

- mowing negatively impacted basal cover in all grass plots,
- thickspike and streambank wheatgrass have coarse leaves that do not cut cleanly,
- close mowing reduces plant cover and basal cover of most of the species,
- buffalograss and blue grama produced the softest turf,
- Canada bluegrass and crested wheatgrass were quite stemmy, with few basal leaves, and
- western wheatgrass and Canada bluegrass are the most tolerant of trampling.

Other general observations include:

- western wheatgrass stayed green the longest in the fall,
- buffalograss and blue grama green up late in the spring and turn yellow early in the fall,
- blue grama and sheep fescue tend to turn yellow under moisture stress, but quickly recover to a normal green color following a moisture event, and
- unmowed blue grama and buffalograss maintain a short stature.

The drought-tolerant grasses tested in the xeriscape demonstration may provide an alternative to the thirsty, introduced lawn grasses. Successful establishment depends on the following factors: proper site preparation, appropriate seeding rate, timely planting date, initial and supplemental irrigation, and reduced mowing. The natural characteristics of the cool-season grasses in this demonstration have wide, rough-textured leaves, medium green to blue color, broad stems, and erect habits. The cool-season bluegrass and the warm-season entries are more lawn-like in appearance. Recognizing and accepting these differences is critical before making a long-term commitment to installing a drought-tolerant turf-type application.

Appendix Table 1. The Cultural and Establishment Trial of Grasses in a Xeriscape Demonstration. The 2010 evaluation of 15 native and non-native grass plots at the Bridger PMC; solid stands planted April 10, 1998; mixture plots planted May 5, 2005.

Cultivar	Common Name	Plot No.	Cover Mowed	Cover	HT	Color[†]	Turf Suitability[‡]	Weed	Resistance[§]
			% basal	*% basal*	*cm*			mowed	unmowed
Solid Stands									
Roadcrest	crested wheatgrass	1	38	48	63	GY	5	3	4
Ephraim	crested wheatgrass	2	42	43	69	GY	6	3	3
Bad River	blue grama	3	77	88	33	PG	1	3	2
Critana	thickspike wheatgrass	4	43	40	74	G	3	2	3
Bismarck	buffalo grass	5	83	67	16	GB	2	4	4
Sodar	streambank	6	38	50	51	GB	2	2	2
Covar	sheep fescue	7	48	52	72	GB	2	2	2
Rosana	western wheatgrass	8	38	52	90	B	2	1	1
Bozoisky-Select	Russian wildrye	9	35	43	102	DG	3	1	1
Foothills	Canada bluegrass	10	43	42	56	G	3	2	3
Simple									
Critana+	thickspike wheatgrass	1	22	30	79	G	1	2	1
Rosana	western wheatgrass	1	35	34	89	B	1	2	1
Covar+	sheep fescue	2	50	73	82	GB	6	2	3
Foothills	Canada bluegrass	2	1	2	43	G	6	4	4
Bad River+	blue grama	3	4	48	24	PG	3	2	2
Covar	sheep fescue	3	37	35	77	GB	3	2	2
Foothills+	Canada bluegrass	4	11	13	48	PG	4	3	3
Roadcrest	crested wheatgrass	4	1	6	74	GY	4	3	3
Bad River+	blue grama	5	47	44	29	PG	1	1	1
Cody	buffalo grass	5	4	31	14	GB	1	1	2

[†] B-Blue, DG-Dark Green, G-Green, GB-Green blue, GY-Green yellow, PG-pale green.

[‡]1 to 10 w/1 best.

[§]1 to 5 w/1 best.

Study Title: Sub-Irrigation Tubes for Semi-Arid Environments

Study Number: MT-05-0003 (active)

Objective: To determine if sub-irrigation tubes increase the survival, growth, and vigor of test plants relative to surface-watered seedlings, as well as to determine if sub-irrigation tubes can be used to offset soil moisture losses to herbaceous competition.

Introduction: Woody seedling survival and establishment under dryland conditions can be difficult even under ideal conditions. The persistent drought being experienced in the Northern Great Plains and Intermountain West has resulted in numerous tree and shrub planting failures and decreased installation of woody practices. Research conducted by the Los Lunas Plant Materials Center suggests that polyvinylchloride (PVC) tubes inserted next to newly planted seedlings may be a cost-effective method of increasing seedling survival and growth, as well as a methodology for encouraging deep rooting of seedlings. This experiment is being conducted in conjunction with and in support of field studies established by Robert Kilian, Area Rangeland Specialist, in 2003 in Baker and Circle, Montana.

Project Description: Two deciduous species (*Fraxinus pennsylvanica* and *Quercus macrocarpa*) and two coniferous species (*Pinus ponderosa* and *Juniperus scopulorum*) were chosen for testing in this study. These species were selected because they have different leaf retention characteristics that may influence winter desiccation, as well as varying rooting habits (shallow vs. tap-rooted) that may influence their performance with and without the irrigation tubes. The study was installed on two sites: Site I is a fallow field (Field 3) that was maintained under clean cultivation over the 2004 growing season, Site II is a vegetated field with an established thickspike wheatgrass cover crop (Field 14). Although planting directly into a site with an established sod-forming grass is not a recommended practice, this test is necessary to address potential questions regarding the ability of sub-irrigation tubes and sub-surface watering to compensate for moisture loss from grass competition.

Project Considerations: It was noted early in project development that several additional water conserving techniques could be used in addition to, or in conjunction with, irrigation tubes in order to identify which technique(s) would provide the most benefits with the least investment of time, labor, and money. Examples include weed barrier, windscreens, and anti-transpirants (anti-desiccants). It was decided that the size of the study would quickly become unmanageable if more than two treatments (with and without tubes) were compared. Additional and separate studies will be necessary to test other water conserving/plant survival and growth-enhancing techniques. Additional questions arose regarding optimum depth of tubes (as it affects installation labor and soil profile wetting pattern) and the number and pattern of openings in tubes (as they affect soil profile wetting pattern and availability of water to seedling roots). It was considered that a combination of soil surface and irrigation tube watering might be needed initially (first 1 to 2 years) on trees with tubes until root growth reached a depth where water delivered by the irrigation tube was definitely available to the roots. As a compromise, it was decided that all test seedlings would receive 1 gallon of water at planting time to eliminate air pockets in the soil, and that seedlings with tubes would be watered with 1.9 gallons through the irrigation tube plus 1 gallon on the soil surface during Year 1 of the study. Trees without tubes were surface irrigated with the same volume of water applied through sub-irrigation tubes plus surface-applied, or 2.9 gallons in 2005. In 2006 and beyond, supplemental irrigation consisted of three applications in the spring and early summer. This irrigation schedule was based on the frequency of hand-watering likely and practical for farmers and ranchers (versus optimum water availability for plant survival and growth). Soil samples will be taken at both test sites to determine soil texture; available N, P, and K levels; pH; and salinity. Conservation Tree and Shrub Suitability Group classifications will be determined for both sites.

Methods and Materials: The experiment consists of 3 reps of 10 seedlings (30 seedlings) of each species for each treatment/site, resulting in 120 seedlings of each species (2 treatments x 2 sites x 30 seedlings/species) or a total of 480 seedlings for the entire study (2 treatments x 2 sites x 30 seedlings/species x 4 species). Holes were dug with an 8-inch auger mounted on a 3-point hitch and powered by the tractor PTO. Two hundred and forty seedlings were planted in fallow Field 3 on April 25, 2005. Two hundred and forty seedlings were planted in Field 14 at the BPMC in an area vegetated

predominantly with 'Critana' thickspike wheatgrass *Elymus lanceolatus* ssp. *lanceolatus* on April 26, 2005. There are, however, two areas within the site dominated by other species including 1) bluebunch wheatgrass *Pseudoroegneria spicata*, as well as 2) alternate rows of 'Bozoisky' Russian wildrye and sainfoin. Test plants within these vegetation types have been noted on the evaluation forms. Seedlings at both planting sites were spaced 6 feet within-row and 12 feet between-row. Rigid seedling protectors were installed on all green ash and bur oak on both sites on May 4 and 5, 2005, to prevent animal damage.

Sub-irrigation tubes were installed in Field 3 and Field 14 on May 5 and 6, 2005, respectively. Sub-irrigation tubes consist of 4-inch inside-diameter, non-perforated, polyvinylchloride (PVC) sewer pipe. Each pipe is 36 inches long, with 2-inch wide, horizon openings every 2 inches along the length of the pipe, beginning 6 inches from the top of the pipe. The width of each horizontal opening is the width of a standard circular saw blade. A 30" to 32" deep hole was augured for each tube with a 4-inch auger powered by a Giddings soil probe. Tube holes were located approximately 10 inches (± 4 inches) uphill from the seedling with the tube openings facing the seedling. Mean tube to plant distance in Field 3 by species was very consistent, ranging from 22.1 to 22.8 cm. Mean tube to plant distance in Field 14 was also consistent, although slightly greater than Field 3, ranging from 25.7 to 26.5 cm. Each tube was inserted in the hole and then residual soil inside the tube removed with a hand auger. The base of each tube was sealed with a pre-moistened, baseball-size sphere of bentonite clay.

All seedlings in both fields were irrigated on May 9 and 10, 2005. Trees with tubes received approximately 1.9 gallons in the tube plus 1 gallon on the soil surface around each plant. Trees without tubes received approximately 2.9 gallons on the soil surface only. Provisions were made at both sites to ensure that supplemental moisture applied to adjacent crops and fields did not become available to the test plants. All plants in Field 3 and Field 14 were provided with two additional irrigations over the course of the growing season, as previously described.

Results from trials in eastern Montana in 2003 and 2004, as well as additional soil wetting trials at the Bridger PMC in 2005, were used to adjust the irrigation tube design in 2006. In 2006, a 36-inch, non-perforated extension was added to the top of the existing sub-irrigation tube in order to increase storage capacity to nearly 3.5 gallons and improve distribution of water to the surface layers of the soil profile, and, therefore, to the root system of the developing seedling. Beginning in 2006, 3 gallons of water were applied at each application.

Weeds are controlled in Field 3 by a combination of hand rouging, mechanical cultivation, and spot-limited spraying with 2 to 3 percent glyphosate. Tall competing vegetation in Field 14 is managed by periodic mowing within- and between-rows on May 26 and then again on June 23 and 24, 2005.

Results: Mean percentage survival data appears in Table 1. Two trees without sub-irrigation tubes died in Field 3 (fallow) in 2009. In Field 14 (vegetated), nine seedlings died in 2009, although three seedlings considered dead in 2008 re-sprouted and were counted as alive in 2009. Of the seedlings in Field 14 that died, seven (78 percent) did not have a sub-irrigation tube and 56 percent were bur oak. Overall, 99 percent of the seedlings planted in 2005 in Field 3 were alive in 2009, whereas 89 percent of the seedlings in Field 14 survived. The largest differences in percentage survival based on the presence or absence of tubes occurred in Field 14 with bur oak (23 percent differential) and green ash (10 percent differential). In Field 3, all seedlings without tubes had a mean percentage survival of 99 percent, whereas seedlings with tubes all survived. In Field 14, seedlings without tubes had a mean percentage survival of 87.5 percent, whereas seedlings with tubes averaged 91 percent survival.

All other 2009 mean evaluation results for Field 3 and Field 14 appear in Tables 2 and 3, respectively. All 2009 raw evaluation data for Field 3 and Field 14 appear in 2009 ATR in Appendices 1 and 2, respectively. Mean plant height by treatment and species appears in Chart 1. Height, vigor rating, and survival data will be collected each fall after growth has ceased until the study is completed. No statistical analyses were performed in 2009 or 2010 (no evaluation data collected).

Table 1. Sub-Irrigation Tube Study, mean percentage survival, Bridger, MT, 2009.

Number of Surviving Plants		Cover	2008 Survival	2009 Survival
			%	%
Field 3				
28	Oak-No Tube	fallow	97	93
30	Oak-Tube	fallow	97	97
28	Ash-No Tube	fallow	100	97
31	Ash-Tube	fallow	100	100
30	Pine-No Tube	fallow	100	100
30	Pine-Tube	fallow	100	100
31	RMJ-No Tube	fallow	100	100
29	RMJ-Tube	fallow	100	100
Field 14				
20	Oak-NT	vegetated	80	67
27	Oak-T	vegetated	87	90
29	Ash-NT	vegetated	97	97
26	Ash-T	vegetated	90	87
26	Pine-NT	vegetated	90	87
27	Pine-T	vegetated	90	90
30	RMj-NT	vegetated	100	100
29	RMj-T	vegetated	100	97

In 2009, the mean height of all species in Field 3 (fallow) exceeded the mean height of the same species x treatment in Field 14 (vegetated). Similarly, mean height growth of all species in Field 3 (fallow) exceeded the mean height growth of the same species x treatment in Field 14 (vegetated). Ponderosa pine had the greatest positive response to tubes with mean height measuring 11.4 cm greater with tubes than without.

Although mean height growth with tubes always exceeded mean growth without tubes in Field 3 within a given species, the differences were often small. Green ash had the greatest positive response to tubes with mean height growth measuring 10.4 cm greater with tubes than without. Mean plant height in Field 14 as a function of tube or no tube was less consistent, however, with only green ash and Rocky Mountain juniper with tubes having greater mean height than trees without tubes. In Field 14, no consistent patterns of mean plant height or mean plant height growth emerged as a result of the use of tubes. All differences in mean height growth as a result of the use of tubes or no tubes were small in 2009.

Basal caliper was measured on all trees for the first time in 2009. Caliper measurements were not possible on the Rocky Mountain juniper since it is a multi-stemmed species. All trees in Field 3 (fallow) without tubes measured larger mean calipers than their counterparts with tubes, and the difference in caliper of the ponderosa pine was fairly significant (9.9 cm). Mean caliper in Field 14 (vegetated) as a function of treatment was irregular in 2009, and differences between treatments within a species were relatively small.

In all cases, the mean vigor rating of a given species x treatment was lower (better) in Field 3 (fallow) than Field 14 (vegetated). No consistent pattern of vigor rating emerged in either planting as a result of the use of tubes or no tubes, and differences were small.

Table 2. Sub-Irrigation Tube Study, 2009 mean evaluation results, tube versus no tube, Field 3 (fallow), Bridger, MT.

Species	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
	cm	*cm*	*mm*	(1-9)
No tube bur oak	94.8	-3.5	15.5	4.1
Tube bur oak	89.1	2.1	14.7	3.9
No tube green ash	382.0	50.3	79.7	3.3
Tube green ash	384.0	60.7	75.3	3.4
No tube ponderosa pine	149.4	41.8	63.8	2.9
Tube ponderosa pine	138.0	43.1	53.9	3.3
No tube Rocky Mountain juniper	181.8	27.1	NA	3.1
Tube Rocky Mountain juniper	186.1	32.0	NA	2.9

Table 3. Sub-Irrigation Tube Study, 2009 mean evaluation results, tube versus no tube, Field 14 (vegetated), Bridger, MT.

Species	**Fall 2009 Height**	**2009 Height Growth**	**Fall 2009 Caliper**	**Fall 2009 Vigor Rating**
	cm	*cm*	*mm*	(1-9)
No tube bur oak	17.4	-4.0	5.6	7.6
Tube bur oak	26.1	-1.8	5.7	7.7
No tube green ash	50.3	0	7.5	7.2
Tube green ash	41.6	-4.3	6.9	7.3
No tube ponderosa pine	54.7	7.7	17.7	6.5
Tube ponderosa pine	56.9	8.6	18.1	6.3
No tube Rocky Mountain juniper	61.5	9.8	15.4	6.8
Tube Rocky Mountain juniper	57.1	10.3	14.2	7.1

No evaluation data was collected on this study in 2010. The final evaluation of this experiment will occur in 2011, and then the plots removed, and the experiment terminated.

Conclusions: The effect of herbaceous competition on test plant growth was still very distinct in 2009. Sub-irrigation tubes did not provide adequate soil moisture to offset losses from competing herbaceous cover, primarily grasses, in Field 14. There were no obvious positive differences in plant growth between trees with tubes and trees without tubes on either site. This strongly suggests that the current tube design is not delivering optimum supplemental moisture to the root zone of the seedling during the early establishment period.

Increased quantity of water, more frequent application of water, closer proximity of the tubes to the trees, or more water applied to the soil surface during early establishment may also be needed.

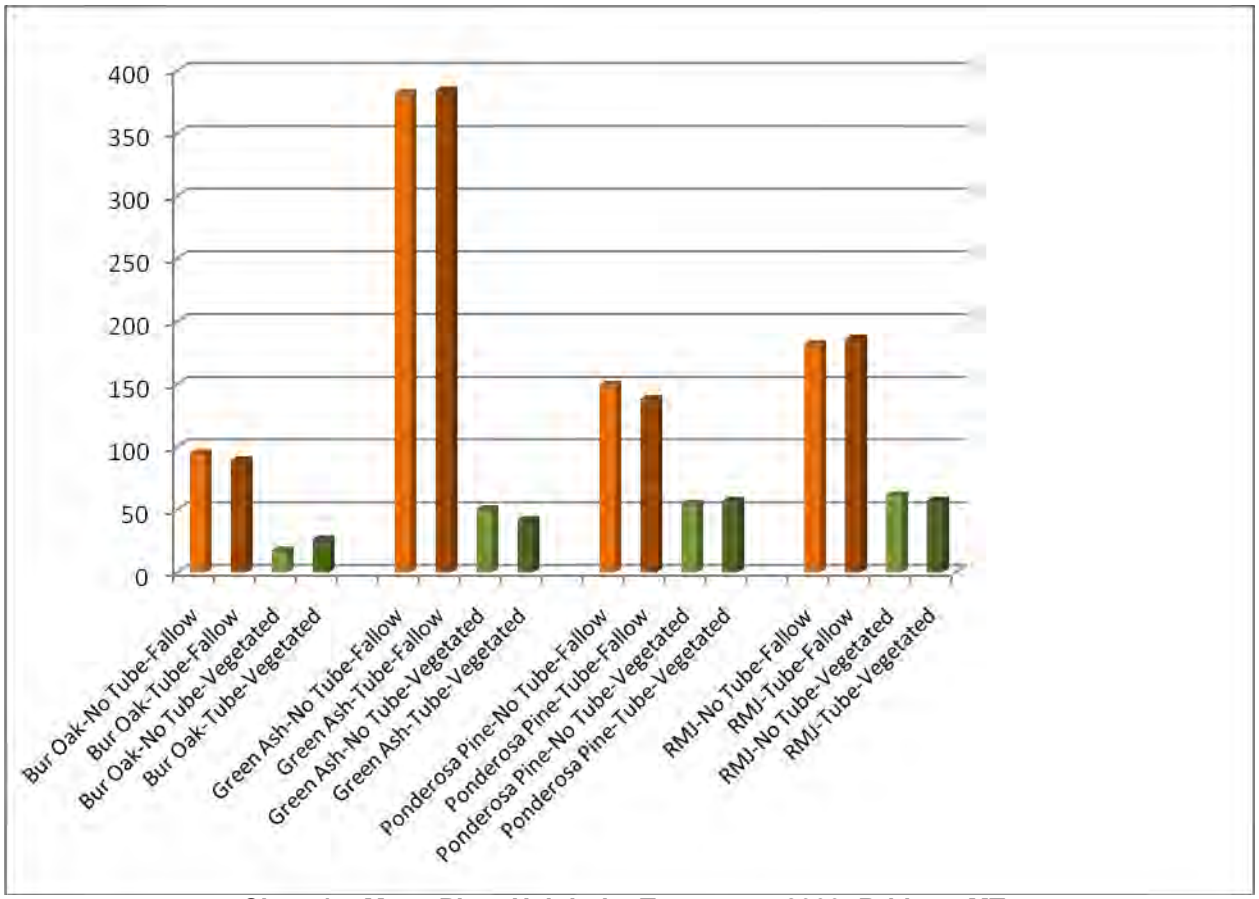

Chart 1 – Mean Plant Height by Treatment, 2009, Bridger, MT.

Study Title: Effects of Soil Salinity Level on the Survival and Growth of Trees and Shrubs Adapted to the Northern Plains and Intermountain West

Study Number: MT-06-0002 (active)

Objective: To determine the relative salinity tolerance of 18 different species of trees and shrubs used in various conservation applications in Montana and Wyoming.

Project Description: The northern Plains and Intermountain West are characterized by substantial areas dominated by saline soils. It is often desirable to establish woody species (trees and shrubs) on these sites for conservation applications such as field windbreaks, shelterbelts, wildlife habitat improvement, mineland reclamation, water conserving landscaping, urban forestry, and others. Limited research, both field and laboratory has been conducted on the saline tolerance of woody plants adapted to this region of the country. Most of the published information relative to Northern Plains and Intermountain West species are based on hearsay or observational/anecdotal information as opposed to scientific research. In addition, the bulk of the research results are based on studies using deicing salts containing Na and Cl compounds, as opposed to the Ca and Mg ions that predominate in western saline soils. The goal of this study is to identify which species are capable of surviving and establishing on saline sites, determine the threshold levels at which plant growth and survival is reduced, determine the maximum level of salinity that these species can tolerate, determine or identify cultural techniques for improving survival, establishment, and growth, and to identify undesirable woody species that may invade and compete with desirable plants on these sites.

Additionally, revegetation with woody plants after Russian olive and salt-cedar removal on salt-affected sites will become increasing important as control efforts for these invasive species increase. Although removal of Russian olive is relatively well documented and successful given follow up control, revegetation after removal and disturbance varies widely by site and climatic conditions. Salt-affected soils, especially sub-irrigated sites, are difficult to re-vegetate. The establishment of woody plants is particularly challenging on these sites as most species are sensitive to soil salts, low soil aeration, and competition from herbaceous vegetation. Weed invasion is often severe on these sites as well.

Furthermore, although plant selection is not within the scope of this project, the results of this study may suggest potential seed sources, Genera, and Species for future, more comprehensive selection testing.

Methods and Materials: This planting was installed in Field 26 at the Bridger Plant Materials Center, Bridger, Montana, in a salt-affected seep consisting of fluctuating levels of salts and water across the site. The test area measures approximately 200 feet north:west, and 160 feet east:west. The site was sprayed with 4 percent glyphosate on October 21, 2005, to control weeds (grass was dormant at the time). Site preparation consisted of mechanical cultivation of a 4-foot wide strip prior to planting in spring 2006. Since the ground cover was thick sod, it was necessary to spray the sod, then auger each planting hole in lieu of a mechanical tree transplanter. The planting consisted of 17 rows of test shrubs spaced 12 feet apart between rows, 5 feet apart within rows, and surrounded by an outside border row. This resulted in 30 test seedlings of a single species in a given row planted in an east:west direction across a salinity gradient (see Table 1). A total of 98 *Shepherdia argentea* 'Sakakawea' were used at Bridger as border plants. Most shrubs were 2-0 stock, although some 1-0 and 3-0 was necessary if 2-0 seedlings were not available or if the stock required 1 or 3 years to produce. All stock was planted bareroot to avoid confounding the study with the effects of propagation media. Each test row provided several planting locations with relatively low salinity levels so that complete regression/correlation curves can be generated. Vegetation between rows was mowed multiple times over the course of each growing season. Weed trimmers were used to control vegetation within the row. Competing herbaceous cover was sprayed annually with 3 to 4 percent glyphosate. A standardized irrigation schedule was developed so that the same amount and

frequency of supplemental water will be applied across all test locations. This may be particularly important in this study since supplemental water could possibly influence the salinity level of the

Table 1. Test species, woody plant salinity tolerance study, MT-06-002, Bridger, MT.

Species	Cultivar or Seed Source	Age
		years
Prunus americana	MITOSIS	2
Shepherdia argentea	North Dakota	2
Caragana arborscens	Missoula	2
Prunus virginiana	Canada Red	2
Prunus tomentosa	North Dakota	2
Prunus besseyi	North Dakota	2
Amelanchier alnifolia	northern Idaho	1
Rhus trilobata	Bighorn	2
Elaeagnus commutata	Unknown	2
Populus deltoides	Daniels County	1
Fraxinus pennsylvanica	MITOSIS	2
Elaeagnus angustifolia	North Dakota	1
Ulmus pumila	Unknown	1
Picea pungens	San Juan N.F.	3
Pinus ponderosa (east)	North Dakota	3
Symphoricarpos occidentalis	NI	NI
Hippophae rhamnoides	NI	2
Ribes aureum	NI	2
Lonicera korolkowii	NI	2

soil in the root zone over time. Two gallons of water were applied to each seedling at planting time, then every other week for a total of four additional irrigations. After the fourth irrigation, water was applied monthly over the remainder of the 2005 growing season. The frequency of watering was adjusted based on the timing and amount of natural precipitation.

Results: Plant and soil evaluation data for 2006, 2007, 2008, and 2009 appears in the 2009 ATR. Mean seedling root length and plant percentage survival over time appears in Table 2.

No evaluation data was collected in 2010. Final evaluations will be completed in 2011, the study removed, and the experiment terminated.

Table 2. Mean seedling root length and percentage survival, 2005 through 2009, Bridger, MT.

Species	2005 Mean Root Length	2006 Percentage Survival	2007 Percentage Survival	2008 Percentage Survival	2009 Percentage Survival
	cm	%	%	%	%
Shepherdia argentea	40	76.7	66.7	60.0	43.3
Prunus virginiana	35	46.7	40.0	30.0	6.7
Picea pungens	22	46.7	13.3	0.0	0.0
Lonicera korolkowii	36	90.0	76.7	70.0	70.0
Elaeagnus commutata	34	80.0	80.0	73.3	70.0
Ribes aureum	28	66.7	66.7	56.7	53.3
Hippophae rhamnoides	20	83.3	76.7	73.3	70.0
Elaeagnus angustifolia	24	96.7	96.7	93.3	93.3
Caragana arborescens	40	76.7	76.7	63.3	60.0
Ulmus pumila	35	90.0	90.0	83.3	83.3
Pinus ponderosa	16	100.0	53.3	10.0	3.3
Symphoricarpos albus	30	100.0	100.0	73.3	43.3
Fraxinus pennsylvanica	27	100.0	100.0	93.3	93.3
Prunus americana	32	86.7	80.0	33.3	23.3
Prunus besseyi	34	83.3	63.3	26.7	0.0
Rhus trilobata	52	76.7	73.3	70.0	66.7
Prunus tomentosa	40	23.3	20.0	16.7	16.7
Populus deltoides	30	100.0	100.0	100.0	96.7
Grand Average		79.1	70.7	57.0	49.6

Study Title: Cultural and Establishment Trial on the Performance of Conservation Grasses for Montana and Wyoming.

Study Number: MT-06-0003.

Objectives: Evaluate the phenological development and stand persistence of plant materials recommended for use in conservation plantings and for species identification during trainings and tours.

Project Description: There are many new cultivars and germplasms available on the commercial market for seeding pasture and hayland, disturbed areas, wildlife habitat enhancements, native landscapes, and saline-impacted areas. These plant materials originate from a wide variety of sources, including superior performing native species, or genetically manipulated introduced species. They may be recommended for use across large geographic areas, but in fact, may lack actual performance data from testing in diverse natural habitats. It is necessary to evaluate plant growth and development, and adaptability to a variety of physical environments, so that seeding recommendations can be made with confidence to producers and consumers in the service area of Montana and Wyoming. A demonstration was set up to evaluate the performance and adaptation of 45 new conservation grasses at the Bridger PMC (Table 1).

Methods and Materials: A small area in Field 10W adjacent to the county road was chosen because it is easily accessible for viewing by local residents and organized tour participants, and because irrigation is readily available. The seedbed preparation on this fallow site consisted of disking, cultipacking, and leveling. On April 26, 2006, a single-row belt seeder was used to establish a series of 1-ft wide by 20-ft long (0.3-meter by 6.1-meter) plots, at a rate of 25 pure-live-seeds per foot (82 seeds per meter). There is 4 ft (1.2-meter) between plots. Weed barrier was installed between plots and around the entire perimeter to encourage active viewing, minimize weed establishment, and lower associated labor costs. Sprinkler irrigation was set up immediately and plots were repeatedly sprinkled at short intervals to promote germination and reduce crusting. The plots received weekly irrigation during the establishment year, and as necessary in the second year. Several species were spring-seeded that are normally dormant, fall-planted, due to weed barrier installation constraints. Since these plots are not replicated, they are primarily used for demonstration purposes.

Discussion: The plots were not evaluated in 2010. Casual observations revealed after four years of establishment, there is a need to rehabilitate several of the plots. Some of the best performers included, but were not limited to ‘Lodorm’ green needlegrass, ‘Continental’ basin wildrye, two Altai wildrye entries, 9019219 bottlebrush squirreltail, Copperhead Germplasm slender wheatgrass, ‘P-7’ bluebunch wheatgrass, ‘Regar’ meadow brome, ‘Sunnyview’ big bluestem, three blue grama entries, and ‘Sunburst’ switchgrass. Many of the bluegrass and squirreltail entries declined in establishment. The installed weed barrier on the 0.12-acre (26 ft by 202 ft) area stayed down despite high winds, and required only a few additional large pins to keep it secure. The plots were adequately maintained with spot-spraying glyphosate and hand-weeding to remove undesirable species. These plots will be maintained and evaluated for several years. Information generated on the adaptation and performance will ultimately determine if additional plants can be added to the PMC’s conservation toolkit. This, in turn, strengthens assistance to the wide variety of producers in countless situations and natural environments in Montana and Wyoming.

Table 1. Cultural and Establishment Trial. New Conservation Grasses for Montana and Wyoming; planted April 26, 2006.

Genus and Species	Native Introduced	Cool/Warm Season	Common Name	Release Name	Origin	Seed Source
Achnatherum hymenoides	N	CS	Indian ricegrass	Rimrock	MT	MTPMC
Achnatherum hymenoides	N	CS	Indian ricegrass	Nezpar	ID	MTPMC
Achnatherum hymenoides	N	CS	Indian ricegrass	White River	NW CO	UTARS
Andropogon gerardii	N	WS	big bluestem	Bison	ND	MTPMC
Andropogon gerardii	N	WS	big bluestem	Sunnyview	SD	SDSU
Bouteloua gracilis	N	WS	blue grama	Alma	CO/NM	Arkansas Valley Seed
Bouteloua gracilis	N	WS	blue grama	Bad River	SD	MTPMC
Bouteloua gracilis	N	WS	blue grama	Birds Eye	NC WY	Wind River Seed
Bromus biebersteinii	I	CS	meadow brome	Regar	Turkey	Wind River Seed
Bromus biebersteinii	I	CS	meadow brome	McBeth	Paddock-Fleet-Regar	MTPMC
Bromus biebersteinii	I	CS	meadow brome	Cache	Regar-Fleet-Paddock	UTARS
Elymus elymoides	N	CS	squirreltail	9019219	WY	MTPMC
Elymus elymoides ssp. *elymoides*	N	CS	squirreltail	Fish Creek	SC ID	UTARS
Elymus elymoides ssp. *californicus*	N	CS	squirreltail	Toe Jam Creek	NW NV	UTARS
Elymus multisetus	N	CS	big squirreltail	Sand Hollow	SE ID	UTARS
Elymus trachycaulus	N	CS	slender wheatgrass	Copperhead	MT	MTPMC
Elymus trachycaulus	N	CS	slender wheatgrass	Pryor	MT	MTPMC
Elymus trachycaulus	N	CS	slender wheatgrass	San Luis	SW CO	COPMC
Elymus trachycaulus	N	CS	slender wheatgrass	Revenue	W. Sask.	MTPMC
Elymus wawawaensis	N	CS	Snake River wg	Secar	NC ID	MTPMC
Leymus angustus	I	CS	Altai wildrye	Mustang	Prairieland-Eejay-Pearl	UTARS
Leymus angustus	I	CS	Altai wildrye	Prairieland	AG Canada	MTPMC
Leymus cinereus	N	CS	basin wildrye	Washoe	MT	MTPMC
Leymus cinereus	N	CS	basin wildrye	Trailhead	MT	MTPMC
Leymus cinereus	N	CS	basin wildrye	Magnar	Saskatchewan	MTPMC
Leymus cinereus	N	CS	basin wildrye	Continental	UT	UTARS
Nassella viridula	N	CS	green needlegrass	Cucharas	SC CO	UTARS
Nassella viridula	N	CS	green needlegrass	Lodorm	ND	MTPMC
Nassella viridula	N	CS	green needlegrass	Fowler	UT	UTARS
Panicum virgatum	N	WS	switchgrass	9005439	WY	MTPMC
Panicum virgatum	N	WS	switchgrass	Forestburg	SD	MTPMC
Panicum virgatum	N	WS	switchgrass	Sunburst	SD	MTPMC
Panicum virgatum	N	WS	switchgrass	Dakotah	ND	MTPMC

Table 1. Cultural and Establishment Trial. New Conservation Grasses for Montana and Wyoming; planted April 26, 2006--Continued.

Genus and Species	Native Introduced	Cool/Warm Season	Common Name	Release Name	Origin	Seed Source
Poa compressa	I	CS	Canada bluegrass	Foothills	MT	MTPMC
Poa compressa	I	CS	Canada bluegrass	Ruebens	ID	WRS
Poa secunda (P. nevadenis)	N	CS	big bluegrass	Opportunity	MT	MTPMC
Poa secunda (P. ampla)	N	CS	big bluegrass	Sherman	NC OR	MTPMC
Poa secunda (P. sandbergii)	N	CS	Sandberg bluegrass	High Plains	MT-WY	MTPMC
Poa secunda (P. sandbergii)	N	CS	Sandberg bluegrass	Reliable	SC WA	UTARS
Poa secunda (P. sandbergii)	N	CS	Sandberg bluegrass	Hanford Source	SC WA	L&H Seed
Pseudoroegneria spicata	N	CS	bluebunch wg	Anatone	SE WA	MTPMC
Pseudoroegneria spicata	N	CS	bluebunch wg	Goldar	SE WA	MTPMC
Pseudoroegneria spicata	N	CS	bluebunch wg	P-7	BC-ID-MT-NV-OR-UT-WA	UTARS
Pseudoroegneria spicata	N	CS	bluebunch wg	9081757	MT	MTPMC

Study Title: Cultural and Establishment Trial on the Performance of Conservation Forbs for Montana and Wyoming

Study Number: MT-06-0004

Objectives: Evaluate the phenological development and stand persistence of plant materials recommended for use in conservation plantings and for species identification during trainings and tours.

Project Description: There are many new cultivars and germplasms available on the commercial market for seeding rangeland improvements, disturbed areas, wildlife habitat enhancements, and native landscapes. These plant materials originate from a wide variety of sources and are mostly natural track-selected native species. They may be recommended for use across large geographic areas, but in fact, may lack actual performance data from testing in diverse natural habitats. It is necessary to evaluate plant growth and development, and adaptability to a variety of physical environments, so that seeding recommendations can be made with confidence to producers and consumers in the service area of Montana and Wyoming. A demonstration was set up to evaluate the performance and adaptation of 29 new conservation legumes and forbs at the Bridger PMC (Table 1).

Methods and Materials: A small area in Field 7W adjacent to the county road was chosen because it is easily accessible for viewing by local residents and organized tour participants, and because irrigation is readily available. The seedbed preparation on this fallow site consisted of disking, cultipacking, and leveling. On May 3, 2006, a single-row belt seeder was used to establish a series of 1-ft wide by 20-ft long (0.3-meter by 6.1-meter) plots, at a rate of 25 pure-live-seeds per foot (82 seeds per meter). There are 3 ft (0.9-meter) between plots. Weed barrier was installed between plots and around the entire perimeter to encourage active viewing, minimize weed establishment, and lower associated labor costs. Sprinkler irrigation was set up immediately and plots were repeatedly sprinkled at short intervals to promote germination and reduce soil crusting. The plots received weekly irrigation during the establishment year and as necessary the second year. Several species were spring-seeded that are normally dormant, fall-planted, due to weed barrier installation constraints. Since these plots are not replicated they will be used primarily for demonstration purposes.

Discussion: The plots were not evaluated in 2010. Casual observations revealed several of the introduced species require a high level of maintenance, several of the native species have not persisted, and after 4 years of establishment, there is a need to rehabilitate many of the plots. Some of the best performers continue to be ‘Chemung’ crownvetch, Canada milkvetch (not yet released by the North Dakota PMC), ‘Lutana’ cicer milkvetch, ‘Ladak’ alfalfa, ‘Prairie Gold’ Maximilian sunflower, Antelope white prairie clover, ‘Kaneb’ and Bismarck purple prairie clover, Maple Grove Germplasm prairie flax, and ‘Appar’ blue flax. An introduced browse plant, ‘Puna’ forage chicory, also did very well. The local deer population heavily browsed on the two alfalfa entries, sainfoin, Puna forage chicory, and several of the other forbs. The installed weed barrier on the 0.06-acre (26-ft. by 108-ft.) area was very stable despite high winds, and required only a few additional large pins to keep it secure. The plots were adequately maintained with spot-spraying glyphosate and hand-weeding to remove undesirable species. These plots will be maintained and evaluated for several years. Information generated on the adaptation and performance will ultimately determine if additional plants can be added to the conservation toolkit. This, in turn, strengthens assistance to the wide variety of producers in countless situations and natural environments in Montana and Wyoming.

Table 1. Cultural and Establishment Trial. New Conservation Forbs for Montana and Wyoming; planted May 3, 2006.

Genus & Species	Native Introduced	Common Name	Release Name	Origin	Seed Source
Astragalus canadensis	N	Canada milkvetch	9069117	ND	NDPMC
Astragalus cicer	I	cicer milkvetch	Lutana	Sweden	MTPMC
Medicago sativa	I	yellow alfalfa	9087571	Smith Ranch, SD	MTPMC
Medicago falcata	I	alfalfa	Ladak	MSU-Bozeman	MTPMC
Dalea candida	N	white prairieclover	Antelope	ND	MTPMC
Dalea purpurea	N	purple prairieclover	Bismarck	SD	NDPMC
Dalea purpurea	N	purple prairieclover	Kaneb	NE KS	KSPMC
Lespedeza capitata	N	roundhead lespedeza	Kanoka	S IA	KSPMC
Coronilla varia	I	crownvetch	Chemung	NY	Etheridge Seed Farm
Onobrychis viciifolia	I	sainfoin	Eski	Turkey	MTPMC
Onobrychis viciifolia	I	sainfoin	Remont	MSU-Bozeman	Wind River Seed
Onobrychis viciifolia	I	sainfoin	Shoshone	UWYO	WY Seed Certification Service
Onobrychis viciifolia	I	sainfoin	Delaney	UWYO	WYSCS
Achillea millefolium var. *occidentalis*		western yarrow	Great Northern	MT	MTPMC
Achillea millefolium	N	western yarrow	Yakima	SC WA	UTARS
Achillea millefolium	N	western yarrow	Eagle	SW ID	FS BOISE
Echinacea angustifolia	N	echinaceae	Bismarck	ND	NDPMC
Helianthus maximiliani	N	Maximilian sunflower	Medicine Creek	SD	NDPMC
Helianthus maximiliani	N	Maximilian sunflower	Prairie Gold	KS	KSPMC
Helianthella pauciflorus	N	stiff sunflower	Bismarck	ND	NDPMC
Linum lewisii	N	prairie flax	Maple Grove	ID	MTPMC
Linum perenne	N	blue flax	Appar	Turkey	MTPMC
Penstemon eriantherus	N	fuzzytongue	Old Works	MT	MTPMC
Penstemon eatonii	N	firecracker penstemon	Richfield	UT	MTPMC
Penstemon venustus	N	alpine penstemon	Clearwater	NC ID	MTPMC
Penstemon strictus	N	Rocky Mountain	9087641	OR	Wind River Seed
Penstemon palmeri	N	Palmer's penstemon	Cedar	SW UT	MTPMC
Penstemon procerus	N	littleflower penstemon	9087547	WY	Wind River Seed
Ratibida columnifera	N	prairie coneflower	Stillwater	MT	MTPMC
Ratibida pinnata	N	grayhead coneflower	Sunglow	KS	KSPMC
Kochia prostata	I	forage kochia	Immigrant	Eurasia	Wind River Seed
Cichorium intybus	I	forage chicory	Puna	New Zealand	Barenbrug USA

Study Title: Container Depth as it Influences Bur Oak Seedling Survival and Growth

Study Number: MT-10-005

Objective: To determine if culturing bur oak seedlings in progressively taller containers results in improved seedling survival and initial height growth.

Project Description: Initial seedling height growth of bur oak is relatively slow. This study builds on preliminary research demonstrating that seedlings propagated in deep containers, and therefore containing long and extensive root systems, survive and grow better than plants propagated in shallow, conventional pots. In theory, deeper roots should facilitate increased access to sub-surface soil moisture over the course of the growing season. This study compares bur oak seedling survival and growth when propagated in three container sizes.

Methods and Materials: Seeds of Ekalaka Germplasm bur oak collected in 2009 at the Bridger PMC were used to sow containers in early 2010. A single seed was planted in each container type in Sunshine #1 mix and placed in a greenhouse maintained at 75 to 80^{0}F day temperatures and 65 to 70^{0}F night time temperatures. All containers were kept moist over the entire growing season. Seedlings were moved from the greenhouse to outdoor benches in July 2010. In September, all plants were relocated to a plastic-covered hoophouse maintained around 35^{0}F for the winter. The plants will again be moved to outside benches in June 2010 for the remainder of the 2011 growing season.

The study design will consist of three blocks of 10 trees of each container size for a total of 30 trees per block (see Figure 1). Each tree will be analyzed as a single plot. Trees will be planted on a minimum of 10-foot centers, resulting in a maximum plot size of 330 feet by 50 feet.

Figure 1 Bur oak depth of rooting study, plot design.

	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6
	10-1	10-2	24-1	10-3	36-1	36-2
	24-2	24-3	10-4	36-3	24-4	10-5
REP I	36-4	24-5	10-6	10-7	36-5	24-6
	10-8	36-6	24-7	24-8	10-9	36-7
	36-8	10-10	39-9	24-9	24-10	36-10
	36-1	10-1	10-2	36-2	36-3	24-1
	24-2	36-4	10-3	36-5	24-3	10-4
REP II	36-6	36-7	10-5	10-6	10-7	36-8
	24-4	24-5	36-9	24-6	10-8	24-7
	24-8	10-9	10-10	36-10	24-9	24-10
	36-1	24-1	36-2	10-1	10-2	36-3
	24-2	10-3	24-3	10-4	24-4	10-5
REP III	10-6	36-6	24-5	36-5	36-6	24-6
	36-7	24-7	36-8	10-7	24-8	10-8
	10-9	24-9	10-10	36-9	24-10	36-10

Results: Baseline plant growth measurements taken in the fall of 2010 appear in Table 1 and Appendix 1. Mean seedling height ranged from 9.4 cm (10-inch containers) to 10.7 cm (36-inch). Basal caliper ranged from 2.31 mm (10-inch) to 2.46 mm (24-inch). Mean seedling height tended to increase with increasing container size, whereas basal caliper results were more variable.

Table 1 Fall 2010 mean evaluation results, bur oak rooting depth study, Bridger, MT.

Seedling Number	Pot Depth	Stock Age	Mean Seedling Height	Mean Basal Caliper
	inches/cm		*cm*	*mm*
30	36/91.4	1-0	10.7	2.38
30	24/61.0	1-0	9.6	2.46
30	10/25.40	1-0	9.4	2.31
	Grand Average		9.9	2.38

Conclusions: No conclusions can be drawn from the preliminary data.

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Appendix 1 Raw 2010 evaluation data, bur oak rooting depth study.

Seedling Number	Container Depth	Stock Age	Seedling Height	Basal Caliper
	inch		*cm*	*mm*
1	36	1-0	10.0	2.37
2	36	1-0	10.5	2.10
3	36	1-0	10.5	1.96
4	36	1-0	11.0	2.74
5	36	1-0	17.5	3.24
6	36	1-0	9.0	1.89
7	36	1-0	12.0	2.31
8	36	1-0	10.0	2.34
9	36	1-0	13.0	2.41
10	36	1-0	13.5	2.54
11	36	1-0	11.0	2.01
12	36	1-0	8.0	1.63
13	36	1-0	14.0	2.40
14	36	1-0	14.5	3.87
15	36	1-0	10.5	2.18
16	36	1-0	13.5	2.54
17	36	1-0	5.5	2.41
18	36	1-0	8.5	2.35
19	36	1-0	12.5	2.72
20	36	1-0	9.5	2.51
21	36	1-0	8.0	1.87
22	36	1-0	10.0	1.89
23	36	1-0	12.5	2.12
24	36	1-0	7.5	2.20
25	36	1-0	11.0	3.39
26	36	1-0	9.0	1.97
27	36	1-0	9.5	2.31
28	36	1-0	11.0	2.62
29	36	1-0	8.5	1.88
30	36	1-0	10.5	2.54
1	24	1-0	8.0	2.67
2	24	1-0	11.0	2.37
3	24	1-0	11.0	2.24
4	24	1-0	10.0	2.22
5	24	1-0	10.5	2.20
6	24	1-0	11.5	2.84
7	24	1-0	7.0	2.54
8	24	1-0	8.0	2.45
9	24	1-0	9.0	2.68
10	24	1-0	7.0	1.89
11	24	1-0	8.5	2.34
12	24	1-0	9.0	1.91
13	24	1-0	10.0	2.44
14	24	1-0	9.5	2.39
15	24	1-0	10.0	2.91

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Appendix 1 Raw 2010 evaluation data, bur oak rooting depth study (Continued).

Seedling Number	Container Depth	Stock Age	Seedling Height	Basal Caliper
	inch		*cm*	*mm*
16	24	1-0	12.5	2.31
17	24	1-0	12.5	2.21
18	24	1-0	10.0	2.17
19	24	1-0	6.0	2.03
20	24	1-0	13.0	2.46
21	24	1-0	8.5	3.48
22	24	1-0	10.0	2.12
23	24	1-0	11.5	3.01
24	24	1-0	8.0	2.46
25	24	1-0	6.0	2.25
26	24	1-0	9.5	2.13
27	24	1-0	10.0	2.30
28	24	1-0	10.0	2.55
29	24	1-0	9.0	2.57
30	24	1-0	11.5	3.56
1	10	1-0	7.0	1.99
2	10	1-0	5.0	2.40
3	10	1-0	7.5	2.16
4	10	1-0	7.0	1.77
5	10	1-0	9.5	2.67
6	10	1-0	8.5	2.18
7	10	1-0	10.5	2.44
8	10	1-0	8.0	2.34
9	10	1-0	12.0	2.79
10	10	1-0	11.5	2.63
11	10	1-0	8.0	2.44
12	10	1-0	6.5	2.06
13	10	1-0	13.0	2.41
14	10	1-0	9.5	1.91
15	10	1-0	13.5	2.51
16	10	1-0	10.5	2.95
17	10	1-0	7.5	1.99
18	10	1-0	12.0	2.57
19	10	1-0	15.0	2.50
20	10	1-0	12.0	2.90
21	10	1-0	7.5	1.99
22	10	1-0	10.0	2.67
23	10	1-0	10.0	2.16
24	10	1-0	7.0	2.02
25	10	1-0	11.0	2.64
26	10	1-0	8.5	2.06
27	10	1-0	11.0	2.24
28	10	1-0	5.5	1.92
29	10	1-0	6.5	1.07
30	10	1-0	10.0	2.82

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Study Title: Container Depth as it Influences Plains Cottonwood Seedling Survival and Growth

Study Number: MT-10-004

Objective: To determine if culturing plains cottonwood seedlings in progressively taller containers results in improved seedling survival and growth along riparian corridors.

Project Description: The reduced ability of plains cottonwood to re-establishment naturally along riparian corridors has resulted in efforts to establish this species through seeding, planting of seedlings, planting of rooted cuttings, inserting un-rooted cuttings directly into the soil, and ripping of roots to encourage sprouting. This study builds on preliminary research demonstrating that seedlings propagated in deep containers, and therefore containing long and extensive root systems, survive and grow better than plants propagated in shallow, conventional pots. In theory, deeper roots should facilitate increased access to sub-surface soil moisture over the course of the growing season. This study compares seedling survival and growth when they are propagated in three container sizes.

Methods and Materials: Seeds of plains cottonwood were collected by the Miles City Area Office in early 2009 and shipped to the Bridger PMC for processing. Containers were sown in mid-2010, a single seed planted in each 7-cubic-inch conetainer in Sunshine #1 mix and then placed in a greenhouse. All containers were kept moist over the growing season. Seedlings were moved from the greenhouse to outdoor benches in August 2009. In September, all plants were relocated to a plastic-covered hoophouse maintained around 35^{0}F for the winter. In the spring of 2010, 30 seedlings each were transplanted into 10-inch, 24-inch, and 36-inch deep containers in Sunshine mix #1 and placed in a greenhouse. Seedlings were moved from the greenhouse to outdoor benches in July 2010. In September, all plants were stored in a plastic-covered hoophouse maintained around 35^{0}F for the winter.

The study design will consist of three blocks of 10 trees of each container size for a total of 30 trees per block (see Figure 1). Each tree will be analyzed as a single plot. Trees will be planted on a minimum of 10-foot centers, resulting in a maximum plot size of 150 feet by 60 feet.

Figure 1. Plains cottonwood depth of rooting study, plot design.

	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6
	10-1	10-2	24-1	10-3	36-1	36-2
	24-2	24-3	10-4	36-3	24-4	10-5
REP I	36-4	24-5	10-6	10-7	36-5	24-6
	10-8	36-6	24-7	24-8	10-9	36-7
	36-8	10-10	39-9	24-9	24-10	36-10
	36-1	10-1	10-2	36-2	36-3	24-1
	24-2	36-4	10-3	36-5	24-3	10-4
REP II	36-6	36-7	10-5	10-6	10-7	36-8
	24-4	24-5	36-9	24-6	10-8	24-7
	24-8	10-9	10-10	36-10	24-9	24-10
	36-1	24-1	36-2	10-1	10-2	36-3
	24-2	10-3	24-3	10-4	24-4	10-5
REP III	10-6	36-6	24-5	36-5	36-6	24-6
	36-7	24-7	36-8	10-7	24-8	10-8
	10-9	24-9	10-10	36-9	24-10	36-10

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Results: Baseline plant growth measurements taken in the fall of 2010 appear in Table 1 and Appendix 1. Mean seedling height ranged from 66.0 cm (24-inch containers) to 86.7 cm (36-inch). Basal caliper ranged from 5.04 mm (10-inch) to 6.29 mm (36-inch). With the exception of the mean height of the 24-ich containers, both mean seedling height and basal caliper tended to increase with increasing container size.

Table 1. Fall 2010 mean evaluation results, plains cottonwood rooting depth study, Bridger, MT.

Seedling Number	Container Depth	Container Volume	Stock Age	Mean Straight Seedling Height	Mean Basal Caliper
	inches/cm	*cm^3*		*cm*	*mm*
30	36/91.4		1-0	86.7	6.29
30	24/61.0		1-0	66.0	5.19
30	10/25.40		1-0	70.3	5.04
	Grand Average			74.4	5.50

Conclusions: No conclusions can be drawn from the preliminary data.

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Appendix 1. Raw 2010 evaluation data, plains cottonwood rooting depth study.

Seedling Number	Container Depth	Stock Age	Seedling Height	Basal Caliper
	inches		*cm*	*mm*
1	36	2-0	61	6.44
2	36	2-0	73	5.94
3	36	2-0	105	7.97
4	36	2-0	98	6.91
5	36	2-0	101	6.99
6	36	2-0	104	6.32
7	36	2-0	92	5.52
8	36	2-0	80	6.04
9	36	2-0	110	5.91
10	36	2-0	103	5.87
11	36	2-0	96	6.17
12	36	2-0	88	5.79
13	36	2-0	93	5.27
14	36	2-0	75	5.20
15	36	2-0	73	5.56
16	36	2-0	74	6.64
17	36	2-0	80	5.59
18	36	2-0	92	6.27
19	36	2-0	100	6.65
20	36	2-0	69	5.93
21	36	2-0	108	6.56
22	36	2-0	93	7.13
23	36	2-0	80	7.15
24	36	2-0	86	7.29
25	36	2-0	84	7.19
26	36	2-0	83	6.78
27	36	2-0	85	5.82
28	36	2-0	64	5.49
29	36	2-0	73	6.16
30	36	2-0	79	6.19
1	24	2-0	58	5.42
2	24	2-0	48.5	4.40
3	24	2-0	36	3.38
4	24	2-0	80	5.73
5	24	2-0	90	5.84
6	24	2-0	60.5	5.08
7	24	2-0	100	5.40
8	24	2-0	72	5.39
9	24	2-0	71	5.66
10	24	2-0	73	4.81
11	24	2-0	75	6.16
12	24	2-0	69	4.88
13	24	2-0	79	5.26

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Appendix 1. Raw 2010 evaluation data, plains cottonwood rooting depth study (Continued).

Seedling Number	Container Depth	Stock Age	Seedling Height	Basal Caliper
	inches		*cm*	*mm*
14	24	2-0	64	4.60
15	24	2-0	47	3.73
16	24	2-0	72	5.60
17	24	2-0	48	4.62
18	24	2-0	73	5.35
19	24	2-0	81	5.07
20	24	2-0	68	5.71
21	24	2-0	59	4.41
22	24	2-0	54	6.03
23	24	2-0	52	3.99
24	24	2-0	68	4.94
25	24	2-0	46	5.10
26	24	2-0	73	5.57
27	24	2-0	60	5.16
28	24	2-0	67	5.85
29	24	2-0	83	6.53
30	24	2-0	54	5.90
1	10	2-0	93	5.79
2	10	2-0	72	4.57
3	10	2-0	56	4.47
4	10	2-0	85.5	6.74
5	10	2-0	62	4.65
6	10	2-0	98	6.62
7	10	2-0	64	4.21
8	10	2-0	92	6.24
9	10	2-0	57	4.08
10	10	2-0	97	4.86
11	10	2-0	55	4.97
12	10	2-0	61.5	4.64
13	10	2-0	78	5.00
14	10	2-0	87	3.91
15	10	2-0	101	6.23
16	10	2-0	50	4.47
17	10	2-0	58	4.33
18	10	2-0	83	5.74
19	10	2-0	57.5	4.98
20	10	2-0	49	4.85
21	10	2-0	84.5	6.43
22	10	2-0	49	4.17
23	10	2-0	55	4.67
24	10	2-0	45	4.86
25	10	2-0	89	5.74
26	10	2-0	46	3.97

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Appendix 1. Raw 2010 evaluation data, plains cottonwood rooting depth study (Continued).

Seedling Number	Container Depth	Stock Age	Seedling Height	Basal Caliper
	inches		*cm*	*mm*
27	10	2-0	75	5.25
28	10	2-0	84.5	5.60
29	10	2-0	63	4.44
30	10	2-0	61	4.63

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VI. COLLABORATIVE AND REIMBURSABLE PROJECTS

YELLOWSTONE NATIONAL PARK
2010 ANNUAL SUMMARY REPORTS
prepared by

Natural Resources Conservation Service
Plant Materials Center
Bridger, Montana

Project Titles:

1. **Development of plant materials for revegetation of disturbed areas related to Federal Land Highway Projects (FLHP).**
2. **Collecting, evaluating, growing, and increasing plant materials for use in non-FLHP disturbances.**

Introduction: The agreements facilitate the collection, increase, and reestablishment of indigenous plant materials for restoration of disturbances resulting from road construction and other improvement projects within Park boundaries. The Bridger PMC (BPMC) has maintained cooperative agreements with Yellowstone National Park (YNP) since FY 1986.

In 2010, 10 allocations of 94 seed lots were distributed to YNP, YNP-contracted growers, and the BPMC. The BPMC-distribution included seven grass lots (six species) and one tree species for planting seed increase fields and container production.

Accomplishments: Yellowstone National Park can forecast future road construction projects with enough lead time to allow seed and/or plant collection and production efforts to begin 3 years in advance of each project.

Wildland seed collections are made by YNP and BPMC crews, dried, and either delivered to the BPMC or picked up by BPMC personnel. In 2010, 42 pounds of 32 collections were made from 22 grasses of 13 species totaling 41 pounds and 10 forbs of seven species totaling 1.2 pounds.

YNP records number of person-hours required to collect each seed lot, from which the approximate cost of collecting native seed can be estimated. In 2010, YNP and BPMC personnel spent more than 115 person-hours seed collecting on eight different sites. There were 94 hours (approximately 4.3 hours per collection) dedicated to collecting grass seed on seven sites and 21 hours (approximately 2.1 hours per collection) for forbs on five sites.

There were seven grass increase blocks planted at the PMC on 1.65 acres in 2010. Seed increase blocks of two grasses on 0.65 acre were removed due to natural decline in production. Currently there are 3.47 acres planted with 15 accessions of 10 grass species in seed increase blocks at the BPMC.

During the past growing season, six grass species were harvested on 1.5 acres. The total amount of seed produced was nearly 99 pounds, with the best grass stand yielding 345 lb/acre. Nearly all of the current year's production was processed and distributed to the Park for fall planting.

The wildland collection and seed increase inventory contains seed dated from 2001 to 2010. The 2005 seed lots of slender wheatgrass and the 2003 seed lots of mountain brome were returned to YNP in 2010. Additionally, all seed lots from 2000 were distributed back to the Park. There are approximately 1,500 lodgepole pine seedlings in the vegetative inventory.

Technology Development: All plant material collections are assigned accession numbers and inventoried in a database. The lot identification numbers have been upgraded to include identification by individual construction projects.

3. Restoration of Gardiner Basin agriculture fields to native species.

Introduction: Effective in fiscal year 2009, a new YNP agreement was developed to address issues associated with enhancing critical wildlife habitat along the northern boundary in the Gardiner Basin. The 3-year project facilitates seed production of two native grasses at the BPMC, along with establishment of restoration test plots on a small portion of the land formerly used for agricultural production and acquired by YNP in the 1930s. The plots will be evaluated on the effectiveness of various weed control methods, seeding techniques, and plant performance.

Accomplishments: The BPMC assisted YNP with seed collection efforts at the Carbella Site. YNP personnel spent more than 62 hours hand-collecting 10 pounds of seed of four grasses on the site. There are 10 lots of five grasses with more than 41 pounds of wildland seed collections from the Carbella site on inventory at the BPMC.

There are three seed increase blocks of two grass species totaling approximately 1 acre at the BPMC. Seed was harvested from two blocks in 2010, including one field in the first year of establishment. The total amount of seed produced was 11 pounds. Forty-four, small, square bales of needle and thread grass aftermath were delivered to YNP.

Seed increase of YNP bluebunch wheatgrass at the Bridger PMC.

Technology Development: On May 13, the BPMC attended a seminar and on-site review by Dr. Hamilton on the results of soil sampling for microbes in different plant communities in the Park. The BPMC provided Dr. Hamilton with seed of several native species for laboratory testing and examination of plant interactions with soil microbes indigenous to YNP. His field studies will generate data on microbial community dynamics related to exotic and native plants and nitrogen cycling in the soil. The data will be analyzed and used to enhance the success rate of native revegetation efforts in YNP.

The first test plot located near the Park's Northern Boundary continues to be maintained in cereal grains in order to stabilize the site. Park-approved herbicides have been applied to eliminate non-native vegetation. The fenced site will be monitored until the revegetation study plots are established in the fall of 2011.

GLACIER NATIONAL PARK
YEAR 2010 ANNUAL SUMMARY REPORT
prepared by

NATURAL RESOURCES CONSERVATION SERVICE
PLANT MATERIALS CENTER
BRIDGER, MONTANA

INTRODUCTION: The Bridger Plant Materials Center has maintained a cooperative agreement with Glacier National Park since FY 1986. This agreement facilitates the collection, increase, and establishment of indigenous plant materials, and the development of technologies for the restoration of disturbances resulting from road construction and other projects within Park boundaries.

Pat Davey Image.

ACCOMPLISHMENTS: In 2010, 215 seed lots representing 98 species were delivered to Glacier or used for Bridger Plant Materials Center seed increase. Total weight of seed delivered in 2010 was 25.7 kilograms (56.7 pounds). The 2010 seed distribution included 44 grasses (30 species), 103 forbs (48 species), and 57 woody plants (30 species). A total of 2328 containerized plants were delivered to Glacier Park in 2010. A total of 326 wildland seed collections, including 90 new accessions, were processed at the Bridger Plant Materials Center in 2010 and are reported in the 2010 Glacier Annual Technical Report.

Active and new seed production fields as of December 2010 appear in Table 1. Seed production was consistently low in 2010, and many aging and poorly established fields were removed. Field seed increase at the Center in 2010 is reported in the Glacier Park 2010 Annual Technical Report.

Table 1. Glacier Park seed production fields at the Bridger Plant Materials Center, December 2010.

Genus & Species	Accession Number	Site	Field	Date Field Planted	Field Size (acres)	2010 Harvest (kg)
Elymus glaucus	9087348	SM[1]	15N	4/14/2009	0.75	-
Elymus glaucus	9087348	SM[2]	15N	4/14/2009	0.52	25.4[4]
Eurybia conspicua	9087433	LM	4	6/21/2005	0.05	0.381
Festuca idahoensis	9058298	Camas	15N	4/14/2009	0.63	0
Symphyotrichum laeve	9081447	LM	4	1998	0.04	-
Symphyotrichum laeve	9081447	LM	4	6/3&23/2004	0.09	0.050[3]

1 From 2007 lot.
2 From 2008 lot.
3 Yield is a combination of both acreages in Field 4.
4 Yield is a combination of both acreages in Field 15.

Container plants sown and held in cold storage at the Bridger Plant Materials Center in 2010 for GNP appear in Table 2.

Table 2. Container plants sown and held in cold storage at the Bridger Plant Materials, December 2010.

Species Name	Glacier Lot Number	Accession Number	Collection Location	Date Sown	Number of Units	Size Container
						cubic inches
Rhamnus alnifolia	03-051	9082175	Goat Haunt	10/29/2010	366 pots	7
Rhamnus alnifolia	03-051	9082175	Goat Haunt	10/29/2010	21 plants	40
Carex microptera	08-028	9087799	Lake McDonald	7/14/2009	600 plants	7
Carex geyeri	08-004	9087925	Lake McDonald	8/10/2009	10 plants	7
Lithosperma ruderale	09-073	9087758	Saint Mary	10/29/2010	198 pots	7
Mahonia repens	07-092	9054489	North Fork	7/23/2008	36 plants	7
Mahonia repens	07-054	9063248	Saint Mary	7/23/2008	191 plants	7
Mahonia repens	08-294	9087360	Goat Haunt	7/23/2008	81 plants	7
Rubus parviflorus	08-144	9078268	Lake McDonald	8/10/2009	104 plants	40
Potentilla fruticosa	-	9082113	Waterton	10/29/2010	19 plants	40
Potentilla fruticosa	-	9082113	Waterton	10/29/2010	173 pots	7
Symphoricarpos albus	08-293	9087424	Goat Haunt	10/29/2010	200 pots	7
Symphoricarpos albus	07-091	9082150	North Fork	10/29/2010	200 pots	7
Symphoricarpos albus	04-257	9087424	Goat Haunt	10/29/2010	200 pots	7
Symphoricarpos albus	07-189	9082129	Saint Mary	10/29/2010	280 pots	7
Symphoricarpos albus	-	9087730	Waterton	10/29/2010	200 pots	7
Symphoricarpos albus	07-163	9082128	Lake McDonald	10/29/2010	120 pots	7

Container/potted plants delivered to Glacier National Park in 2010 appear in Table 3.

Table 3. Container/potted plants delivered to Glacier National Park, 2010.

Species Name	Glacier Lot Number	Accession Number	Collection Location	Date Sown	Number of Containers	Size Container
						cubic inches
Festuca occidentalis	07-015	9087751	Lake McDonald	5/1/2008	1000	7
Mahonia repens	07-054	9063248	Saint Mary	2008	1913	4
Rosa woodsii	Multiple	9063260	Lake McDonald		246	10
Rubus parviflorus	06-038	9078268	Lake McDonald	8/10/2009	169	40

TECHNOLOGY DEVELOPMENT AND ASSISTANCE: A prototype electronic labeling system for wildland seed collection was developed by the Natural Resources Conservation Service State Office staff in cooperation with the Plant Materials Center. Glacier National Park staff were trained in nursery irrigation system design, cutting and container propagation, hardening-off, media preparation and using the new labeling system during the summer visit by BPMC and State Office staff on July 12-16, 2010.

United States Department of Agriculture

Natural Resources Conservation Service

Bridger Plant Materials Center

September 2010

Initial Evaluation Planting
Wyoming BLM
2010 Progress Report

Native Wildflower Initial Evaluation Planting at Bridger, Montana.

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Wyoming BLM and NRCS Bridger Plant Materials Center
Inter-Agency Agreement 67-0325-08-022
Initial Evaluation Planting
Fiscal Year 2010 Progress Report

Introduction

The objective of the Inter-Agency Agreement between the USDI Wyoming Bureau of Land Management (BLM) and the USDA Natural Resources Conservation Service Bridger Plant Materials Center (BPMC) is to use a common garden experiment to evaluate the performance and phenology of several native forbs species collected by the BLM. Information will be used to select accessions of native forbs for commercial seed production for reclamation, restoration, and fire rehabilitation applications.

The BLM cooperative project was initiated to mutually address priority conservation needs as outlined in the BPMC's 2001 Long-Range Plan (LRP). The LRP identifies important land management issues such as restoring ecosystem structure and function following disturbance, minimizing weed invasion, increasing desirable plant cover and diversity, enhancing wildlife habitat, and reducing soil erosion. It further dictates the BPMC identify and collect suitable plant materials, assemble and install evaluation plantings, determine proper establishment techniques, select superior performing accessions for commercial release, and develop and transfer technology. The BLM study will be conducted as a 4-year Initial Evaluation Planting (IEP) to observe the characteristics and performance of numerous collections.

Methods and Materials

In the fall of 2008, the BPMC received five wildland seed collections from BLM. The U.S. Forest Service's Bend Seed Extractory in Oregon, forwarded pertinent details on several samples (Table 1). The seed collections were assigned accession numbers, and the collections of bluebunch wheatgrass and antelope bitterbrush were placed in storage. An appropriate amount of each sample, based on seeding rate and seeds per pound, were weighed and packaged for inclusion in a larger-scale BPMC evaluation planting. On November 17, 2008, three BLM prairie thermopsis collections, *Thermopsis rhombifolia*, along with 76 other accessions, were hand-planted with a single-row belt seeder to a depth of approximately 13 millimeters (½ inch), at a rate of approximately 50 bulk seeds per meter (15 seeds per linear foot) of row. Standard plot length was 4.6 meters (15 foot), but length was variable depending on seed availability. Within each row, the distance between plots was 0.3 meter (1 foot), and between-row width spacing was 1.22 meters (4 foot). Planting order was alphabetical by functional group, beginning with native legumes and progressing through native wildflowers. Shortly after planting, fabric barrier was installed between the rows to reduce weed problems.

On April 22, 2009, five entries from Wyoming's Little Snake River Conservation District were seeded at the end of the ninth row in plots 26 and 27, and in the first three plots of the tenth row. On August 25, 2009, the BPMC received a penstemon collection from Wyoming BLM. On December 7, 2009, Wyoming BLM seed collections of pale agoseris and prairie thermopsis were received from the Seed Extractory in Oregon. On March 10, 2010, seed of the four 2009 BLM collections were planted in plots 4-7 of the tenth row.

In early spring 2010, the study area was periodically monitored for plant growth and development. Weed control measures were repeated over the course of the growing season. On July 9 and September 22, evaluations were conducted on plant vigor and height.

Results

For the purpose of this report, comparisons were made only among the entries of prairie thermopsis (Table 2). Seedling emergence began in late March and ended mid- April, with the three BLM collections emerging before March 31 (Figure 1). Leaves unfolded in the BLM entries before mid-April (Figure 2).

Floral initiation was observed in late April to early May in six plots (Figures 3 and 4), with no flowers produced in 11 of the 17 entries, including the three BLM collections. A Wyoming collection from Carbon County, originally sent as *Thermopsis rhombifolia* (accession 9087535) was re-identified, based on seed pod characteristics, as *Thermopsis montana*. Seed pods differ in shape, with the former strongly curved (Figure 5), while the latter is straight and erect. There is no discernible difference in the flowers of the two species (Figure 6). Seed was harvested from 9087535 on July 14 and 21; none of the other entries produced seed. Individual plant numbers per plot seemed to increase from the previous year due to spreading rhizomes, but density was not counted. The 9078644 collection from McCone County, Montana performed best with very high vigor rating and height (53 cm). Performance of the BLM collections held steady from the previous year. The 2010 average plant height was 38 cm, compared to an average 17 cm in 2009. Results of the entire wildflower evaluation study will be available upon request in early 2011.

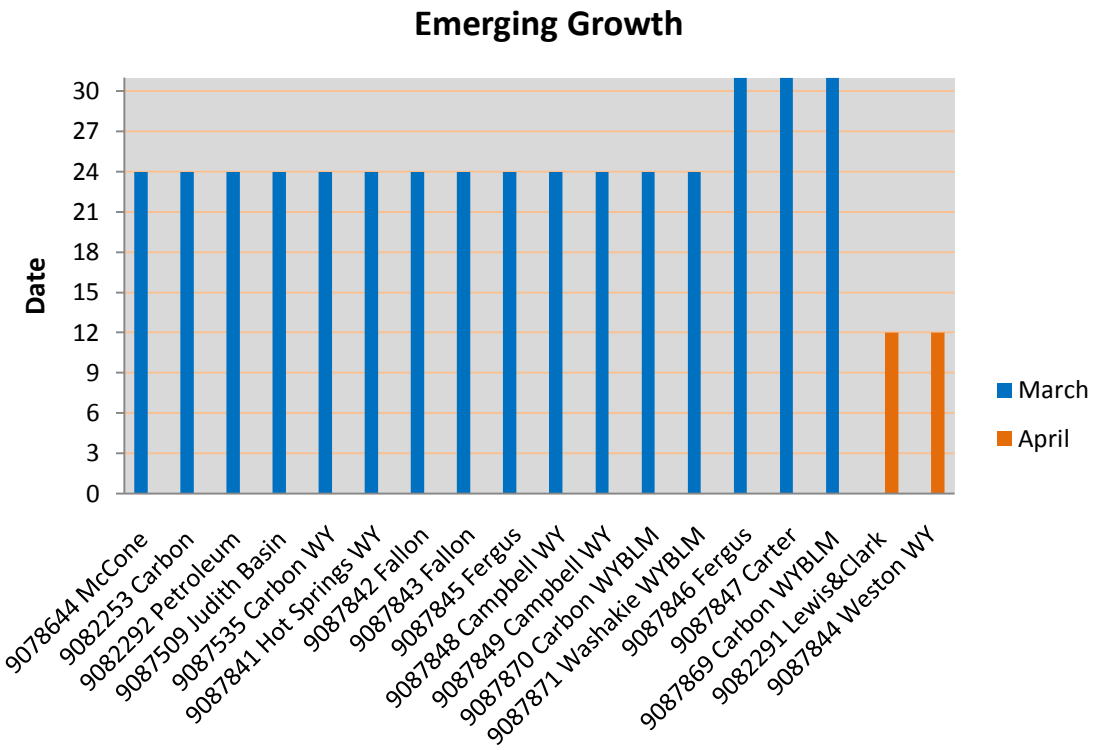

Figure 1. Graph of Emerging Growth Dates.

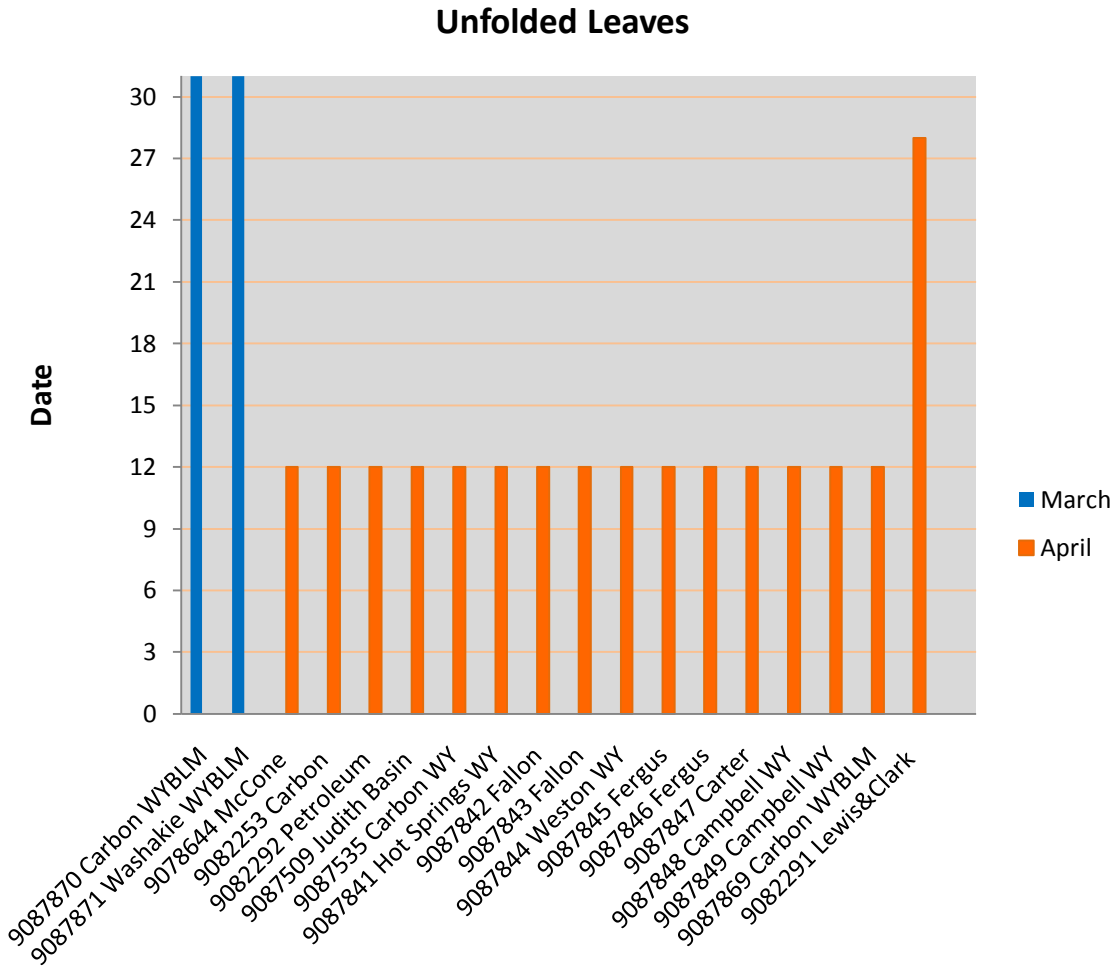

Figure 2. Graph of Unfolding Leaf Dates

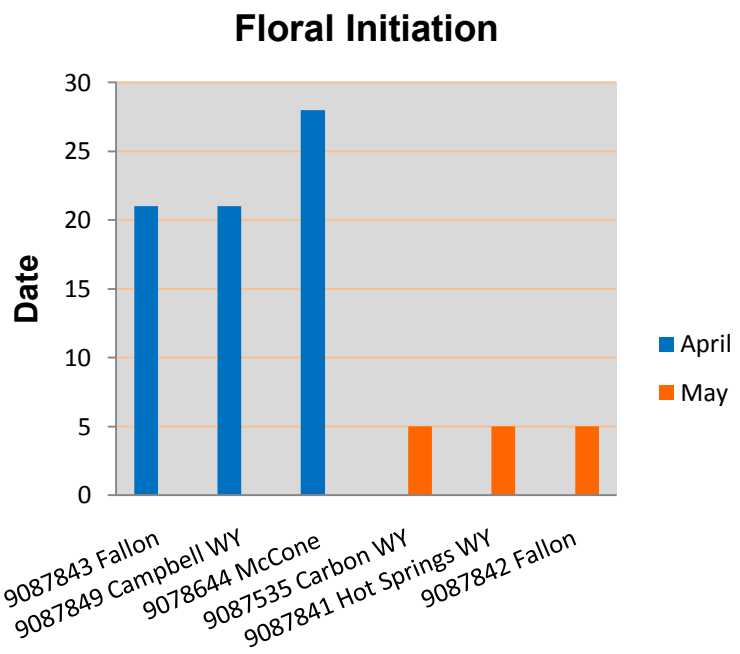

Figure 3. Graph of Floral Initiation Dates

Discussion

Prairie thermopsis performed well in a previous trial at the BPMC and continues to be a species of interest for eventual selection and release to the commercial seed industry. It is drought tolerant and does well in a wide range of soil types, including finer textured materials of acid to alkaline reaction. Prairie thermopsis is an early bloomer in many native plant communities and is pollinator-friendly. The strong production of spreading rhizomes acts to stabilize the soil and nodulating roots fix significant quantities of nitrogen. It has little forage value and there are unsubstantiated reports of toxicity to livestock due to the supposed presence of the alkaloid, cytisin. Mechanical or chemical scarification of the seed improves germination. Seed production potential is moderate, with viability good for a minimum of three years (Figure 7).

In addition to testing the performance of prairie thermopsis, there are an additional 34 native herbaceous species currently established in the IEP. The study area allows for expansion and the BPMC looks forward to planting more BLM wildflower entries effective through fiscal year 2012.

Table 1. Seed specifics of the Wyoming BLM collections received at the Bridger PMC.

Accession	Genus & Species	Date Collected	County Origin	Collector	Amount†	Seeds†	Viability†	Seeded in IEP
					kg	*lb*	*% TZ*	*Yes/No*
9087869	*Thermopsis rhombifolia*	8/04/08	Carbon	Drizin, J. & P. Nguyen	0.432	24,900	95	Y
9087870	*T. rhombifolia*	8/11/08	Carbon	Drizin, J. & P. Nguyen	0.256	22,100	95	Y
9087871	*T. rhombifolia*	7/16/08	Washakie	Warren, Y.	0.015	21,200	-	Y
9088142	*T. rhombifolia*	8/12/09	Carbon	O'Leary, E. & S. Paavola	0.006	-	-	Y
9088143	*T. rhombifolia*	8/05/09	Carbon	O'Leary, E. & S. Paavola	0.008	-	-	Y
9088144	*Agoseris glauca*	6/15/09	Carbon	O'Leary, E. & S. Paavola	0.001	-	-	Y
9088005	*Penstemon*	7/31/09	Sweetwater	Biasotti, V.	0.020	-	-	Y
9087909	*Pseudoroegneria spicata*	7/21/08	Carbon	Drizin, J. & P. Nguyen	0.028	168,600	95	N
9088140	*P.spicata*	7/22/09	Carbon	O'Leary, E. & S. Paavola	0.002	-	-	N
9088141	*P. spicata*	8/26/09	Carbon	O'Leary, E. & S. Paavola	0.002	-	-	N
9087915	*Purshia tridentata*	8/15/08	Carbon	Drizin, J. & P. Nguyen	0.132	21,200	37	N
11 collections	5 species	11 days	3 counties	6 collectors	0.902	-	-	-

† Information provided by the Bend Seed Extractory.

Table 2. The 2010 performance of Wyoming BLM seed collections in the Initial Evaluation Planting at the Plant Materials Center in Bridger, Montana; seeded November 17, 2008.

Accession	Genus & Species	Date Collected	County Origin	Vigor†	Height
				1-9	*cm*
9087535‡	*Thermopsis montana*	8/17/05	Carbon, Wyoming	1	61
9078644	*Thermopsis rhombifolia*	6/20/97	McCone, Montana	2	53
9087509	*T. rhombifolia*	7/25/03	Judith Basin, Montana	3	47
9087843	*T. rhombifolia*	7/05/07	Fallon, Montana	3	43
9087842	*T. rhombifolia*	7/10/07	Fallon, Montana	3	40
9087841	*T. rhombifolia*	7/02/07	Hot Springs, Wyoming	3	36
9082292	*T. rhombifolia*	7/04/03	Petroleum, Montana	4	46
9087845	*T. rhombifolia*	7/10/07	Fergus, Montana	4	43
9082253	*T. rhombifolia*	7/22/02	Carbon, Montana	4	41
9087848	*T. rhombifolia*	7/18/07	Campbell, Wyoming	4	32
9087871	*T. rhombifolia*	7/16/08	Washakie, WYBLM	5	40
9087846	*T. rhombifolia*	7/12/07	Fergus, Montana	5	36
9087849	*T. rhombifolia*	7/14/07	Campbell, Wyoming	5	24
9087847	*T. rhombifolia*	7/25/07	Carter, Montana	6	21
9087844	*T. rhombifolia*	7/03/07	Weston, Wyoming	7	27
9087870	*T. rhombifolia*	8/11/08	Carbon, WY BLM	7	26
9087869	*T. rhombifolia*	8/04/08	Carbon, WY BLM	7	24
9082291	*T. rhombifolia*	7/06/03	Lewis & Clark, Montana	-	0
9088142§	*T. rhombifolia*	8/12/09	Carbon, WY BLM	-	0
9088143§	*T. rhombifolia*	8/05/09	Carbon, WY BLM	-	0

† Rated 1-9 with 1 best; ‡ Species identification changed based on seed pod characteristics; § Seeded March 10, 2010.

Figure 4. Plots flowering in early May.

Figure 5. Mature seed pod of *Thermopsis rhombifolia.*

Figure 6. Flower of *Thermopsis montana*.

Figure 7. Seed of *Thermopsis rhombifolia.*

CRATERS OF THE MOON NATIONAL MONUMENT AND PRESERVE
YEAR 2010 ANNUAL SUMMARY REPORT
prepared by

NATURAL RESOURCES CONSERVATION SERVICE
PLANT MATERIALS CENTER
BRIDGER, MONTANA

INTRODUCTION: The Bridger Plant Materials Center entered into a cooperative agreement with Craters of the Moon National Monument and Preserve in FY 2010. This agreement facilitates the processing, propagation, and establishment of indigenous plant materials and the development of propagation technologies for the restoration of disturbances resulting from road construction and other projects within National Monument (NM) boundaries.

ACCOMPLISHMENTS: In late 2009, the BPMC received and processed 15 wildland collections indigenous to Craters NM (see Table 1). Each lot was processed, accessioned, and inventoried.

Table 1. Craters of the Moon 2009 seed stocks cleaned at the BPMC as of February 2010.

Species	Accession Number	2009 Collection Date	2009 Collection Location	2009 Bulk Clean Seed
				g
Achnatherum hymenoides	9088146	7/10-7/31	Golden Chariot	505
Achnatherum thurberianum	9088147	7/17-7/22	Golden Chariot	138
Artemisia tridentata sub. *vaseyana*	9088148	10/13	Tree Molds Parking	189
Chaenactis douglasii - Lot A	9088149	7/10-8/4	Group Camp	pending
Chaenactis douglasii - Lot B	9088149	7/10-8/4	Group Camp	32
Chamaebatiatia millefolium	9088150	9/10-9/14	across N. Crater Flow	138
Ericameria nauseosa	9088151	9/4-10/15	Tree Molds Road	168
Eriogonum ovalifolium var. *depressum*	9088152	7/14-7/23	Lava Cascades	8
Eriogonum umbellatum	9088153	8/10-8/20	Base of Big Craters	633
Leymus cinereus	9088154	8/19-9/16	North end/ Res. Camp	4,536
Mimulus nanus	9088155	7/20-7/21		161
Penstemon deustus var. *deustus*	9088156	8/5-8/6	Spatter Cones Parking	139
Phacelia hastata	9088157	7/22-8/4	Golden Chariot	243
Pinus flexilis	9088158	8/28-8/31	?	719
Poa secunda	9088159	7/9-7/22	Golden Chariot	560
Purshia tridentata	9088160	7/24-7/30	Vulture Mead.	2,641
				(184-reclean)

After processing, each lot was shipped to the Wyoming Seed Analysis Laboratory for germination testing, and in some cases, purity testing (see Table 2). As a result of very low initial viability of *Purshia tridentata* (9088160), this lot was re-cleaned using a gravity table and multiple cut tests in order to improve the number of pure live seed. As a rule, the viability and purity of the tested lots was relatively high for wildland collections.

Plant propagation began in early 2010 with cold:moist chilling treatments of some species in order to break dormancy. Target production, number of containers sown, and resultant plant production appears in Table 3. The low percentage germination of two species probably reflects low seed vigor and/or viability. Additional sowing of these species is planned for early 2011. All plants were over-wintered in a coldframe and will be transplanted in 2011 to larger pots and held until spring 2012 when they will be delivered to Craters of the Moon National Monument.

Table 2. Seed analysis results, 2009 wildland collections from Craters National Monument.

Species	Accession Number	2009 Bulk Clean Seed	Purity	Viability
		g	%	%
Achnatherum hymenoides	9088146	505	NA	46
Achnatherum thurberianum	9088147	138	NA	96
Artemisia tridentata sub. *vaseyana*	9088148	189	NA	97
Chaenactis douglasii - Lot A	9088149	pending	NA	96
Chaenactis douglasii - Lot B	9088149	32	NA	92
Chamaebatiatia millefolium	9088150	138	NA	92
Ericameria nauseosa	9088151	168	NA	88
Eriogonum ovalifolium var. *depressum*	9088152	8	NA	77
Eriogonum umbellatum	9088153	633	97.54	84
Leymus cinereus	9088154	4,536	94.84	89
Mimulus nanus	9088155	161	NA	84
Penstemon deustus var. *deustus*	9088156	139	NA	87
Phacelia hastata	9088157	243	NA	98
Pinus flexilis	9088158	719	NA	72
Poa secunda	9088159	560	91.02	98
Purshia tridentata	9088160	2,641	98.86	2
		(184-reclean)		

Table 3. Container production in 2010 for Craters of the Moon National Monument.

Species	Accession Number	Target Production	Number Sown	On-Hand	Balance
Artemisia tridentata sub. *vaseyana*	9088148	450	600	496	+46
Ericameria nauseosa	9088151	225	400	355	+130
Pinus flexilis	9088158	275	400	210	-65
Purshia tridentata	9088160	450	800	164	-286

VII. PLANT MATERIALS SPECIALIST REPORTS and OFF-SITE PLANTINGS/DEMONSTRATIONS

REGISTER OF MONTANA HERBACEOUS ESTABLISHED PLANTINGS-2010

BILLINGS,MT	02008	POPELKA,ED	WILDLIFE HABITAT	ACTIVE 2011
BILLINGS,MT	97095	BUR OF LAND MANAG	RESTORATION	CLOSED 2010
BILLINGS,MT	09031	BUR OF LAND MANAG	WILDLIFE HABITAT	ACTIVE 2010
BOZEMAN,MT	03074	WILLIAMS,W/D.CARACCI	NATIVE RANGE	ACTIVE 2012
BROADUS,MT	00118	SMITH,GENE	LATE FALL/WINTER PA	CLOSED 2010
BROADUS,MT	98121	MANGEN RANCH	HAYLAND/PASTURELAND	CLOSED 2010
CHINOOK,MT	03138	RATY,KEITH	HAYLAND	ACTIVE 2012
CHOTEAU, MT	04054	BASTA, RAY	WINTER WILDLIFE COVE	ACTIVE 2013
CIRCLE,MT	99053	C.R. SEEDS	TALL WILDLIFE COVER	CLOSED 2010
COLUMBUS,MT	02085	COLES,DAVID	DEMONSTRATION	ACTIVE 2011
CONRAD,MT	04093	VANDYKE,DUANE	PASTURE	ACTIVE 2013
CONRAD,MT	99045	JOHNSON,PAUL	FIELD PLANTING	ACTIVE 2008
EUREKA,MT	98066	GIBSON,SPENCER	WILDLIFE	CLOSED 2010
FORSYTH,MT	00034	LENZ,AL	IRRIGATED PASTRE TR	INACTIVE 2010
FORSYTH,MT	01062	FERGUSON,DICK	VARIETAL EVAL	CLOSED 2010
FORSYTH, MT	06036	ICOPINI FAMILY TRUST	DEMONSTRATION PLANTI	ACTIVE 2010
FORSYTH, MT	06037	ICOPINI FAMILY TRUST	DEMONSTRATION PLANTI	ACTIVE 2010
FORSYTH, MT	06071	WEIGHT, CRAIG	IRRIGATED PASTURE	ACTIVE 2010
FORSYTH,MT	93094	PAYER,JACK	PASTURE DEMO	CLOSED 2010
FORSYTH,MT	94059	HOFER,PAUL & RACHEL	PASTURE & HAYLAND	ACTIVE 2006
FORSYTH,MT	94123	PAYER,JACK	SALINE SEEP DEM	CLOSED 2010
FORT BELKNAP,MT	04080	FT.BELKNAP RESERV	CULTURALLY SIGNIFICA	ACTIVE 2013
HARDIN, MT	10401	GREENWOOD FARM	HAYLAND&GRAZING	ACTIVE 2010
JOLIET,MT	86098	SKORUPA,BILL	SEED PRODUCTION	CLOSED 2010
JORDAN,MT	97028	GIBBS,PAT	PASTURE&HAYLAND	CLOSED 2010
JORDAN,MT	97056	JERREL,RAY	PASTURE	CLOSED 2010
JORDAN,MT	99044	HENSLEIGH,JERRY	EXTENDED GRAZING	CLOSED 2010
LIVINGSTON,MT	97055	PINKERTON RANCH(1)	PASTURE	CLOSED 2010
MALTA,MT	00115	KINDLE,BRYAN	IRRIGATED PASTURE	ACTIVE 2009
MILES CITY,MT	96049	DRGA,FRED	SEED PRODUCTION	CLOSED 2010
MILES CITY,MT	97053	GEORGE,ROBERT	HAYLAND	CLOSED 2010
PLENTYWOOD,MT	03140	FRENCH,DEAN	SALINE PASTURE	ACTIVE 2012
PLENTYWOOD,MT	03141	HILYARD,RICK	HAY	ACTIVE 2012
SHERIDAN,MT	01058	SAUERBIER RANCH	CRITICAL AREA SEEDIN	ACTIVE 2010
SIDNEY,MT	04038	SIDNEY AIRPORT	GRASS RUNWAY	CLOSED 2013
SIDNEY, MT	06038	SIDNEY PARKS AND REC	DEMONSTRATION	CLOSED 2010
STANFORD,MT	03075	DOVER,DAVID	SPRING PASTURE	ACTIVE 2012
STANFORD,MT	97040	HOLZER,DICK	PASTURE	CLOSED 2010
STANFORD,MT	97054	KOLAR,VINCE	PASTURE	CLOSED 2010
STANFORD,MT	98071	HECOCK,DALE	HAYLAND	CLOSED 2010
TOWNSENT, MT	11201	COX, CLIFF	PASTURE IMPROVEMENT	ACTIVE 2011
WHITE SULPH SPR,MT	03113	GRANDE,JOHN	PASTURE	ACTIVE 2012
WHITEHALL,MT	98097	FITZGERALD,CORY	WINTER PASTURE	CLOSED 2010
WIBAUX, MT	04053	BEGGEN, RALPH	PASTURE	ACTIVE 2013

REGISTER OF MONTANA WOODY ESTABLISHED PLANTINGS-2010

BAKER,MT	01074	FISCHER,CHIP&ANN	WILDLIFE/SCREEN/AEST	ACTIVE 2009
BAKER,MT	94047	GOOKIN,MARVIN & SHAR	FARMSTEAD WINDBREAK	ACTIVE 2008
BAKER,MT	96051	TRONSTAD,JOHN	WILDLIFE/FEEDLOT WIN	ACTIVE 2010
BIG SANDY,MT	92052	RAY,JAMES	FARMSTEAD WINDBREAK	ACTIVE 2006
BIG SANDY,MT	92053	BROWN,WILLIAM	FARMSTEAD WINDBREAK	ACTIVE 2006
CHESTER,MT	95048	BELCHER,LOIS	WIND EROSION	ACTIVE 2009
CHESTER,MT	95051	SKARI,TRUDY	WIND EROSION	ACTIVE 2009
CHESTER,MT	95052	KJK FARMS	WILDLIFE	ACTIVE 2009
CHINOOK,MT	00119	GRABOFSKY,RICK	WILDLIFE DEMONSTRATI	ACTIVE 2009
CHINOOK, MT	06056	GRABOFSKY, RICHARD	WINDBREAK/SHELTERBEL	CLOSED 2010
CIRCLE,MT	04068	MCCONE CONSERV. DIST	WINDBREAK	ACTIVE 2013
FORSYTH,MT	96050	BENNETT,BRYON	SHELTERBELT	ACTIVE 2010
GLASGOW,MT	94051	ANDERSON,ARNOLD	FARMSTEAD WINDBREAK	CLOSED 2010
HAVRE, MT	06057	NYSTROM, CONRAD	WINDBREAK/SHELTERBEL	ACTIVE 2010
JOLIET,MT	93060	EVERTZ,GREG	FARMSTEAD SHELTERBEL	ACTIVE 2007
LIVINGSTON,MT	95063	PETERSON,MAHLON	WINDBREAK	CLOSED 2010
SHELBY,MT	92042	TOOLE CTY FAIR GROUN	BARRIER	ACTIVE 2006
SHELBY,MT	95044	BYE,GRIFF	FARMSTEAD WINDBREAK	ACTIVE 2009
SIDNEY,MT	94050	HUNTER,MILO	FARM DEMO WINDBREAK	ACTIVE 2008
STANFORD, MT	04036	METCALFE, TERRY	WINDBREAK	ACTIVE 2013
TOWNSEND,MT	95067	COX,CLIFF	FARMSTEAD WINDBREAK	ACTIVE 2009
WIBAUX, MT	06041	MISKE RANCH	FARMSTEAD WINDBREAK	ACTIVE 2010

WYOMING HERBACEOUS ESTABLISHED PLANTINGS-2010

BAGGS,WY	90124	SNYDER OIL CORP.	RECLAMATION	CLOSED 2010
BAGGS,WY	04092	TOLLE,ELDON	FALL/WINTER PASTURE	CLOSED 2010
BUFFALO, WY	06008	LOHSE, TOM	SAGE GROUSE HABITAT	ACTIVE 2010
BUFFALO, WY	06035	LOHSE, TOM	SAGE GROUSE HABITAT	ACTIVE 2010
COKEVILLE,WY	97114	COOK,KAA&KENNETH	PASTURE/HAYLAND	CLOSED 2010
FORT WASHAKIE,WY	05050	WIND RIVER ELEMENTRY	EDUCATION/DEMONSTRAT	ACTIVE 2009
FORT WASHAKIE,WY	09021	FRED TAMMANY	EDUCATION/DEMONSTRAT	ACTIVE 2009
GILETTE,WY	08001	FOUNDATION COAL	CRITICAL AREA	ACTIVE 2010
JACKSON,WY	02062	WDOT	HIGHWAY REVEGETATION	ACTIVE 2011
LUSK, WY	04052	EITEL, EDWARD	FIELD TRIAL	ACTIVE 2013
LYMAN, WY	06039	UNITA COUNTY CD	HIGH ELE PASTURE	ACTIVE 2010
PINEDALE,WY	02070	BARNES,CALVIN	HAY	ACTIVE 2011
SARATOGA,WY	99144	KRAFT,JERRY	FIELD PLANTING	ACTIVE 2008
SHERIDAN,WY	02024	PADLOCK RANCH	RECLAMATION	ACTIVE 2011
SHERIDAN,WY	02042	PADLOCK RANCH	RECLAMATION	ACTIVE 2011
SHERIDAN,WY	05056	FRANK,DAVID	STREAM CHANNEL REVEG	ACTIVE 2009
SUNDANCE,WY	97062	MCDONALD,J.O.	HAYLAND	ACTIVE 2006
TORRINGTON, WY	06028	HEINRICH-BIBBY	PASTURE AND RANGE PL	ACTIVE 2010
TORRINGTON, WY	10101	WY GAME&FISH	WILDLIFE	ACTIVE 2010
WHEATLAND,WY	00100	SWAN/MCQUISTEN	CRP	ACTIVE 2010

WYOMING WOODY ESTABLISHED PLANTINGS-2010

BUFFALO, WY	06058	CROSS H RANCH	WINDBREAK	CLOSED 2010
DOUGLAS,WY	92044	ROTARY CLUB	URBAN BEAUTIFICATION	ACTIVE 2006
KAYCEE,WY	09102	WALTERS, BILL&ERIN	WINDBREAK	ACTIVE 2010
PINEDALE,WY	92067	HOCKER,ROSS	FARMSTEAD WINDBREAK	ACTIVE 2006
PINEDALE,WY	99078	NELLIS,JIM	STREAM STABILIZATION	ACTIVE 2008
PINEDALE,WY	92068	RADAKOVICH,ROY	WILDLIFE	ACTIVE 2007
SARATOGA,WY	92062	PALM,KAY LYNN	FARMSTEAD WINDBREAK	ACTIVE 2006
SHERIDAN, WY	06054	UCROSS LAND CO.		ACTIVE 2010
SHERIDAN,WY	94082	FLYING COWBOYS R/C C	FIELD WINDBREAK	ACTIVE 2008
SHERIDAN,WY	94061	NICKEL,MIKE	WILDLIFE HABITAT	ACTIVE 2008
SHERIDAN,WY	95059	SYMONS,CURT	WILDLIFE	ACTIVE 2009
TORRINGTON,WY	95066	KELLER,RICHARD	FARMSTEAD WINDBREAK	ACTIVE 2009
TORRINGTON,WY	92031	SAUL,RICHARD	WINDBREAK	ACTIVE 2006
WHEATLAND,WY	94074	COLE,SCOTT&MARIAN	WILDLIFE HABITAT	ACTIVE 2008
WORLAND,WY	97037	DOVER,DAN	WILDLIFE HABITAT	ACTIVE 2006

Riverton Well Pad Reclamation Field Planting 2010-Results

Sampling

The density of seeded grass, seeded forbs, seeded shrubs, annual grass, and weeds were counted within ten 0.5 by 0.2 meter frames from random locations within each treatment plot.

Analysis

The densities were averaged for each group and the average was used for analysis of variance. The Devon and ConocoPhillips sites were analyzed separately. Because irrigation was not applied, those plots were used as replicates. Each well pad was treated as a soil variable. The model used was a split-split plot with soil type (well pad) as the whole plot, cover-crop as the subplot, and seeding method as the sub-subplot. Some sample variables had to many zeros (seeded shrubs, annual grass, some seeded forb) to meet the assumptions of normal variance required for ANOVA and no statistical significant could be determined for those variables. When p-values were less than 0.05, Tukey's means separations were used to determine differences among treatments.

Results

Table 1. Mean densities (plants per square meter) in treatment. Where treatments affected density ($p<0.05$), letters following the means indicate treatment differences. Interaction effects are not shown in the table but are described in the narrative.

Table 1.

	Seeded grass		Seeded forbs		Seeded shrubs*		Weeds	
Soil	Beaver	Lysite	Beaver	Lysite	Beaver	Lysite	Beaver	Lysite
Clay	61 a	19 a	8 a	0.1 b	1.0	0	147	1940 a
Sand	52 a	12 ab	7 a	7.0 a	0.5	0.6	471	796 ab
Saline	4 b	10 b	0 b	0.0 b	0.3	0	210	109 b
Cover Crop								
none	53	15	5	3	0.3	0.3	382 a	1056
barley	26	12	5	3	0.8	0.1	171 b	841
Seeding Method								
Drill	41	16 a	6	4	0.5	0.1	289	797
Broadcast	38	11 b	4	1	0.7	0.3	264	1100

*Shrub establishment was too sparse to run the analysis and significance was not determined.

Soil type (well pad) affected establishment of grasses and forbs; establishment was lower on the saline site than sandy and clay at Beaver Creek, and lower than the clay site, but not the sandy site, at Lysite. At Lysite on the sandy site, grass establishment was lower ($p<0.05$) where seed was broadcast over the cover-crop (8 plants/m^2) than where it was drilled into the cover-crop (17 plants/m^2).

At Lysite, grass establishment was greater at where it was drill seeded than where it was broadcast. Seeding method didn't make a difference at Beaver Creek.

At Beaver Creek, fewer forbs established where they were broadcast over the cover crop (2 plants/m^2) than where they were drilled into the cover-crop (7 plants/m^2). At Lysite on the clay site, more forbs established where no cover-crop was sown compared to where barley was seeded (two plants to nil/m^2).

The cover-crop reduced weeds at Beaver Creek but not at Lysite. At Beaver Creek, the effect of cover-crop depended on the soil type. There was only a significant reduction of weeds caused by the cover-crop on the sandy site where there were 744 weeds/m^2 with no cover-crop, and 200 weeds/m^2 where a cover-crop was sown. Also at Beaver Creek, on the clay site, there were more weeds (2460 plants/m^2) where seeds were broadcast than where they were drill seeded (1420 plants/m^2).

These were the only statistically significant treatment effects on density.

Frequency

Table 2. Mean frequencies (percent occurrence in the sample frame) in treatment. Where treatments affected frequency ($p<0.05$), letters following the means indicate treatment differences. Interaction effects are not shown in the table but are described in the narrative.

Table 2.

	Seeded grass		Seeded forbs		Seeded shrubs*	
Soil	Beaver	Lysite	Beaver	Lysite	Beaver	Lysite
Clay	83 a	70	44	5	8	0
Sand	80 ab	60	45	36	5	1
Saline	15 b	40	0	0	3	0
Cover Crop						
none	62	62	32	13	3	0
barley	57	52	28	14	7	<1
Seeding Method						
Drill	61	66 a	33	19	5	<1
Broadcast	58	48 b	26	8	5	0

*Forb establishment at Lysite and Shrub establishment at both sites was too sparse to run the analysis and significance was not determined.

Soil type affected the frequency at which grass occurred in the sample frames; seeded grass occurred more often (83%) on the clay site than on the saline site (15%). The sandy site was no different than the saline site though the numbers are not too different because there was more variability on the sand. At Lysite, seeded grass occurred at a greater percent where it was drilled than where it was broadcast.

Data for the seeded forbs and shrubs did not meet the requirements of normal distribution and data transformations did not help, thus ANOVA could not be used to determine treatment effects. But there are some obvious differences.

Frequencies of weeds in the plots where not analyzed because their frequencies were essentially 100% in all treatments (with the exception of the saline sites).

Study Title: Field Evaluation Planting Shell-Pinedale, Wyoming

Cooperators: Shell Exploration and Production Company, Sublette County Conservation District, Bureau of Land Management, Wyoming Game and Fish Department, and the USDA--NRCS Bridger Plant Materials Center

Study Number: MT-05-100

Objectives: The major planting objectives coincide with objectives outlined in the Pinedale Resource Area Cooperative Working Agreement (PRACWA, 2005), which will:

1. Test cultivars, varieties, and germplasms of grass, forb, and shrub species for adaptation to the Pinedale Resource Area with emphasis on plant species native to the Rocky Mountain Region that provide forage production; a diverse ecosystem; and habitat for sage grouse, mule deer, antelope, and other wildlife species, especially those dependent upon sagebrush communities.
2. Test seeding mixtures and rates for adaptation and desired ecological diversity in the Pinedale Resource Area.
3. Distribute results to public and private land managers, as well as other interested individuals.

Project Description: With national attention on issues associated with sagebrush systems and sensitive species such as sage grouse, there is a need to prioritize vegetative restoration efforts in oil and gas development areas on both private and public lands in southwestern Wyoming. The Shell Exploration and Production Company (hereby referred to as Shell), Sublette County Conservation District, Bureau of Land Management (BLM), Wyoming Game and Fish Department (WGFD), and USDA--NRCS all have teamed up to adopt appropriate reclamation techniques in association with oil and gas production activities taking place in the Pinedale Anticline and Jonah Gas Field regions located in Sublette County. Local resource professionals and land managers entered into discussions that led to the signing of a cooperative working agreement with a common goal to —develop reclamation and rangeland restoration trials to determine the best native plants and establishment techniques for restoring, enhancing, and maintaining native rangeland and sagebrush ecosystem diversity, forage production, and wildlife habitat." The working agreement, to date, encompasses two projects: the first to test plant materials in cooperation with Shell, and the second to test shrubs in cooperation with Questar.

Site Description: The site is approximately 3.8 acres in size and located approximately 30 miles south of Pinedale, Wyoming, on the west side of Highway 191 off the Luman Road (Figure 1). The site is a previously disturbed well-pad that is currently in need of reclamation. Site characteristics are:

Major Land Resource Area (MLRA): 34A--Cool Central Desertic Basins and Plateaus.

Legal Description: N ½ SW ¼ Section 10, T29N R107W.

Elevation: 7,195 feet (2,193 m).

Precipitation: Approximately 10 inches annually, mainly in the form of snow. Peak growing season precipitation is from May to July.

Growing Season: 70 days.

Soils Information: The soils are mostly deep and well drained. Surface layers are 5 inches or more thick with sandy clay loam subsoils. The major soil series correlated include Bluerim-Forelle complex and Bluerim-Cotha complex. Soil texture is sandy loam with 75.2% sand, 18.8% silt, and 6% clay. The results of soil laboratory tests on surface (0 to 5 inches) and subsurface (5 to 10 inches) characteristics include, respectively: ph 7.8-8.1, low excess carbonate, soluble salts (mmhos/cm) 0.34-0.46, sodium (ppm) 52-122, organic matter 0.7-1.0%, carbon exchange capacity 15.4-20.5, and parts-per-million of nitrate 11-17, phosphorus 4-6, potassium 123-177, magnesium 313-370, calcium 2427-3330, sulfur 16-38, zinc 0.4-0.5, iron 4.3-6.9, manganese 0.5-1.7, copper 1.2-1.5, boron 0.7-0.9, and sodium adsorption ratio (SAR) 0.84-1.7.

Ecological Site Description: Sandy, 10- to 14-inches precipitation zone, Foothills and Basins West. The dominant vegetative cover type is classified as sagebrush steppe and the potential natural vegetation is estimated at 70% grass and grass-like plants, 10% forbs, and 20% woody plants. The key grass species are needle and thread, thickspike wheatgrass, Indian ricegrass, and bluebunch wheatgrass. The forbs include aster, buckwheat, clover, evening primrose,

fleabane, and fringed sagewort. Shrub cover is dominated by big sagebrush, green and rubber rabbitbrush, antelope bitterbrush, and winterfat. The total annual production (air-dry weight) ranges from 700 lb/acre in unfavorable years up to 1,500 lb/acre in favorable years.

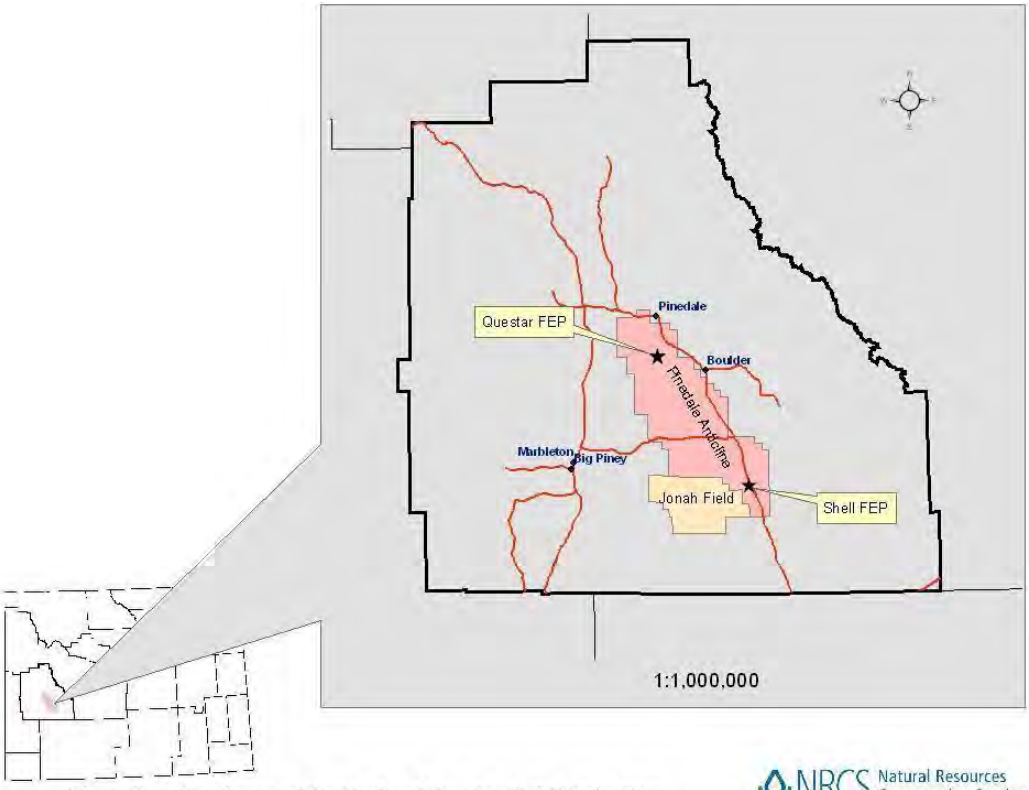

Fig. 1. Locational map of the Shell and Questar Field Evaluation Plantings in Sublette County, near Pinedale, Wyoming.

NRCS Natural Resources Conservation Service

Methods and Materials: The 4.5-acre site was disturbed in 2002 and an oil/gas well pad was constructed. Approximately 6 inches of topsoil was stripped and stockpiled for 37 months and reapplied to the pad following development. The soil was ripped to mitigate heavy equipment compaction and restore infiltration, then firmed and smoothed. Seedbed conditions were moderately fluffy and less than ideal for precise seed placement. Substantive debris that could prevent consistent seeding, such as large rock or sagebrush litter, was removed. The hydro-seeded area was prepared to a smooth slope without roughening to catch seed. Also, the entire quantity of mulch, with the seed, was hydro-applied to the site.

Adaptation of 15 grass, 22 forb, and 13 shrub species, mostly native to the Pinedale Resource Area, were tested in a Randomized Complete Block study with four replications (Figure 2). Plots were 4 feet by 20 feet (80 ft^2), and the 72 entries were dormant-seeded in the fall of 2005 as monocultures using a Kincaid Precision Cone-seeder. Two seeding mixtures, Bridger and Shell (see Tables 1 and 2 for species composition), were tested on adjacent plots. Each mixture was seeded with a Truax™ drill (1-acre plots) and an ATV-mounted broadcast seeder (0.5-acre plots).

Following planting of the broadcast-seeded plots, the area was roughened with a wooden pallet pulled behind the ATV. In addition, the Shell mixture was hydro-seeded to a 1-acre plot on a smooth slope in a one-step mulch application (Figure 3). Scientific plant nomenclature is standardized by the USDA NRCS Plants Database (USDA, 2009).

Figure 2. The Shell FEP replicated plot design. Seeded October 19, 2005, near Pinedale, Wyoming.

Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The species composition and seeding rates of the Bridger Mixture, planted October 19, 2005, near Pinedale, Wyoming.

Common name	Genus and Species	Seeds	Mix	PLS†	Seeding Rate†	Drill Rate†	Broadcast Rate†
		lb	*%*	*%*	*lb/acre*	*seeds/ft²*	*seeds/ft²*
Pryor slender wheatgrass	*Elymus trachycaulus*	95,000	12.8	87.44	2.3	5	10
Critana thickspike wheatgrass	*Elymus lanceolatus*	145,000	12.8	~90.00	1.5	5	10
Rosana western wheatgrass	*Pascopyrum smithii*	93,000	12.8	87.90	2.3	5	10
High Plains Sandberg bluegrass	*Poa secunda* (*P. sandbergii*)	925,000	12.8	~80.00	0.25	5	10
Rimrock Indian ricegrass	*Achnatherum hymenoides*	155,000	12.8	98.83	1.4	5	10
Trailhead basin wildrye	*Leymus cinereus*	125,000	7.7	85.85	1.0	3	6
Great Northern western yarrow	*A. millefolium* var. *occidentalis*	4,500,000	5.1	~90.00	0.02	2	4
Stillwater prairie coneflower	*Ratibida columnifera*	600,000	5.1	93.16	0.15	2	4
Maple Grove prairie flax	*Linum lewisii*	278,000	5.1	90.25	0.31	2	4
Silverleaf phacelia	*Phacelia hastata*	454,000	5.1	91.57	0.19	2	4
Scarlet globemallow	*Sphaeralcea coccinea*	500,000	2.6	71.56	0.17	1	2
Wytana fourwing saltbush	*Atriplex* X *aptera*	49,000	1.3	48.05	0.45	0.5	1
Open Range winterfat	*Krascheninnikovia lanata*	352,000	1.3	~90.00	0.06	0.5	1
Wyoming big sage	*A. tridentata* ssp. *wyomingensis*	2,400,000	1.3	13.38	0.01	0.5	1
Fringed sage	*Artemisia frigida*	4,550,000	1.3	85.71	0.005	0.5	1
Totals:	15 species	-	99.9	-	10	39	78

† Pure Live Seed.

Table 2. Field Evaluation Planting—Shell-Pinedale, Wyoming. The species composition and seeding rate of the Shell Mixture, planted October 19, 2005, near Pinedale, Wyoming.

Common Name	Genus & Species	Seeds	Mix	PLS†	Seeding Rate†	Drill Rate†	Broadcast Rate†
		lb	*%*	*%*	*lb/acre*	*seeds/ft²*	*seeds/ft²*
Wyoming big sagebrush	*A. tridentata* ssp. *wyomingensis*	2,500,000	41.50	5.269	0.50	28.70	57.40
Sandberg bluegrass	*Poa secunda (P. sandbergii)*	925,000	30.71	10.539	1.00	21.24	42.48
Fringed sagewort	*Artemisia frigida*	4,536,000	7.53	0.530	0.05	5.21	10.42
Rydberg's penstemon	*Penstemon rydbergii*	4,400,000	7.30	0.525	0.05	5.05	10.10
Indian ricegrass	*Achnatherum hymenoides*	141,000	4.68	10.541	1.00	3.245	6.48
North American white yarrow	*Achillea millefolium*	2,770,000	4.60	0.529	0.05	3.18	6.36
Winterfat – bearded	*Krascheninnikovia lanata*	56,700	1.88	10.537	1.00	1.30	2.60
Fourwing saltbush	*Atriplex canescens*	52,000	0.86	5.268	0.50	0.60	1.20
Scarlet globemallow	*Sphaeralcea coccinea*	500,000	0.50	3.096	0.03	0.34	0.68
Silvery lupine	*Lupinus argenteus*	13,000	0.43	10.544	1.00	0.30	0.60
Totals:	10 species	-	99.99	-	5.18	69.16	138.16

† Pure Live Seed.

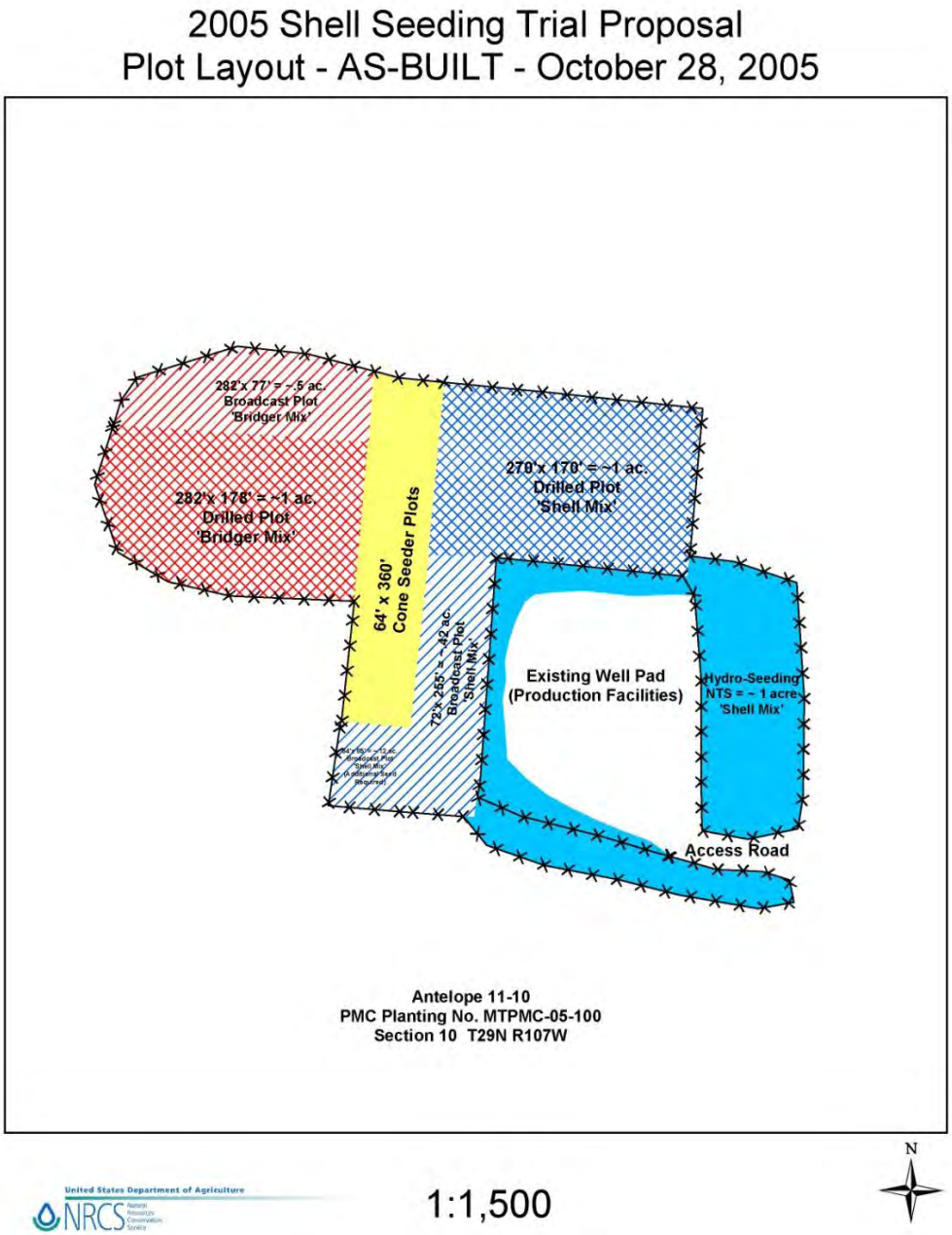

Figure 3. Shell FEP plot layout. Seeded October 19, 2005, near Pinedale, Wyoming.

Evaluations: On July 27 and 28, several teams worked to evaluate the plots. In the replicated plots, evaluation factors included a relative rating of plant vigor and stand establishment, height in inches, plant counts, and photo points. In the replicated plots, plants in the **first** row were counted in 1-foot increments on the tape at 4, 9, and 14 feet. In the fourth row, plants were counted in 1-foot increments at 5, 10, and

15 feet. The grass plots were clipped to determine annual biomass production. Additional comments were noted on items such as the presence of animal and bird life, and grazing or browsing activity. In the broadcast and drill-seeded mixture treatments, plants were counted in 20, 9.62 ft^2 plots (total sampled 192 ft^2). A relative rating of plant vigor and stand establishment, height in inches, and other comments were also recorded.

Results--Replicated Plots: A total of 72 different plant entries were evaluated in the replicated plots (64 ft. by 360 ft.), which included 32 grasses, 24 forbs, and 16 shrubs, as shown in Appendix Table 1. The average percentage establishment varied widely and ranged from fair to extremely poor. Analysis of variance and mean separations were performed using Statistix 2008.

Grass. The analysis of variance of the 2010 replicated grass data showed biomass production, plant density, and height was different among accessions ($p \leq 0.05$) as reported in Table 3. Relative changes in production from 2008 to 2010 are depicted in Figures 4, 6, 8, 10, 12, and 14. Relative changes in density from 2007 to 2010 are depicted in Figures 5, 7, 9, 11, 13, and 15.

In the basin wildrye entries, L-46 and Washoe Germplasm, produced significantly more biomass than 28 other grasses, but not more than ‗Trailhead' or ‗Continental' basin wildrye. ‗Magnar' was significantly taller than the other wildrye, while vigor was moderate in all six entries. Basin wildrye is the tallest statured grass and naturally produces a greater amount of biomass than the shorter growing Salina wildrye (Figure 4.). Plant density increased over time in ‗Salina' and Trailhead, was unchanged in Washoe, and dramatically decreased in L-46, Continental, and Magnar (Figure 5).

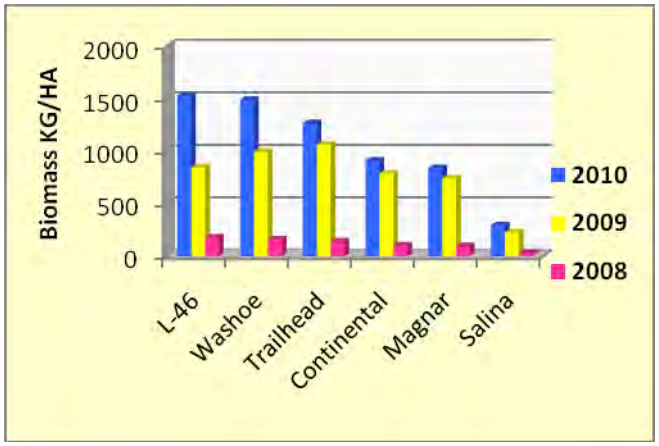

Figure 4. Three years of biomass production in five basin wildryes and Salina wildrye.

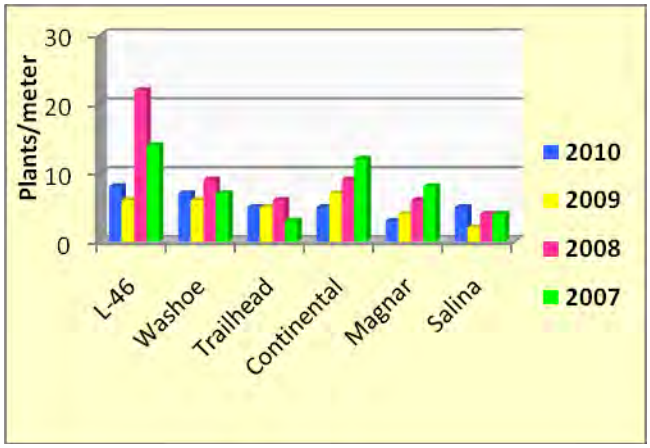

Figure 5. Four years of plant density counts in five basin wildryes and Salina wildrye

Table 3. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 replicated plot performance of 32 grasses seeded on October 19, 2005.

Accession/Common Name	Production		Density		Height		Stand†	Vigor†
	kg/ha	*lb/ac*	*plts/m²*	*plts/ft²*	*cm*	*inches*		
Grass								
L-46 basin wildrye	1,528.14 a*	1,363.41	25.57 bc*	2.38	80.7 abcd*	31.8	3.5	4.8
Washoe basin wildrye	1,488.26 a	1,327.83	21.99 bcd	2.04	81.9 abc	32.3	4.0	5.5
Trailhead basin wildrye	1,265.47 ab	1,129.06	17.95 bcde	1.67	84.5 ab	33.3	4.3	5.3
Continental basin wildrye	910.50 abc	812.35	17.03 bcdefg	1.58	77.2 abcde	30.4	4.5	5.5
Magnar basin wildrye	840.16 bcd	749.59	10.74 defgh	1.00	94.0 a	37.0	5.0	6.0
Critana thickspike wheatgrass	805.59 bcd	718.75	30.95 b	2.88	52.1 fghijkl	20.5	3.8	3.3
P-24 bluebunch wheatgrass	740.21 bcde	660.41	25.57 bc	2.38	58.4 efgh	23.0	3.5	3.5
P-19 bluebunch wheatgrass	665.11 bcdef	593.42	13.02 cdefgh	1.21	70.0 bcdef	26.8	6.0	4.0
Sodar thickspike wheatgrass	526.50 cdefg	469.75	45.75 a	4.25	51.4 fghijkl	20.3	5.0	4.5
9019219 bottlebrush squirreltail	491.83 cdefg	438.81	12.57 cdefgh	1.17	29.9 m	11.8	5.0	2.3
Secar Snake River wheatgrass	477.65 cdefg	426.16	6.72 efgh	0.63	54.6 fghij	21.5	6.8	4.8
Goldar bluebunch wheatgrass	413.95 cdefg	369.32	9.88 defgh	0.92	47.6 fghijklm	18.8	6.5	5.5
Anatone bluebunch wheatgrass	375.73 cdefg	335.23	13.46 cdefgh	1.25	52.7 fghijkl	20.8	6.3	5.0
P-22 bluebunch wheatgrass	358.74 cdefg	320.07	5.38 efgh	0.50	55.3 fghi	21.8	6.0	5.0
San Luis slender wheatgrass	317.63 cdefg	283.39	6.30 efgh	0.59	62.2 cdefg	24.5	7.0	4.5
Pryor slender wheatgrass	304.86 cdefg	272.00	4.49 efgh	0.42	61.0 defgh	24.0	7.5	4.5
Salina wildrye	296.05 cdefg	264.13	17.49 bcdef	1.63	55.3 fghi	21.8	6.8	5.3
Bannock thickspike wheatgrass	239.17 defg	213.39	15.24 cdefgh	1.42	59.1 efgh	23.3	6.5	4.5
Rodan western wheatgrass	177.52 efg	158.38	22.44 bcd	2.09	41.3 hijklm	16.3	7.0	5.8
9092261 Sandberg bluegrass‡	172.85 efg	154.22	1.83 h	0.17	53.3 fghijk	21.0	8.5	3.5
Rosana western wheatgrass	155.99 efg	139.18	13.46 cdefgh	1.25	45.1 ghijklm	17.8	7.0	6.5
E-45 Snake River wheatgrass	145.84 efg	130.12	3.15 fgh	0.29	48.9 fghijklm	19.3	8.5	6.0
Covar sheep fescue	105.84 fg	94.43	1.35 h	0.13	43.8 ghijklm	17.3	9.0	5.3
Copperhead slender wheatgrass	102.61 fg	91.55	11.22 cdefgh	1.04	46.4 ghijklm	18.3	8.0	5.8
Sherman big bluegrass	97.74 fg	87.20	2.69 gh	0.25	45.1 ghijklm	17.8	7.5	5.3
Pueblo bottlebrush squirreltail	92.95 fg	82.93	0.91 h	0.09	35.6 ijklm	14.0	9.0	5.8
High Plains Sandberg bluegrass	82.54 fg	73.64	5.84 efgh	0.54	34.3 jklm	13.5	8.0	5.0
Rimrock Indian ricegrass	65.46 fg	58.40	3.58 efgh	0.33	32.4 lm	12.8	8.3	6.3
Opportunity Nevada bluegrass	59.24 fg	52.86	1.80 h	0.17	45.7 ghijklm	18.0	8.8	5.0
9087539 prairie Junegrass	37.05 g	33.06	0.89 h	0.08	33.0 klm	13.0	8.5	5.8
Wapiti bottlebrush squirreltail	30.46 g	27.17	0.89 h	0.08	47.0 ghijklm	18.5	9.0	5.5
Nezpar Indian ricegrass	21.37 g	19.06	1.80 h	0.17	47.0 ghijklm	18.5	9.0	7.3

* Means followed by the same letter are not significantly different determined by LSD (P<0.05).

† Rated 1-9 with 1 best.

‡ Previously identified as prairie Junegrass.

‡ No plants in sample area but present within seeded plot (see appendix table 1).

Table 4. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 replicated plot performance of 24 forbs and 16 shrubs; seeded on October 19, 2005 -- Continued.

Accession/Common Name	Density		Height		Stand†	Vigor†
	plts/m²	*plts/ft²*	*cm*	*inches*		
9087557 black sagebrush	0.89 cd	0.08	21.0 def	8.3	8.8	6.5
9087558 basin big sagebrush	0.89 cd	0.08	60.0 a	23.5	8.8	4.3
9087556 white sagebrush	0.46 cd	0.04	19.1 def	7.5	9.0	4.8
9087555 prairie sagewort	0.46 cd	0.04	44.1 abc	17.4	9.0	6.0
9087562 antelope bitterbrush	0.46 cd	0.04	16.2 ef	6.4	8.5	6.8
9087559 Wyoming big sagebrush	0.46 cd	0.04	31.1 bcdef	12.3	9.0	6.0
Northern Cold Desert winterfat‡	-	-	43.8 abc	17.3	9.0	5.8
Maybell antelope bitterbrush‡	-	-	12.1 f	4.8	9.0	7.8
9087560 basin saltbush	-	-	-	-	-	-
9087561 shadscale saltbush	-	-	-	-	-	-

* Means followed by the same letter are not significantly different determined by LSD (P<0.05).

† Rated 1-9 with 1 best.

‡ No plants in sample area but present within seeded plot (see appendix table 1).

In the rhizomatous species, ‗Critana' thickspike wheatgrass produced the most biomass, but not significantly more than ‗Sodar' streambank wheatgrass, ‗Bannock' thickspike wheatgrass, or ‗Rosana' and ‗Rodan' western wheatgrass. The rhizomatous grasses were similar in height at approximately 20 inches. Vigor was best in Critana, while Rosana was the least vigorous. In 2010, Sodar was the only rhizomatous entry to increase production from the previous year (Figure 6). Plant density was significantly greater in Sodar than in the other 31 grasses. Sodar and Rosana increased in density from the previous year (Figure 7). As rhizomatous grasses continue to spread and establish, it becomes more of a challenge to accurately determine the number of culms.

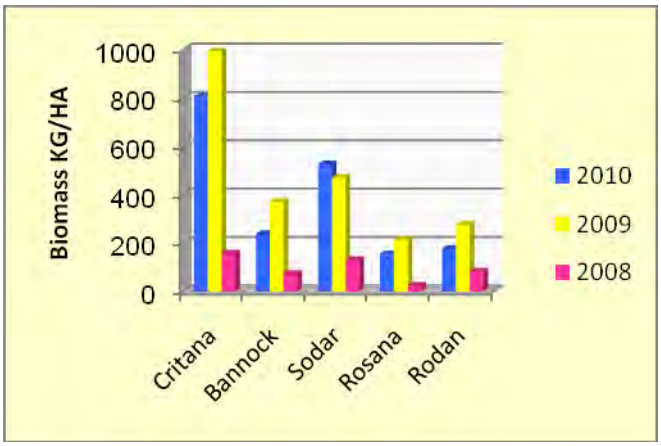

Figure 6. Three years of biomass production in five rhizomatous wheatgrasses.

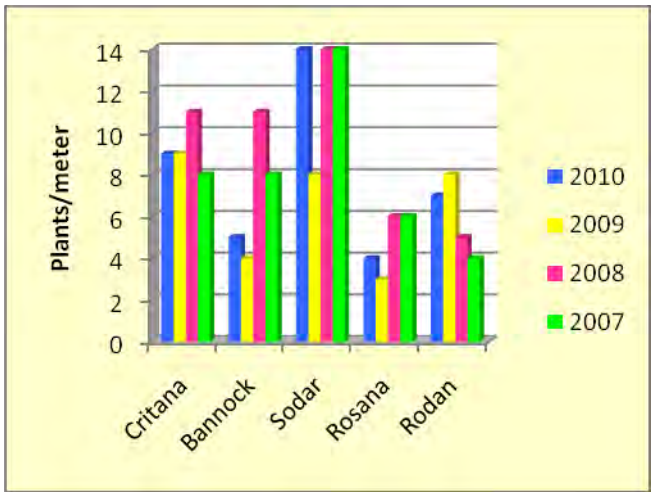

Figure 7. Four years of plant density counts in five rhizomatous wheatgrasses.

In 2010, P-24 bluebunch wheatgrass produced the greatest amount of biomass, but not significantly more than P-22, P-19, ‗Goldar', or Anatone. There were significantly more plants counted in P-24 than in Goldar and P-22. P-19 was the tallest, while Anatone was the shortest. P-24 rated the highest vigor and Goldar was least vigorous. ‗Secar' Snake River wheatgrass produced more than three times the amount of biomass, had twice the number of plants, and was taller and more vigorous than E-45 Snake River wheatgrass. The seven entries of bluebunch and Snake River wheatgrass increased biomass production over 3 years (Figure 8), while there was a downward trend in the number of plants (Figure 9).

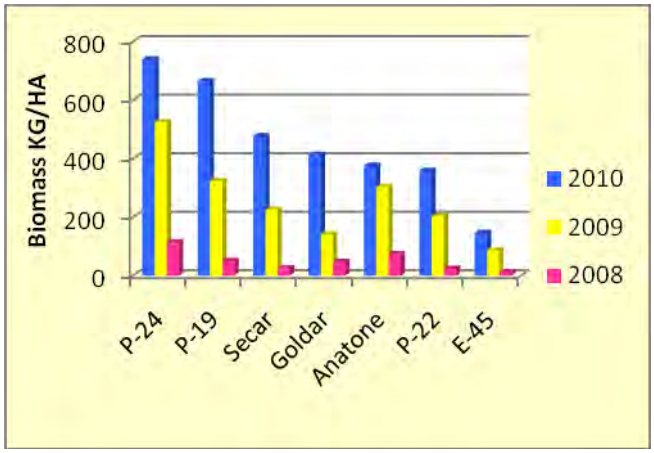

Figure 8. Three years of biomass production in five bluebunch and two Snake River wheatgrasses.

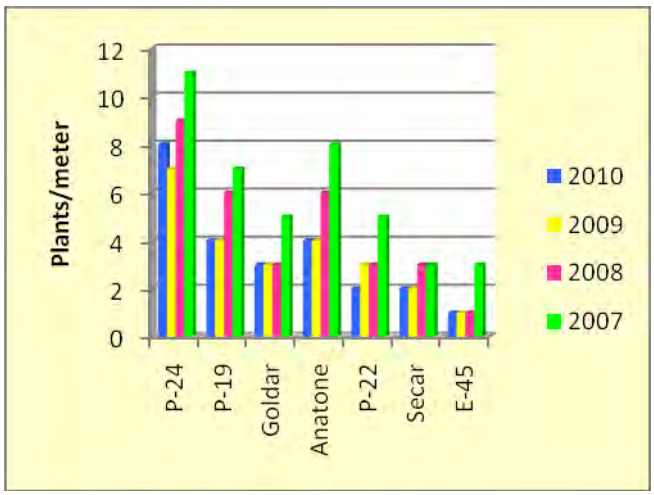

Figure 9. Four years of plant density counts in five bluebunch and two Snake River wheatgrasses

In 2010, San Luis' slender wheatgrass biomass production was not significantly more than Pryor' or Copperhead slender wheatgrass, but was more than three times greater than Copperhead. Copperhead had nearly three times the number of plants than Pryor. The height and vigor ratings were very similar in San Luis and Pryor, while the stature of Copperhead was shorter and the plants less vigorous. In the bottlebrush squirreltail entries, the 9019219 accession produced 82% and 93% more biomass than Pueblo and Wapiti, respectively. The 9019219 entry had a much higher plant count of shorter statured plants, and it was rated as the most vigorous grass in the trial. There was an upward production trend in two of the three slender wheatgrasses and in all three squirreltails, with Copperhead slender wheatgrass producing approximately 18% less in 2010 than in 2009 (Figure 10). There was general downward trend in plant densities with the exception of Copperhead and 9019219, as either unchanged or increased from the previous year (Figure 11).

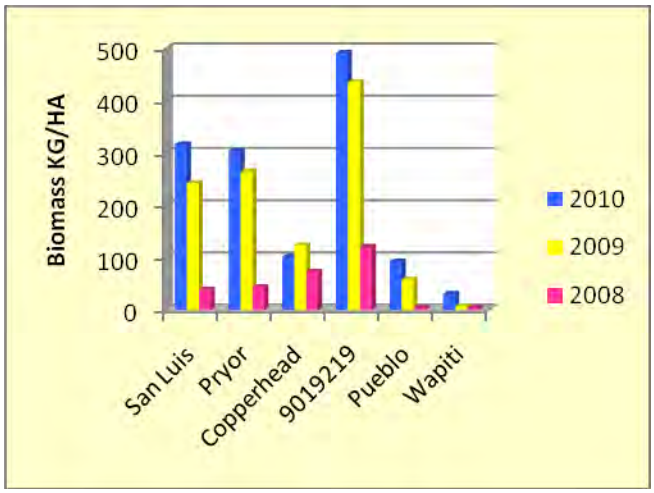

Figure 10. Three years of biomass production in three slender wheatgrasses and three bottlebrush squirreltails.

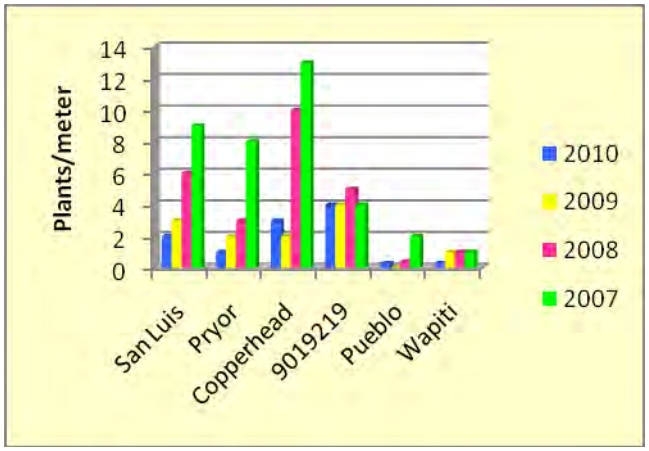

Figure 11. Four years of plant density counts in three slender wheatgrasses and three bottlebrush squirreltails.

In 2010, there was no significant difference in biomass production of the four bluegrass entries, but the 9092261 accession yield was three times higher than Opportunity Germplasm Nevada bluegrass. There were three times more plants of High Plains Germplasm Sandberg bluegrass than Opportunity. The 9092261 Sandberg was substantially taller and more robust than the other bluegrasses. After three years, 9092261 Sandberg produced the greatest amount of biomass (Figure 12), while High Plains Sandberg had the highest plant density (Figure 13). _Sherman' big bluegrass experienced the biggest decline in production and density.

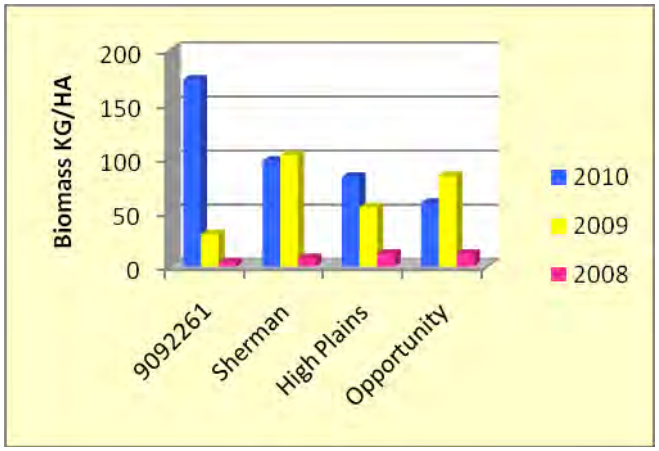

Figure 12. Three years of biomass production in four bluegrasses.

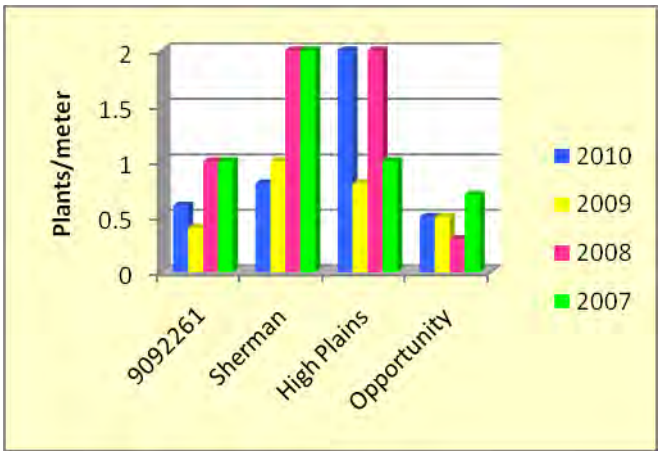

Figure 13. Four years of plant density counts in four bluegrasses.

In 2010, _Rimrock' Indian ricegrass produced three times more biomass and had twice the plant density as _Nezpar' Indian ricegrass. Nezpar produced the lowest amount of biomass in the replicated grass plots. It was taller than Rimrock, but Nezpar received the lowest vigor rating. _Covar' sheep fescue produced a moderate amount of biomass considering it had the third lowest number of plants. It's height and vigor were moderately low. Prairie Junegrass produced a low amount of biomass from very few plants that were short and moderately robust. After 3 years, only Covar increased production (Figure 14). Covar and Rimrock maintained plant density and the number of plants declined in Nezpar and prairie Junegrass (Figure 15).

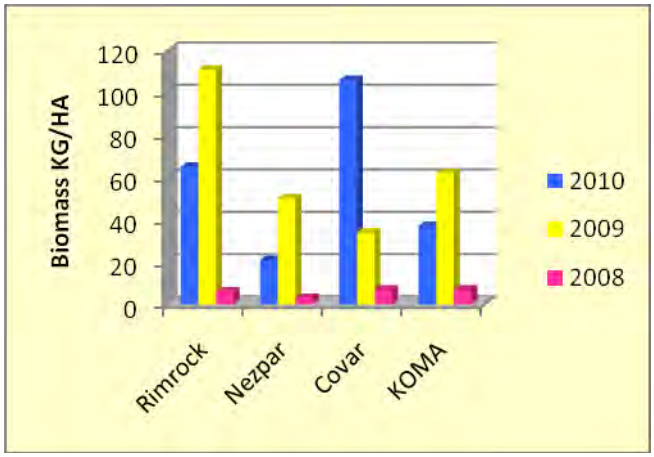

Figure 14. Three years of biomass production in Rimrock and Nezpar Indian ricegrass, Covar sheep fescue, and prairie Junegrass (KOMA).

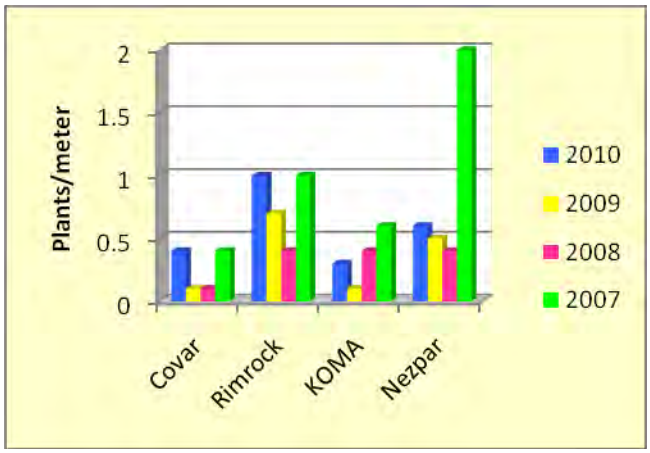

Figure 15. Four years of plant density in Rimrock and Nezpar Indian ricegrass, Covar sheep fescue, and prairie Junegrass (KOMA).

Forb. The analysis of variance of the 2010 replicated forb data showed plant density and height was different among accessions ($p \leq 0.05$) as reported in Table 4. The relative trend in plant density is depicted in Figure 16.

In 2010, plant density in western yarrow 9087541 and Appar' blue flax was significantly greater than sulfurflower buckwheat, Maple Grove Lewis flax, and Stillwater prairie coneflower. Plant establishment was very low compared to the actual seeding rate. Palmer's penstemon and Richfield Eaton's penstemon were significantly taller than the other 10 entries. The average stand and vigor ratings were poor and moderate, respectively. Eight of the test species (33%) were counted in their respective plot, but plants were outside the actual sample area. American vetch, wavyleaf Indian paintbrush, aspen fleabane, and pinkladies were not observed in the plots. After 4 years, the best performers were Appar blue flax, western yarrow 9087541, Palmer's penstemon, Richfield Eatons penstemon, Old Works fuzzytongue penstemon, gray aster, Maple Grove Lewis flax, and Stillwater prairie coneflower (Figure 16). During 3 of the 4 years, other entries that performed well included silverleaf phacelia, sulfurflower buckwheat, and Pacific aster.

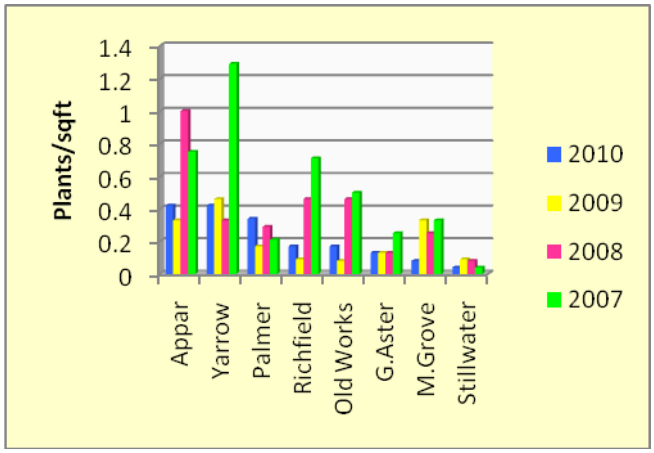

Figure 16. Four years of plant density in eight native forbs.

Shrub. The analysis of variance of the 2010 replicated shrub data showed plant density and height was different among accessions ($p \leq 0.05$) as reported in Table 4. The relative trend in plant density is depicted in Figure 17.

In 2010, plant density in Wytana' fourwing saltbush was significantly greater than in the other 12 species. Two of the test species were counted as present in their respective plots, but plants were outside the sample area. Plant establishment was very low compared to the actual seeding rate. Basin and shadscale saltbush were not present in the plots. The species with the tallest growth were basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), as well as Hatch' winterfat, spiny hopsage, and prairie sagewort (*Artemisia frigida*). Snake River and Wytana fourwing saltbush vigor ratings were very good. After 4 years, the best performing shrubs were Wytana and Snake River Plains fourwing saltbush, Gardners saltbush, Open Range and Hatch winterfat, and black sagebrush (Figure 17). Northern Cold Desert winterfat and basin big sagebrush were good performers in 3 of the 4 years.

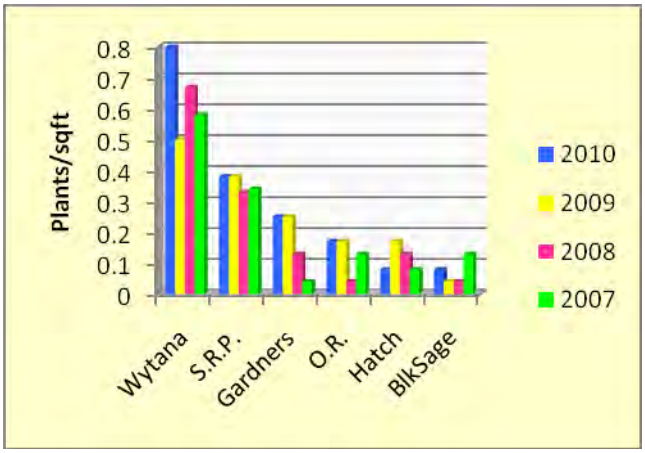

Figure 17. Four years of plant density in six native shrubs.

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Table 4. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 replicated plot performance of 24 forbs and 16 shrubs; seeded on October 19, 2005.

Accession/Common Name	Density		Height		Stand†	Vigor†
	plts/m²	*plts/ft²*	*cm*	*inches*		
Forbs						
9087541 western yarrow	4.49 a*	0.42	41.3 cdef*	16.3	7.8	4.0
Appar prairie flax	4.47 a	0.42	45.7 cde	18.0	6.0	3.0
9087546 Palmer's penstemon	3.61 ab	0.34	95.9 a	37.8	7.0	2.0
Old Works fuzzytongue penstemon	1.83 bc	0.17	24.1 efgh	9.5	8.5	5.8
Richfield Eaton's penstemon	1.80 bc	0.17	73.0 b	28.9	8.0	3.8
9087554 Pacific aster	1.80 bc	0.17	13.7 ghi	5.4	8.5	6.3
9081632 silverleaf phacelia	1.35 bc	0.13	7.0 ghi	2.8	9.0	8.0
9087553 gray aster	1.34 bc	0.13	39.4 cdef	15.5	8.3	2.5
9087552 sulfurflower buckwheat	0.92 c	0.09	10.2 ghi	4.0	8.8	6.5
Maple Grove Lewis flax	0.89 c	0.08	38.1 cdef	15.0	8.3	5.8
Stillwater prairie coneflower	0.46 c	0.04	47.0 cd	18.5	8.8	3.3
9087551 Munro's globemallow‡	-	-	52.1 bc	20.5	9.0	4.8
9087545 Eaton's penstemon‡	-	-	27.9 defg	11.0	9.0	6.5
Great Northern western yarrow‡	-	-	22.9 fgh	9.0	8.8	5.8
Clearwater Venus penstemon‡	-	-	21.6 fghi	8.5	9.0	6.3
Antelope white prairie clover‡	-	-	10.8 ghi	4.3	9.0	7.8
9087543 Rocky Mountain beeplant‡	-	-	5.1 hi	2.0	9.0	8.5
9087542 wavyleaf Indian paintbrush‡	-	-	5.1 hi	2.0	9.0	9.0
9087550 scarlet globemallow‡	-	-	4.5 hi	1.8	9.0	8.3
9087540 American vetch	-	-	-	-	-	-
9087544 aspen fleabane	-	-	-	-	-	-
9087547 littleflower penstemon	-	-	-	-	-	-
9087548 pale evening-primrose	-	-	-	-	-	-
9087549 pinkladies	-	-	-	-	-	-
Shrubs						
Wytana fourwing saltbush	8.53 a*	0.80	35.6 bcde*	14.0	6.5	2.3
Snake River Plains fourwing saltbush	4.04 b	0.38	47.6 ab	18.8	6.8	1.8
9016134 Gardner's saltbush	2.69 bc	0.25	23.5 cdef	9.3	8.3	5.3
Open Range winterfat	1.78 bcd	0.17	40.0 abcd	15.8	8.8	4.3
9087563 spiny hopsage	0.92 cd	0.09	38.7 abcd	15.3	8.3	4.5
Hatch winterfat	0.89 cd	0.08	45.5 abc	17.5	8.8	5.0

* Means followed by the same letter are not significantly different determined by LSD ($P<0.05$).
† Rated 1-9 with 1 best.
‡ No plants in sample area but present within seeded plot (see Appendix Table 1).

Table 4. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 replicated plot performance of 24 forbs and 16 shrubs; seeded on October 19, 2005 -- Continued.

Accession/Common Name	Density		Height		Stand†	Vigor†
	plts/m²	*plts/ft²*	*cm*	*inches*		
9087557 black sagebrush	0.89 cd	0.08	21.0 def	8.3	8.8	6.5
9087558 basin big sagebrush	0.89 cd	0.08	60.0 a	23.5	8.8	4.3
9087556 white sagebrush	0.46 cd	0.04	19.1 def	7.5	9.0	4.8
9087555 prairie sagewort	0.46 cd	0.04	44.1 abc	17.4	9.0	6.0
9087562 antelope bitterbrush	0.46 cd	0.04	16.2 ef	6.4	8.5	6.8
9087559 Wyoming big sagebrush	0.46 cd	0.04	31.1 bcdef	12.3	9.0	6.0
Northern Cold Desert winterfat‡	-	-	43.8 abc	17.3	9.0	5.8
Maybell antelope bitterbrush‡	-	-	12.1 f	4.8	9.0	7.8
9087560 basin saltbush	-	-	-	-	-	-
9087561 shadscale saltbush	-	-	-	-	-	-

* Means followed by the same letter are not significantly different determined by LSD (P<0.05).
† Rated 1-9 with 1 best.
‡ No plants in sample area but present within seeded plot (see appendix table 1).

Results--Mixture Plots:

Drill-Seeded.
The two seed mixtures are composed differently in species richness, relative proportion of life forms, and seeding rate. The 15-species Bridger Mix is 40% grass, 33% forb, and 27% shrub, and was seeded at a rate of 10.12 PLS lb/acre (refer back to Table 1). The 10-species Shell Mix is 20% grass, 40% forb, and 40% shrub, and was seeded at a rate of 5.18 PLS lb/acre (refer back to Table 2). Twenty, randomly-located transects sampled species abundance in 9.62 ft^2 experimental units in each of the five treatments. Evaluation factors across a treatment area included plant density, relative vigor (health), and plant height in inches.

Bridger Mix: There was a decrease in the number of grass plants/ft^2 in the 1-acre treatment with the Bridger Mix in 2010 compared to 2009, at 1.2 and 1.7, respectively (Table 5). Rosana western wheatgrass and Critana thickspike wheatgrass had the greatest numbers of plants. The change in density was attributed to a decrease in the number of plants in all six grass entries and Wytana fourwing saltbush. Not present in sample plots last year, but counted in the current year evaluation, were Maple Grove prairie flax, silverleaf phacelia, Stillwater prairie coneflower, Open Range winterfat, and Wyoming big sagebrush. Of the species seeded in the mix, 80% were present in the sampled area. The species, in order of most-to-least frequency, were Critana thickspike wheatgrass (65%), Rosana western wheatgrass (50%), Pryor slender wheatgrass (35%), Rimrock Indian ricegrass (30%), Trailhead basin wildrye (25%), Wytana fourwing saltbush (15%), silverleaf phacelia and Wyoming big sagebrush (10%), and High Plains Sandberg bluegrass, Stillwater prairie coneflower, Maple Grove Lewis flax, and Open Range winterfat (5%). Overall vigor was fair and the average plant height was slightly shorter than in 2009, at 15 inches. Fringed sagewort was present outside the sample area, with only scarlet globemallow not present on-site. At the end of a 4-year period, the larger-seeded grass species established the best, but plant densities across the plot were extremely low (Figure 18.).

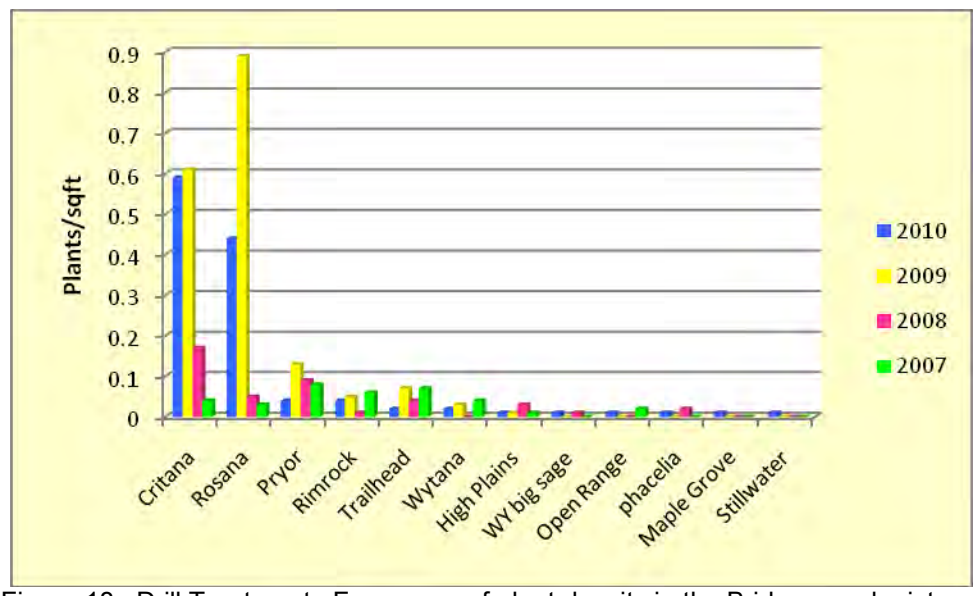

Figure 18. Drill Treatment: Four years of plant density in the Bridger seed mixture.

Shell Mix: There was an increase in the number of plants/ft^2 in the 1-acre treatment with the Shell Mix in 2010 compared to 2009, at 0.55 and 0.46, respectively (Table 6). Grass densities were up 34% from the previous year, with the biggest gain in the population of Sandberg bluegrass, followed by Rimrock Indian ricegrass. Plant density remained constant in fourwing saltbush, while there was a decline in winterfat and Wyoming big sagebrush. The number of seeded species present in the sample area was unchanged from the previous year at 50%. The species, in order of most-to-least frequency, were Wyoming big sagebrush (90%), Sandberg bluegrass (85%), Rimrock Indian ricegrass (60%), fourwing saltbush (40%), and winterfat (5%). The vigor rating for Wyoming big sagebrush was excellent, and species‘ vigor overall

was very good. Plant height increased in four of the five species from the previous year, while winterfat was considerably shorter. Fringed sage was present outside the sampled area, and the remaining 40% of the seeded species not present included Rydberg's penstemon, native yarrow, scarlet globemallow, and silvery lupine. At the end of a 4-year period, two grasses had the best establishment, but plant densities across the plot were extremely low (Figure 19).

Table 5. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 species performance of the Bridger seed mixture in the Truax drill treatment.

Accession	Symbol	Emergence	Stand	Health†	Avg Height
		plants/hectare	*plants/sq ft*	*vigor*	*cm*
High Plains Sandberg bluegrass	POSE	561	0.01	4	48.3
Rimrock Indian ricegrass	ACHY	4,305	0.04	4	27.2
Pryor slender wheatgrass	ELTRT	4,305	0.04	4	61.7
Rosana western wheatgrass	PASM	47,359	0.44	3	34.5
Critana thickspike wheatgrass	ELLAL	63,505	0.59	2	43.0
Trailhead basin wildrye	LECI4	2,152	0.02	5	70.0
Great Northern western yarrow‡	ACMIO	0	-	3	-
Stillwater prairie coneflower	RACO3	561	0.01	7	63.5
Maple Grove prairie flax	LILE3	561	0.01	8	7.0
silverleaf phacelia	PHHA	1,077	0.01	8	3.8
scarlet globemallow	SPCO	0	-	-	-
Open Range winterfat	KRLA2	561	0.01	5	35.6
Wytana fourwing saltbush	ATxAP	1,683	0.02	4	31.2
fringed sagewort‡	ARFR4	0	-	7	-
Wyoming big sagebrush	ARTRW8	1,077	0.01	4	43.2
	Total:	127,709	1.19	-	-

† Rated 1-9 with 1 best.
‡ No plants in sample area but present in seeded treatment.

Table 6. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 species performance of the Bridger seed mixture in the broadcast treatment.

Accession	Symbol	Emergence	Stand	Health†	Avg Height
		plants/hectare	*plants/sq ft*	*vigor*	*cm*
High Plains Sandberg bluegrass	POSE	8,611	0.08	5	29.2
Rimrock Indian ricegrass	ACHY	2,152	0.02	5	31.2
Pryor slender wheatgrass	ELTRT	17,223	0.16	3	59.4
Rosana western wheatgrass	PASM	53,818	0.50	3	32.8
Critana thickspike wheatgrass	ELLAL	95,796	0.89	2	46.5
Trailhead basin wildrye	LECI4	3,230	0.03	7	47.0
Great Northern western yarrow‡	ACMIO	0	-	5	-
Stillwater prairie coneflower‡	RACO3	0	-	8	-
Maple Grove prairie flax	LILE3	2,801	0.03	3	33.0
silverleaf phacelia‡	PHHA	0	-	8	-
scarlet globemallow‡	SPCO	0	-	-	-
Open Range winterfat	KRLA2	1,682	0.02	5	33.0
Wytana fourwing saltbush	ATxAP	6,726	0.06	3	30.2
fringed sagewort‡	ARFR4	0	-	7	-
Wyoming big sagebrush	ARTRW8	4,483	0.04	4	28.7
	Total:	197,537	1.84	-	-

† Rated 1-9 with 1 best.
‡ No plants in sample area but present in seeded treatment.

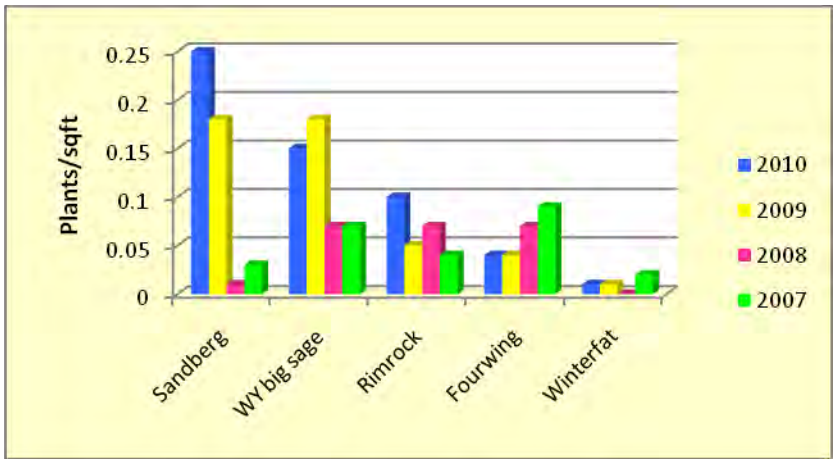

Figure 19. Drill Treatment: Four years of plant density in the Shell seed mixture.

In 2010, there were 53% more plants in the Bridger mixture, with 44% fewer seeds planted per acre, compared to the Shell mixture. The number of grass species continued to dominate the Bridger mix, while the trend appeared to change in the shrub-dominated Shell mixture, toward an increase in grasses. Forb establishment was extremely low in the Bridger plot and nonexistent in the Shell plot.

Broadcast-Seeded.

Bridger Mix: There was an increase in the number of plants/ft^2 in the 0.5-acre treatment with the Bridger Mix in 2010 compared to 2009, at 1.84 and 1.64, respectively (Table 7). The biggest increase was attributed to the rhizomatous spread of Rosana western wheatgrass and Critana thickspike wheatgrass, followed by Pryor slender wheatgrass, and Wyoming big sagebrush. The number of plants of Wytana fourwing saltbush remained constant, while there were substantial declines in High Plains Sandberg bluegrass, Rimrock Indian ricegrass, Trailhead basin wildrye, and Maple Grove prairie flax. Of the species in the mix, 66% were present in the sample area. The species not present in the sampled areas, but present within its seeded plot, were Great Northern western yarrow, Stillwater prairie coneflower, and fringed sagewort. The species, in order of most-to-least frequency, were Rosana western wheatgrass (80%), Critana thickspike wheatgrass (75%), Pryor slender wheatgrass (70%), High Plains Sandberg bluegrass (55%), Wytana fourwing saltbush (50%), Wyoming big sagebrush (40%), Rimrock Indian ricegrass, Trailhead basin wildrye, and Maple Grove prairie flax (20%), and Open Range winterfat (5%). Overall vigor was moderate, and plant height was mostly unchanged. Scarlet globemallow was not present on-site. At the end of a 4-year period, two grasses had the best establishment, but plant densities across the plot were extremely low (Figure 20).

Shell Mix: There was a decrease in the total number of plants/ft^2 in the 0.5-acre treatment with the Shell Mix in 2010 compared to 2009, at 1.65 and 1.72, respectively (Table 8). The overall decline was due to fewer plants of Rimrock Indian ricegrass, fringed sagewort, fourwing saltbush, and Wyoming big sagebrush. There was a substantial increase in Sandberg bluegrass compared to the previous year, at 1.19 and 1.07 plants/ft^2, respectively. Species composition remained constant at 60% of the original seeded mix present in the sample area. The species, in order of most-to-least frequency, were Sandberg bluegrass (100%), Wyoming big sagebrush (80%), winterfat (25%), fourwing saltbush (20%), and fringed sage and Rimrock Indian ricegrass (5%). Species vigor was good overall, while plant height was mostly shorter than in 2009. The remaining 40% of the seeded species mix not present on-site included silvery lupine, Rydberg's penstemon, native yarrow, and scarlet globemallow. At the end of a 4-year period, Sandberg bluegrass and Wyoming big sagebrush had the best establishment, but plant densities across the plot were extremely low (Figure 21).

Table 7. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 species performance of the Shell seed mixture in the Truax drill treatment.

Accession	Symbol	Emergence	Stand	Health	Avg Height
		plants/hectare	*plants/sq ft*	*vigor*	*cm*
Sandberg bluegrass	POSE	26,909	0.25	2	24.6
Rimrock Indian ricegrass	ACHY	10,764	0.10	5	70.0
common yarrow	ACMIO	0	-	-	-
Rydberg's penstemon	PERY	0	-	-	-
silvery lupine	LUAR3	0	-	-	-
scarlet globemallow	SPCO	0	-	-	-
fringed sagewort[‡]	ARFR4	0	-	3	-
fourwing saltbush	ATCA	4,305	0.04	2	31.8
winterfat	KRLA2	561	0.01	4	33.0
Wyoming big sagebrush	ARTRW8	16,146	0.15	1	43.9
	Total:	58,684	0.55	-	-

[†] Rated 1-9 with 1 best.
[‡] No plants in sample area but present in seeded treatment.

Table 8. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2010 species performance of the Shell seed mixture in the broadcast seeding treatment.

Accession	Symbol	Emergence	Stand	Health	Avg Height
		plants/hectare	*plants/sq ft*	*vigor*	*cm*
Sandberg bluegrass	POSE	128,088	1.19	3	17.5
Rimrock Indian ricegrass	ACHY	561	0.01	5	7.6
common yarrow	ACMIO	0	-	-	-
Rydberg's penstemon	PERY	0	-	-	-
silvery lupine	LUAR3	0	-	-	-
scarlet globemallow	SPCO	0	-	-	-
fringed sagewort	ARFR4	1,683	0.02	4	15.2
fourwing saltbush	ATCA	2,244	0.02	2	27.9
winterfat	KRLA2	3,363	0.03	2	35.1
Wyoming big sagebrush	ARTRW8	41,977	0.39	2	33.0
	Total:	177,917	1.65	-	-

[†] Rated 1-9 with 1 best.

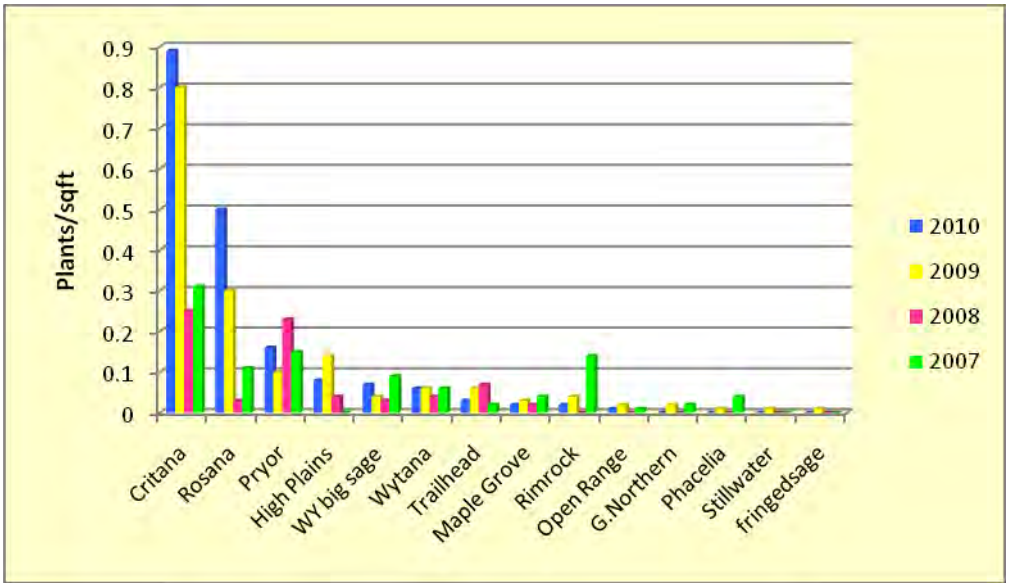

Figure 20. Broadcast Treatment. Four years of plant density in the Bridger seed mixture.

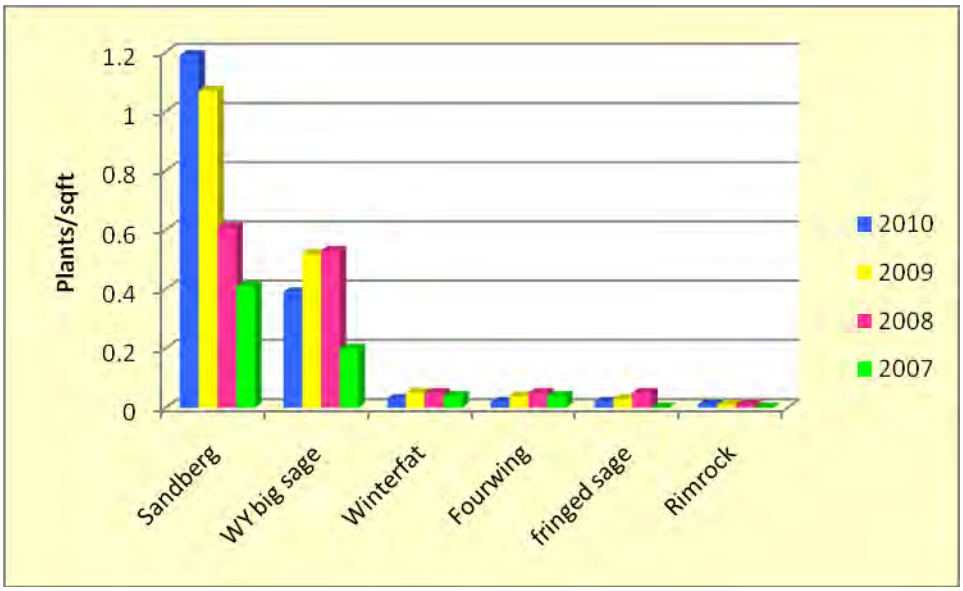

Figure 21. Broadcast Treatment. Four years of plant density in the Shell seed mixture.

In 2010, 5 years post-seeding of the broadcast treatments, the Bridger mix plot had 8,000 more plants/acre than in the plot of the Shell mix. Plant densities in the broadcast-seeded treatments of both mixes were more than three times greater than those of the Shell mix drill-seeded treatment. Plant densities in the drill-seeded treatment were more than twice as high in the Bridger mix compared to the Shell mix. The species composition existing in the Bridger mix was 91% grass, 8% shrub, and 2% forb. The Shell mix broadcast plot, seeded 80% non-grass, is now composed of 72% grass. The native plant community, as described in the Ecological Site Description, is most closely represented in the plot establishment of the Bridger mix.

Hydro-Seeded.

A cursory examination was conducted in the hydro-seeded treatment, as Shell may have drill-seeded the area to stabilize the site. The hydro-seeding method was the least successful, and in fact, was considered a failure. Mixing seed directly into the slurry and applying as a one-step mulch application on a smooth slope surface, promotes seed movement and seedling desiccation due to drying and shrinking

of the mulch. To restrict seed movement and promote seed-to-soil contact, a two-step approach is preferred where (1) the seed is separately mixed in a trace amount of mulch and applied directly to a roughened soil surface, followed by (2) a second application of mulch to reduce soil erosion and enhance micro-climate conditions necessary for germination and establishment (Holzworth, 2007).

The natural terrain of the site is rolling and the percentage slope mostly ranges from less than 1 to 8, with up to 12% slope in portions of the hydro-seeded treatment. In the steeper gradients, plots were tracked with minor rills where water moved downhill. Minor soil movement due to wind erosion was evident in small accumulations adjacent to the fence and in low lying areas.

Summary: The replicated plots on the Shell site indicate plant materials, currently developed, established in moderate numbers using drill seeding under the environmental and disturbance conditions of the area. Accessions of *Elymus elymoides, Elymus lanceolatus*, *Elymus trachycaulus*, *Leymus cinereus*, and *Pseudoroegneria spicata* demonstrated rapid establishment important in stabilizing severely disturbed soils. This is supported in the results of a similar trial conducted from 1987-2002 at Soda Lake, near Pinedale (USDA, 2008). Although forb establishment was below expectations, *Achillea millefolium*, *Cleome serrulata*, *Eurybia glauca*, *Linum, Penstemon*, *Phacelia hastata,* and *Symphyotrichum laeve* showed the greatest promise for providing diversity of this functional group important to wildlife habitat. Similarly, shrub establishment after five growing seasons was slow in 10 species critical to many types of wildlife. They were *Artemisia frigid, Artemisia ludoviciana, Artemisia nova, Artemisia tridentata* ssp. *tridentata*, *Artemisia tridentata* ssp. *wyomingensis, Atriplex aptera*, *Atriplex canescens*, *Grayia spinosa*, *Krascheninnikovia lanata,* and *Purshia tridentata*. Although establishment was below estimates of a full stand, many of these species were most often encountered in the seeding mixture trials, suggesting an increased seeding rate may improve establishment.

Species performance of the drill-seeded Shell mixture is substantially lower than in the other three treatments. Shrub cover dominated over the existing grass, which could inhibit future establishment of a more diverse plant community. Results of the hydro-seeded treatment suggest the one-step practice of hydro-seeding may not be effective and should be seriously reconsidered as the planting method of choice in the restoration of native plant communities on these sites.

Environmental factors such as low precipitation, higher temperatures, and increase of weedy species, inhibit seedling establishment (Monsen et al., 2004). The native species with the highest establishment are those taking advantage of early spring moisture. Drought tolerance is the key to long-term survival in this harsh climate. The effects of mechanical site preparation and seeding techniques on disturbed sites may elevate soil erosion during the early stages of plant establishment (Pierson et al., 2007). Those factors, along with a need to determine appropriate planting techniques, should be taken into consideration during all aspects of planning for the exploration of oil and gas in southwest Wyoming.

The 5-year evaluation period ended for the trial in 2010. Results will be summarized and published (NRCS lead author) for general use to address reclamation, forage production, and wildlife habitat issues. The results will be available to a wide audience, including but not limited to: private landowners; Soil & Water Conservation Districts; industry; NRCS Field Offices in Wyoming, Colorado, Montana, Idaho, and Utah; BLM Field Offices; and Wyoming Game & Fish Department Regional Offices. It is anticipated that the results will extend to other areas of the Intermountain West that have similar site conditions (soils, elevation, precipitation, growing days, etc.). In addition, trial results will scientifically augment and support data from other studies such as the Soda Lake (1996) and Questar (2007) FEPs near Pinedale, Wyoming.

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Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Grasses							
Covar	FEOV	1	0.00	9	5	19	
Covar	FEOV	2	0.00	9	6	16	5 plants
Covar	FEOV	3	0.00	9	6	14	4 plants
Covar	FEOV	4	0.50	9	4	20	
Sodar	ELLAL	1	6.67	3	5	16	
Sodar	ELLAL	2	3.83	6	3	19	
Sodar	ELLAL	3	0.50	8	6	19	
Sodar	ELLAL	4	6.00	3	2	27	
Sherman	POSE	1	0.50	7	5	19	
Sherman	POSE	2	0.00	9	6	9	4 plants
Sherman	POSE	3	0.00	8	5	21	18 plants
Sherman	POSE	4	0.50	6	5	22	
Pryor	ELTRT	1	0.67	6	4	29	
Pryor	ELTRT	2	0.83	7	3	19	
Pryor	ELTRT	3	0.17	9	5	23	14 plants
Pryor	ELTRT	4	0.00	8	6	25	
Magnar	LECI4	1	1.50	3	6	40	
Magnar	LECI4	2	0.83	4	6	28	
Magnar	LECI4	3	0.33	9	7	35	11 plants
Magnar	LECI4	4	1.33	4	5	45	
Nezpar	ACHY	1	0.17	9	8	24	6 plants
Nezpar	ACHY	2	0.17	9	7	19	6 plants
Nezpar	ACHY	3	0.00	9	7	16	13 plants
Nezpar	ACHY	4	0.33	9	7	15	
Critana	ELLAL	1	1.00	6	5	18	
Critana	ELLAL	2	1.83	4	4	18	
Critana	ELLAL	3	5.67	2	2	19	
Critana	ELLAL	4	3.00	3	2	27	
Rosana	PASM	1	2.00	7	6	20	
Rosana	PASM	2	1.33	7	7	17	
Rosana	PASM	3	1.67	6	5	18	
Rosana	PASM	4	0.00	8	8	16	
Rodan	PASM	1	0.17	8	6	16	
Rodan	PASM	2	1.50	8	8	11	
Rodan	PASM	3	5.00	6	4	20	
Rodan	PASM	4	1.67	6	5	18	LECI4 competing
Trailhead	LECI4	1	4.33	3	6	23	
Trailhead	LECI4	2	0.50	8	8	9	
Trailhead	LECI4	3	1.17	3	3	48	plants look great
Trailhead	LECI4	4	0.67	3	4	53	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005--Continued.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Rimrock	ACHY	1	0.33	9	8	13	8 plants (grazed)
Rimrock	ACHY	2	0.17	8	6	12	
Rimrock	ACHY	3	0.33	8	5	14	
Rimrock	ACHY	4	0.50	8	6	12	
San Luis	ELTRT	1	1.17	7	4	24	
San Luis	ELTRT	2	0.17	7	3	26	
San Luis	ELTRT	3	0.00	9	7	24	5 plants
San Luis	ELTRT	4	1.00	5	4	24	
Goldar	PSSPS	1	0.00	9	6	14	4 plants
Goldar	PSSPS	2	1.17	6	6	17	
Goldar	PSSPS	3	1.33	5	5	23	
Goldar	PSSPS	4	1.17	6	5	21	
Anatone	PSSPS	1	1.67	5	6	23	
Anatone	PSSPS	2	1.83	5	4	19	
Anatone	PSSPS	3	0.67	8	5	22	
Anatone	PSSPS	4	0.83	7	5	19	
9019219	ELEL5	1	0.33	6	2	12	
9019219	ELEL5	2	1.67	5	2	8	
9019219	ELEL5	3	1.67	4	2	13	
9019219	ELEL5	4	1.00	5	2	14	
Bannock	ELLAL	1	2.83	4	4	31	
Bannock	ELLAL	2	0.83	7	5	17	
Bannock	ELLAL	3	0.83	7	5	19	
Bannock	ELLAL	4	1.17	8	4	26	
Pueblo	ELEL5	1	0.17	9	5	16	
Pueblo	ELEL5	2	0.00	9	7	7	1 plant
Pueblo	ELEL5	3	0.00	9	6	16	4 plants
Pueblo	ELEL5	4	0.17	9	5	17	
Wapiti	ELEL5	1	0.33	9	6	15	7 plants
Wapiti	ELEL5	2	0.00	9	6	26	1 big plant
Wapiti	ELEL5	3	0.00	9	5	19	5 KOMA plants
Wapiti	ELEL5	4	0.00	9	7	14	2 plants
Salina	ELSA	1	3.00	7	2	28	misID last yr
Salina	ELSA	2	1.50	7	2	19	misID last yr
Salina	ELSA	3	1.17	6	5	25	
Salina	ELSA	4	0.83	8	7	15	
High Plains	POSE	1	0.67	8	6	12	grazed
High Plains	POSE	2	1.17	7	5	12	
High Plains	POSE	3	0.00	8	5	13	?
High Plains	POSE	4	0.33	9	4	17	16 plants
Copperhead	ELTRT	1	3.00	7	5	21	
Copperhead	ELTRT	2	0.67	8	5	19	some grazing
Copperhead	ELTRT	3	0.00	9	7	11	grazed
Copperhead	ELTRT	4	0.50	8	6	22	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005--Continued.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Washoe	LECI4	1	2.67	4	6	31	
Washoe	LECI4	2	2.17	3	5	24	
Washoe	LECI4	3	2.00	3	5	43	
Washoe	LECI4	4	1.33	6	7	31	
Opportunity	POSE	1	0.00	9	5	16	4 plants
Opportunity	POSE	2	0.17	9	5	17	6 plants
Opportunity	POSE	3	0.17	8	5	24	
Opportunity	POSE	4	0.33	9	5	15	6 plants
Secar	ELWA	1	0.83	6	4	26	
Secar	ELWA	2	0.50	6	4	14	
Secar	ELWA	3	0.67	6	4	25	
Secar	ELWA	4	0.50	9	7	21	
9087539	KOMA	1	0.00	8	5	12	
9087539	KOMA	2	0.00	9	6	12	6 plants
9087539	KOMA	3	0.33	8	6	15	27 plants
9087539	KOMA	4	0.00	9	6	13	8 plants
P-24	PSSPS	1	4.50	3	4	26	
P-24	PSSPS	2	1.83	5	6	16	
P-24	PSSPS	3	1.17	2	1	27	
P-24	PSSPS	4	2.00	4	3	23	
P-19	PSSPS	1	1.00	5	4	31	
P-19	PSSPS	2	2.00	6	3	23	
P-19	PSSPS	3	1.17	6	4	28	
P-19	PSSPS	4	0.67	7	5	25	
P-22	PSSPS	1	0.83	6	5	24	
P-22	PSSPS	2	1.00	3	4	19	
P-22	PSSPS	3	0.00	8	6	20	14 plants
P-22	PSSPS	4	0.17	7	5	24	
E-45	ELWA	1	0.67	7	5	18	
E-45	ELWA	2	0.00	9	7	18	8 plants
E-45	ELWA	3	0.00	9	5	26	14 plants
E-45	ELWA	4	0.50	9	7	15	8 plants
Continental	LECI4	1	2.83	4	7	12	
Continental	LECI4	2	1.17	5	3	30	
Continental	LECI4	3	1.50	3	4	43.5	
Continental	LECI4	4	0.83	6	8	36	
L-46	LECI4	1	3.50	3	4	30	
L-46	LECI4	2	3.00	5	6	19	
L-46	LECI4	3	1.50	3	5	38	
L-46	LECI4	4	1.50	3	4	40	
9092261	POSE	1	0.17	9	3	19	4 plants in plot
9092261	POSE	2	0.17	8	2	24	
9092261	POSE	3	0.17	9	5	22	11 plants
9092261	POSE	4	0.17	8	4	19	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005--Continued.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Shrubs							
Wytana	ATxAP	1	0.67	6	2	13	
Wytana	ATxAP	2	0.50	5	1	18	
Wytana	ATxAP	3	1.50	7	4	7	27 plants
Wytana	ATxAP	4	0.50	8	2	18	16 plants
Hatch	KRLA2	1	0.00	9	5	20	4 plants
Hatch	KRLA2	2	0.00	9	5	19	4 plants
Hatch	KRLA2	3	0.00	9	5	17	4 plants
Hatch	KRLA2	4	0.33	8	5	14	17 plants
9016134	ATGA	1	0.33	8	6	6	12 plants
9016134	ATGA	2	0.00	9	5	9	8 plants
9016134	ATGA	3	0.50	8	6	8	12 plants
9016134	ATGA	4	0.17	8	4	14	3 plants
Maybell	PUTR2	1	0.00	9	9	0	failure
Maybell	PUTR2	2	0.00	9	9	0	failure
Maybell	PUTR2	3	0.00	9	7	9	1 plant
Maybell	PUTR2	4	0.00	9	6	10	1 plant
Open Range	KRLA2	1	0.33	8	3	17	14 plants
Open Range	KRLA2	2	0.00	9	5	10	5 plants
Open Range	KRLA2	3	0.00	9	4	20	3 plants
Open Range	KRLA2	4	0.33	9	5	16	7 plants
Snake River Plains	ATCA	1	0.17	8	1	22	10 big plants
Snake River Plains	ATCA	2	0.33	7	3	20	18 big plants
Snake River Plains	ATCA	3	0.50	8	1	21	13 plants
Snake River Plains	ATCA	4	0.50	6	2	12	28 plants
Northern Cold Desert	KRLA2	1	0.00	9	4	20	7 plants
Northern Cold Desert	KRLA2	2	0.00	9	7	13	4 plants
Northern Cold Desert	KRLA2	3	0.00	9	6	19	5 plants
Northern Cold Desert	KRLA2	4	0.00	9	6	17	4 plants
9087555	ARFR4	1	0.00	9	2	13	1 plant
9087555	ARFR4	2	0.17	9	4	17	2 plants
9087555	ARFR4	3	0.00	9	9	0	failure
9087555	ARFR4	4	0.00	9	9	0	failure
9087556	ARLU	1	0.00	9	5	7	10 plants
9087556	ARLU	2	0.00	9	1	21	2 plants
9087556	ARLU	3	0.17	9	4	15.5	5 plants
9087556	ARLU	4	0.00	9	3	26	1 plant
9087557	ARNO4	1	0.00	9	5	13	2 plants
9087557	ARNO4	2	0.00	9	9	0	failure
9087557	ARNO4	3	0.33	9	7	8	2 plants
9087557	ARNO4	4	0.00	8	5	12	3 plants
9087558	ARTRT	1	0.00	9	3	27	5 plants
9087558	ARTRT	2	0.00	9	6	19	5 plants
9087558	ARTRT	3	0.33	8	4	16	9 plants
9087558	ARTRT	4	0.00	9	4	32	3 plants

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005--Continued.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
9087559	ARTRW8	1	0.00	9	5	16	2 plants
9087559	ARTRW8	2	0.17	9	4	16	
9087559	ARTRW8	3	0.00	9	6	17	1 plant
9087559	ARTRW8	4	0.00	9	9	0	failure
9087560	ATTR3	1	0.00	9	9	0	failure
9087560	ATTR3	2	0.00	9	9	0	failure
9087560	ATTR3	3	0.00	9	9	0	failure
9087560	ATTR3	4	0.00	9	9	0	failure
9087561	ATCO	1	0.00	9	9	0	failure
9087561	ATCO	2	0.00	9	9	0	failure
9087561	ATCO	3	0.00	9	9	0	failure
9087561	ATCO	4	0.00	9	9	0	failure
9087562	PUTR2	1	0.00	9	7	8	2 plants
9087562	PUTR2	2	0.00	9	7	7	4 plants
9087562	PUTR2	3	0.17	8	6	7.5	10 plants
9087562	PUTR2	4	0.00	8	7	3	4 plants
9087563	GRSP	1	0.17	9	3	18	6 plants
9087563	GRSP	2	0.00	8	8	6	13 plants (browsing)
9087563	GRSP	3	0.17	8	4	17	
9087563	GRSP	4	0.00	8	3	20	6 plants
Forbs							
9087541	ACMIO	1	1.17	5	1	24	big plants
9087541	ACMIO	2	0.00	9	9	0	failure
9087541	ACMIO	3	0.33	9	4	19	7 plants
9087541	ACMIO	4	0.17	8	2	22	
Great Northern	ACMIO	1	0.00	9	9	0	failure
Great Northern	ACMIO	2	0.00	9	3	17	5 plants
Great Northern	ACMIO	3	0.00	8	2	19	
Great Northern	ACMIO	4	0.00	9	9	0	failure
9087542	CAAP4	1	0.00	9	9	0	failure
9087542	CAAP4	2	0.00	9	9	8	2 plants
9087542	CAAP4	3	0.00	9	9	0	failure
9087542	CAAP4	4	0.00	9	9	0	failure
9087543	CLSE	1	0.00	9	8	3	2 plants
9087543	CLSE	2	0.00	9	9	0	failure
9087543	CLSE	3	0.00	9	9	5	1 plant
9087543	CLSE	4	0.00	9	9	0	failure
Antelope	DACA7	1	0.00	9	5	8	3 plants
Antelope	DACA7	2	0.00	9	9	0	failure
Antelope	DACA7	3	0.00	9	9	0	failure
Antelope	DACA7	4	0.00	9	8	9	2 plants

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005--Continued.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
9087544	ERSP4	1	0.00	9	9	0	failure
9087544	ERSP4	2	0.00	9	9	0	failure
9087544	ERSP4	3	0.00	9	9	0	failure
9087544	ERSP4	4	0.00	9	9	0	failure
9087552	ERUM	1	0.00	9	7	3	5 plants
9087552	ERUM	2	0.17	9	7	3	10 plants
9087552	ERUM	3	0.00	9	7	7	5 plants
9087552	ERUM	4	0.17	8	5	3	1 flowering
9087553	EUGL19	1	0.33	7	1	14	16 big plants
9087553	EUGL19	2	0.17	9	4	15	4 plants
9087553	EUGL19	3	0.00	8	3	15	11 plants
9087553	EUGL19	4	0.00	9	2	18	7 plants
Maple Grove	LILE3	1	0.33	7	3	24	
Maple Grove	LILE3	2	0.00	9	9	0	failure
Maple Grove	LILE3	3	0.00	9	7	14	1 plant (+1 outside plot)
Maple Grove	LILE3	4	0.00	8	4	22	
Appar	LIPE2	1	0.33	8	4	18	
Appar	LIPE2	2	0.00	9	5	16	4 plants
Appar	LIPE2	3	0.83	4	1	18	65 plants
Appar	LIPE2	4	0.50	3	2	20	
9087548	OEPA	1	0.00	9	9	0	failure
9087548	OEPA	2	0.00	9	9	0	failure
9087548	OEPA	3	0.00	9	9	0	failure
9087548	OEPA	4	0.00	9	9	0	failure
9087549	OESP2	1	0.00	9	9	0	failure
9087549	OESP2	2	0.00	9	9	0	failure
9087549	OESP2	3	0.00	9	9	0	failure
9087549	OESP2	4	0.00	9	9	0	failure
9087545	PEEA	1	0.00	9	5	11	6 plants
9087545	PEEA	2	0.00	9	9	3	1 new plant
9087545	PEEA	3	0.00	9	5	16	8 plants
9087545	PEEA	4	0.00	9	5	14	
Richfield	PEEA	1	0.00	9	2	34	9 plants
Richfield	PEEA	2	0.17	8	4	32	15 plants
Richfield	PEEA	3	0.00	8	5	19	8 plants
Richfield	PEEA	4	0.50	7	4	30	22 plants
Old Works	PEER	1	0.17	8	6	8	14 plants
Old Works	PEER	2	0.17	8	6	9	13 plants (lots of new)
Old Works	PEER	3	0.17	8	4	11	18 plants
Old Works	PEER	4	0.17	9	6	10	11 plants
9087546	PEPA8	1	0.17	7	1	46	>20 plants
9087546	PEPA8	2	0.67	7	1	37	
9087546	PEPA8	3	0.33	6	3	38	30 plants
9087546	PEPA8	4	0.17	8	3	30	11 plants

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting--Shell-Pinedale, Wyoming. The final evaluation of replicated plots conducted July 27, 2010. Planted on October 19, 2005--Continued.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
9087547	PEPR2	1	0.00	9	9	0	failure
9087547	PEPR2	2	0.00	9	9	0	failure
9087547	PEPR2	3	0.00	9	9	0	failure
9087547	PEPR2	4	0.00	9	9	0	failure
Clearwater	PEVE2	1	0.00	9	7	7	3 plants
Clearwater	PEVE2	2	0.00	9	9	0	failure
Clearwater	PEVE2	3	0.00	9	6	16	6 plants
Clearwater	PEVE2	4	0.00	9	5	11	1 plant
9081632	PHHA	1	0.17	9	8	2	3 plants
9081632	PHHA	2	0.00	9	9	0	failure
9081632	PHHA	3	0.33	9	7	6	11 plants
9081632	PHHA	4	0.00	9	8	3	2 plants
Stillwater	RACO3	1	0.00	9	2	15	9 plants
Stillwater	RACO3	2	0.00	9	5	17	4 plants
Stillwater	RACO3	3	0.17	8	2	19	8 plants
Stillwater	RACO3	4	0.00	9	4	23	plants all over
9087550	SPCO	1	0.00	9	8	3	1 plant
9087550	SPCO	2	0.00	9	9	0	failure
9087550	SPCO	3	0.00	9	7	4	3 plants
9087550	SPCO	4	0.00	9	9	0	failure
9087551	SPMU2	1	0.00	9	2	17	1 plant
9087551	SPMU2	2	0.00	9	9	0	failure
9087551	SPMU2	3	0.00	9	4	41	1 plant
9087551	SPMU2	4	0.00	9	4	24	2 plants
9087554	SYCH4	1	0.33	8	5	2	all plants grazed
9087554	SYCH4	2	0.17	8	6	8	10 plants
9087554	SYCH4	3	0.00	9	6	5.5	1 plant
9087554	SYCH4	4	0.17	9	8	6	heavy graze
9087540	VIAM	1	0.00	9	9	0	failure
9087540	VIAM	2	0.00	9	9	0	failure
9087540	VIAM	3	0.00	9	9	0	failure
9087540	VIAM	4	0.00	9	9	0	failure

† Rated 1-9 with 1 best.

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Secondary authors: Susan R. Winslow (NRCS Bridger PMC) and Karen Clause (NRCS Pinedale, WY)
Conference: Society for Range Management 64th Annual Meeting
Location: Billings, MT
Dates: February 6-10, 2011
Abstract submission deadline: September 1, 2010

Presentation title: Seeded Native Forb and Shrub Establishment on Disturbed Sites in Southwestern Wyoming

Abstract: Restoring native forb and shrub species for wildlife habitat to disturbances is challenging. Our objective was to evaluate native forb and shrub species establishment for restoration of disturbed high elevation sagebrush steppe. In October 2005, on a well-pad disturbance near Pinedale, Wyoming, 23 native forbs species and 16 accessions of 12 native shrub species were drill-seeded in single species plots in a randomized complete block design with four replications. Establishment was evaluated by counting species densities annually from 2007 through 2010 and differences among accessions were analyzed using ANOVA. In general, forb densities were low indicating forb establishment was poor and no differences among species were detected with the exception of fewer *Cleome serrulata* plants (less than one plant per square meter) compared to other species in years 2008 and 2010. The trend over time was decreasing forb density. There were no differences among shrub species or accessions over time. In 2008, 'Wytana' *Atriplex aptera* had the greatest establishment (395 plants/ha) followed by 'Snake River Plains' *Atriplex canescens* (197 plants/ha) and *Grayia spinosa* (110 plants/ha). These densities are satisfactory for wildlife food and cover on this site. Densities of the other shrub accessions were similar to each other and ranged from 101 to 21 plants/ha. Broadcast seeding may have improved the establishment of both forbs and shrubs. Our results suggest shrub cultivars can be used to restore wildlife habitat on disturbed sites. However, the forb results suggest more work needs to be done to develop establishment technologies and seed sources of forb species important for wildlife habitat.

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Abstract submission deadline: September 1, 2010

Presentation title: Comparing seed mixes and seeding techniques for restoring plant communities in Wyoming's high desert

Abstract: There is a need to restore native plant communities critical to wildlife habitat on high elevation sagebrush steppe disturbed by development, especially forbs and shrubs. This demonstration addressed two important factors influencing plant community establishment: species selection and seed placement. The species selection issue was examined using two seed mixtures: one with a high proportion of shrub seeds (36% grasses, 13% forbs, and 53% shrubs), and the other with a high proportion of grass seeds (72% grasses, 23% forbs, and 5% shrubs). The seed placement issue was examined by seeding method--either drill seeded or broadcast seeded. The demonstration was established in October 2005, on a reclaimed gas well near Pinedale, Wyoming. Plant community development was evaluated by counting plants per species within 20, randomly placed, 0.89-m^2 hoops, in each of the 0.2-ha broadcast treatments and in the 0.41-ha drill treatments. After five years, composition in the shrub mix was 72% grass and 28% shrubs, with less than 1% forbs where seeds were broadcast; and 64% grass and 36% shrubs, with less than 1% forbs where seeds were drilled. Community composition of the grass mix was 91% grass, 2% forbs, and 7% shrubs where seeds were broadcast; and 95% grass, 2% forbs, and 3% shrubs where seeds were drilled. Where the shrub mix was broadcast, the small-seeded *Poa secunda* was the predominant grass, while large-seeded grasses were most common where the grass mix was drilled. The demonstration planting indicates there is great need to improve availability of adapted forb species. Our observations suggest plant community development can be enhanced by increasing seed density and percentage composition of desired species and using seeding methods that optimize seed placement to facilitate germination and establishment.

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Dates: February 6-10, 2011
Abstract submission deadline: September 1, 2010

Presentation title: Establishment and persistence of native grass in Wyoming's high desert

Abstract: There is a critical need to identify native grass species that establish well and persist on highly disturbed sites on high elevation sagebrush-steppe communities important to wildlife such as mule deer, antelope and sage-grouse. Our objectives were to compare the establishment and persistence of grass accessions and cultivars native to the Rocky Mountain region. In October 2005, 32 entries of 15 native grass species were drill-seeded in single-species plots in a randomized complete block design with four replications on a reclaimed well-pad site near Pinedale, Wyoming. Plant density and height were recorded in each of the 5 years post-seeding, whereas biomass sampling began in 2008. Analysis of variance indicated plant counts depended on seeded entries. In 2010, plant densities of 'Sodar' streambank wheatgrass (46 plants/m^2) were greater than all other grasses. Densities of the other top performers were 'Critana' thickspike wheatgrass (31 plants/m^2), P-24 bluebunch wheatgrass and L-46 basin wildrye (26 plants/m^2), 'Rodan' western wheatgrass and Washoe basin wildrye (22 plants/m^2), 'Trailhead' basin wildrye (18 plants/m^2), and Salina wildrye and 'Continental' basin wildrye (17 plants/m^2). In general, rhizomatous grass densities increased over time while densities of bunchgrasses remained constant or decreased. Mean plant height was species-specific, with basin wildrye exceeding 84 cm, while Sandberg bluegrass, bottlebrush squirreltail, and Indian ricegrass were 13 cm. Averaged over all entries, biomass production was 327 kg/ha in 2009, compared to 59 kg/ha in 2008. In 2010, basin wildrye, thickspike and bluebunch wheatgrass, and bottlebrush squirreltail had greater mean biomass than other species. Results suggest, currently selected plant materials such as accessions of bottlebrush squirreltail, basin wildrye, and thickspike, western, bluebunch wheatgrass, and Sandberg bluegrass provide good options to restore disturbance, improve soil stability, contribute to ecosystem function, and enhance wildlife habitat.

Study Title: Hay and Pasture Grass Performance in the Big Horn Basin

Study Number: MT 06-0007

Objective: The objective of the trial is to conduct a comparative evaluation of 13 grass and 2 legume species seeded in solid stands and in alternate rows. This trial is a cooperative effort between the USDA Plant Materials Center in Bridger, Montana, and the University of Wyoming Research and Extension Center in Powell, Wyoming (cooperators include Susan Winslow, PMC Agronomist, Bridger, Montana; Mike Killen, Farm Manager, Research and Extension Center, Powell, Wyoming; and Randall Violett, Research Associate II, Research and Extension Center, Powell, Wyoming).

Methods and Materials: This study was located at the Powell R&E Center at an elevation of 4,365 feet above sea level. Typically, this location has about 155 days above 28° F during the spring to fall growing season. The soil type at the study site is a Garland clay loam (fine, mixed, mesic Typic Haplargid). The site was fertilized with P_2O_5 at the rate 200 lb/acre of P on March 30, 2006. The seedbed was then prepared, and the grass and legume species were planted using a four-row Kincaid Precision Cone Planter with 22-inch row spacing on April 28, 2006 (Table 1). Each plot was randomly assigned a variety for each of the four replications in a Randomized Complete Block Design and was planted in 18-foot-long plots (Figure 1). The 2006 growing season was used for an establishment year and no harvest data was collected. Fall fertilizer was applied on October 6, 2006, at the rate of 50 lb/acre of nitrogen. During the 2007 growing season, fertilizer was applied on March 18 at the rate of 100 lb/acre of nitrogen. In 2008 and 2009, fertilizer was applied on March 23 and March 15, respectively, at the rate of 100 lb/acre of nitrogen. Irrigation was accomplished using gravity flow, gated pipe on 22-inch furrows and the amount of water applied is determined by the length of time for each set (12 hours=1 inch of water). Irrigation occurred an average of seven times during the growing season for an average of 14 inches of additional water per growing season. Total water received by the crop each year averaged 16.55 inches. Plots were harvested using a Swift Forage Harvester on time in late June, and the alternate-row plots were harvested a second time in early August. On March 18, 2010, the plots were fertilized with 180-75-0. Irrigation was applied five times for a total of 10 additional inches of water on top of the 4.33 inches received as precipitation for a total of 14.33 inches of water.

Results--Monoculture Plots: The 3-year summary of average forage harvest data in the replicated monoculture grass plots are reported in Table 2. In 2007, biomass harvests were conducted on all 18 native and 21 non-native entries from a total of 156 plots (Appendix Table 1). The forage yields in tons of dry matter/acre ranged from 5.36 to 1.24, with an annual average of 3.50 tons in the introduced species and 2.82 tons in the native species (Table 2). The top five performers were 'Luna' and 'Manska' pubescent wheatgrass, 'Rush' intermediate wheatgrass, and 'Pryor' and 'First Strike' slender wheatgrass. Two of the top 10 producers were native grasses.

In 2008, biomass harvests were conducted on all 39 grasses, with a high percentage contamination of non-seeded species in 32 plots of 7 native and 1 non-native species (Appendix Table 2). The forage yields in tons of dry matter/acre ranged from 5.35 to 2.19, with an annual average of 3.52 tons in the introduced species and 2.09 tons in the native species (Table 2). No forage yields were reported from the weed infested plots. The top five performers were Luna pubescent wheatgrass, 'Reliant' intermediate wheatgrass, First Strike slender wheatgrass, 'Mustang' Altai wildrye, and 'Rosana' western wheatgrass. Four of the top 10 performers were native grasses.

In 2009, biomass harvests were conducted on all 39 grasses, with a high percentage contamination of non-seeded species in 36 plots of 7 native and 2 non-native species (Appendix Table 3). The forage yields in tons of dry matter/acre ranged from 4.58 to 2.19, with an annual average of 3.24 ton in the introduced species and 2.43 ton in the native species (Table 2). No forage yields were reported from the weed infested plots. The top five performers were 'Hycrest II' crested wheatgrass, Rush intermediate wheatgrass, Pryor and First Strike slender wheatgrass, 'Prairieland' Altai wildrye, and 'Vavilov' Siberian wheatgrass wheatgrass. One of the top 10 performers was a native grass.

Table 1. Comparative Evaluation Planting—Powell, Wyoming. The 2006 species and seed lot specifics, planted April 28, 2006.

Genus & Species	Common Name	Plot Entry/ Accession	Source	Year	Purity	Germ	PLS	Seeds/lb	Seeds/g	Seeds/row	g/row
					%	%					
Thinopyrum intermedium	pubescent wheatgrass	1 Luna	Wind River	2004	95.92	92	88.25	90000	198.2	600	3.0
		2 Greenleaf	Wind River	2004	98.89	93	91.97	90000	198.2	600	3.0
		3 Manska	ND PMC	1999	96.99	94	91.17	90000	198.2	600	3.0
	intermediate wheatgrass	4 Oahe	ND PMC	1991	94.80	83	78.68	89000	196.0	600	3.1
		5 Reliant	ND PMC	1999	96.55	94	90.76	89000	196.0	600	3.1
		6 Rush	ID PMC	1999	98.55	90	88.70	89000	196.0	600	3.1
Agropyron cristatum	crested wheatgrass	7 Hycrest	ID PMC	2005	99.20	92	91.26	225000	495.6	600	1.2
		8 Hycrest II	ARS Logan	2004	98.00	97	95.06	225000	495.6	600	1.2
		9 CD II	ARS Logan	2004	98.00	97	95.06	182000	400.9	600	1.5
		10 Douglas	ARS Logan	2001	96.00	96	92.16	200000	440.5	600	1.4
Agropyron fragile	Siberian wheatgrass	11 P-27	ID PMC	1999	98.80	96	94.85	205000	451.5	600	1.3
		12 Vavilov	ARS Logan	2004	98.00	95	93.10	170000	374.4	600	1.6
		13 Vavilov II	ARS Logan	2004	98.00	95	93.10	170000	374.4	600	1.6
Pseudoroegneria spicata	bluebunch wheatgrass	14 Goldar	ID PMC	2003	99.43	87	86.50	130000	286.3	600	2.1
		15 Anatone	ID PMC	2004	98.99	89	88.10	140000	308.4	600	1.9
		16 P-7	ID PMC	2005	97.49	93	90.67	140000	308.4	600	1.9
		17 9081636	MT PMC	2003	95.00	88	83.60	140000	308.4	600	1.9
P. spicata ssp. *inerme*	beardless bluebunch	18 Whitmar	WA PMC	2001	93.43	93	86.89	120000	264.3	600	2.3
Elymus wawawaiensis	Snake R. wheatgrass	19 Secar	WA PMC	2004	93.29	94	87.69	140000	308.4	600	1.9
Elymus trachycaulus	slender wheatgrass	20 Pryor	MT PMC	2004	99.93	96	95.93	98000	215.9	600	2.8
		21 San Luis	CO EPC	1999	99.37	90	89.43	125000	275.3	600	2.2
		22 Copperhead	MT PMC	2000	97.88	94	92.01	125000	275.3	600	2.2
		23 First Strike	ARS Logan	2002	97.00	95	92.15	125000	275.3	600	2.2
Pascopyrum smithii	western wheatgrass	24 Rosana	MT PMC	2005	98.39	97	95.44	95000	209.3	600	2.9
		25 Rodan	ND PMC	2004	91.29	89	81.25	95000	209.3	600	2.9
		26 Army	ARS Logan	2005	94.00	90	84.60	95000	209.3	600	2.9

Table 1. Comparative Evaluation Planting—Powell, Wyoming. The 2006 species and seed lot specifics, planted April 28, 2006—Continued.

Genus & Species	Common Name	Plot Entry/ Accession	Source	Year	Purity	Germ	PLS	Seeds/lb	Seeds/g	Seeds/row	g/row
Psathyrostachys juncea	Russian wildrye	27 Bozoisky-Select	ARS Logan	2004	98.00	96	94.08	160000	352.4	600	1.7
		28 Bozoisky II	ARS Logan	1998	97.00	96	93.12	160000	352.4	600	1.7
		29 Mankota	ND PMC	1999	97.69	90	87.92	160000	352.4	600	1.7
		30 Swift	Wind R.	2004	99.52	97	96.53	160000	352.4	600	1.7
Poa secunda	Sandberg bluegrass	31 High Plains	MT PMC	2005	99.23	83	82.36	925000	2037.4	600	0.3
	big bluegrass	32 Sherman	WA PMC	2000	97.37	87	84.71	900000	1982.4	600	0.3
		33 Opportunity	MT PMC	2001	96.44	98	94.51	900000	1982.4	600	0.3
Poa compressa	Canada bluegrass	34 Foothills	MT PMC	2003	98.40	90	88.56	1600000	3524.2	600	0.2
		35 Reubens	Wind R.	2003	97.09	90	87.38	1600000	3524.2	600	0.2
Leymus angustus	Altai wildrye	36 Prairieland	MT PMC	2004	90.50	83	75.12	60000	132.2	600	4.5
		37 Mustang	ARS Logan	2004	97.00	88	85.36	60000	132.2	600	4.5
Elymus elymoides	bottlebrush squirreltail	38 9019219	MT PMC	2003	95.00	90	85.50	190000	418.5	600	1.4
		39 Sand Hollow	ARS Logan	2000	97.00	95	92.15	190000	418.5	600	1.4
Thinopyrum intermedium	pubescent wheatgrass	Manska	ND PMC	1999	96.99	94	91.17	90000	198.2	600	3.0
Psathyrostachys juncea	Russian wildrye	Bozoisky-Select	ARS Logan	2004	98.00	96	94.08	160000	352.4	600	1.7
Bromus biebersteinii	meadow brome	McBeth	MSU	2004	98.00	86	84.28	95000	209.3	600	2.9
Onobrychis viciifolia	sainfoin	Shoshone	U of WY	2005	99.56	85	84.63	18000	39.6	400	10.1
Medicago sativa	alfalfa	Dormal Plus	Commercial	2004	99.00	95	94.05	220000	484.6	500	1.0
Thinopyrum elongatum	tall wheatgrass	Jose	Commercial	2003	89.99	94	84.59	79000	174.0	600	3.4

Rep 1			Rep 2			Rep 3			Rep 4		
1	26	27	5	25	37	38	4	23	27	7	26
2	25	28	12	9	24	1	25	16	16	22	31
3	24	29	36	31	32	10	17	21	39	9	5
4	23	30	15	3	7	39	33	9	17	11	14
5	22	31	33	22	28	18	11	32	10	4	37
6	21	32	30	38	8	20	8	36	34	28	25
7	20	33	17	20	14	26	15	7	3	21	20
8	19	34	11	2	29	13	28	37	24	13	1
9	18	35	26	23	16	24	2	27	19	18	15
10	17	36	01	4	35	5	29	19	8	2	6
11	16	37	13	27	6	14	12	35	33	35	36
12	15	38	21	34	39	31	34	22	23	12	29
13	14	39	10	19	18	3	30	6	38	32	30
Pub/Sain	MBr/Sain	RWR/Sain	MBr/Alf	RWR/Alf	Pub/Alf	RWR/Alf	MBr/Alf	Pub/Alf	MBr/Sain	Pub/Sain	RWR/Sain
RWR/Alf	Pub/alf	MBr/Alf	Pub/Sain	RWR/Sain	MBr/Sain	MBr/Sain	Pub/Sain	RWR/Sain	RWR/Alf	Pub/Alf	MBr/Alf

Individual plots 7.3' X 18' Overall Dimensions: 280' X 124.1'

Figure 1. Comparative Evaluation Planting—Powell, Wyoming. Hay and pasture grass performance in the Big Horn Basin. Planted on April 28, 2006.

Table 2. Comparative Evaluation Planting--Powell, Wyoming. The 3-year yield summary of replicated grass monoculture plots in the Big Horn Basin; planted April 28, 2006.

Entry #	Scientific Name	Common Name	Accession	2007 Yield ton DM/A	2008 Yield ton DM/A	2009 Yield ton DM/A	3 yr Tot DM Yield	3 yr Ave DM Yield
1	*Thinopyrum intermedium*	pubescent wheatgrass	Luna	5.36	5.35	3.48	14.19	4.73
2			Greenleaf	4.40	4.03	3.23	11.66	3.89
3			Manska	5.33	4.03	3.48	12.83	4.28
4		intermediate wheatgrass	Oahe	4.49	3.60	3.71	11.79	3.93
5			Reliant	4.58	4.34	3.51	12.42	4.14
6			Rush	4.99	3.89	4.28	13.17	4.39
7	*Agropyron cristatum*	crested wheatgrass	Hycrest	3.35	3.63	3.85	10.84	3.61
8			Hycrest II	4.15	3.96	4.58	12.68	4.23
9			CD II	4.03	3.83	3.37	11.23	3.74
10			Douglas	2.76	3.29	2.94	8.98	2.99
11	*Agropyron fragile*	Siberian wheatgrass	P-27	3.40	3.58	3.84	10.82	3.61
12			Vavilov	4.42	3.82	3.94	12.17	4.06
13			Vavilov II	4.56	3.99	3.78	12.32	4.11
14	*Pseudoroegneria spicata*	bluebunch wheatgrass	Goldar	3.29	2.98	3.11	9.39	3.13
15			Anatone	2.82	3.15	3.15	9.12	3.04
16			P-7	2.46	2.83	3.45	8.74	2.91
17			9081636	2.01	0.00†	0.00†	2.01	0.67
18	*P. spicata* ssp. *inermis*	beardless bluebunch	Whitmar	2.06	2.34	2.43	6.83	2.28
19	*Elymus wawawaiensis*	Snake River wheatgrass	Secar	2.83	2.49	2.56	7.88	2.63
20	*Elymus trachycaulus*	slender wheatgrass	Pryor	4.77	3.98	4.25	12.99	4.33
21			San Luis	3.80	3.68	3.16	10.64	3.55
22			Copperhead	3.44	0.00†	0.00†	3.44	1.15
23			First Strike	4.64	4.30	3.40	12.34	4.11
24	*Pascopyrum smithii*	western wheatgrass	Rosana	3.60	4.07	2.92	10.59	3.53
25			Rodan	2.88	3.72	2.46	9.06	3.02
26			Army	3.01	4.02	2.61	9.63	3.21
27	*Psathyrostachys juncea*	Russian wildrye	Bozoisky-Select	1.89	3.43	2.65	7.98	2.66
28			Bozoisky II	2.02	3.37	3.50	8.88	2.96
29			Mankota	1.97	2.88	3.28	8.13	2.71
30			Swift	1.47	2.19	2.61	6.27	2.09
31	*Poa secunda*	Sandberg bluegrass	High Plains	1.94	0.00†	0.00†	1.94	0.65
32		big bluegrass	Sherman	1.55	0.00†	0.00†	1.55	0.52
33		Opportunity	9081633	1.24	0.00†	0.00†	1.24	0.41
34	*Poa compressa*	Canada bluegrass	Foothills	2.19	2.78	0.00†	4.97	1.66
35			Reubens	1.92	0.00†	0.00†	1.92	0.64
36	*Leymus angustus*	Altai wildrye	Prairieland	2.89	3.80	4.12	10.82	3.61
37			Mustang	3.28	4.16	3.91	11.34	3.78
38	*Elymus elymoides*	bottlebrush squirreltail	9019219	2.13	0.00†	0.00†	2.13	0.71
39			Sand Hollow	2.38	0.00†	0.00†	2.38	0.79

† Replicated plots 1-4 weed infested.

At the end of 3 years, the best producers in average tons of dry matter/acre were Luna (4.73) and Manska (4.28) pubescent wheatgrass and Rush (4.39) and Reliant (4.14) intermediate wheatgrass, Hycrest II (4.23) crested wheatgrass, 'Vavilov II' (4.11), and Vavilov (4.06) Siberian wheatgrass, and Pryor (4.33) and First Strike (4.11) slender wheatgrass (Table 2). Mustang (3.78) Altai wildrye outperformed Prairieland (3.61); Rosana (3.53) western wheatgrass outperformed 'Army' (3.21) and `Rodan' (3.02); `Goldar' (3.13) bluebunch wheatgrass outperformed 'Anatone' (3.04), P-7 (2.91), 'Whitmar' (2.28), 9081636 (0.67), and 'Secar' (2.63) Snake River wheatgrass; and 'Bozoisky II' (2.96) Russian wildrye produced more than 'Bozoisky-Select' (2.66). Overall, the five bluegrass entries were poor performers, as were the two entries of bottlebrush squirreltail. Third-year forage yields of most entries were similar to first-year yields.

The replicated monoculture plots were removed in 2010. The data will be statistically analyzed and summarized in a future annual technical report.

Results--Alternate-Row Plots: The 4-year summary of average forage harvest data in the alternate-row plots are reported in Table 3. In 2007, 48 plots of three grass and two legume species were harvested in two cuttings (Appendix Tables 4A and 4B). The highest hay yields in the first cutting (Table 3) were 11.52 tons/acre of Manska pubescent wheatgrass (5.57) and 'Shoshone' sainfoin (5.95), followed by 10.44 tons/acre of 'McBeth' meadow brome (4.94) and sainfoin (5.50). The highest hay yields in the second cutting (Table 3) were 5.04 tons/acre of `Bozoisky-Select' Russian wildrye (0.48) and Dormal Plus alfalfa (4.56). In 2007, the greatest amount of total forage produced was 14.39 tons/acre of pubescent wheatgrass (6.12) and sainfoin (8.27). The highest total annual grass forage produced was McBeth meadow brome at 6.29 tons/acre. The highest total annual legume forage produced was Dormal Plus alfalfa at 9.15 tons/acre.

In 2008, 48 plots of the five species were harvested in two cuttings (Appendix Tables 5A and 5B). The highest hay yields in the first cutting (Table 3) were 7.75 tons/acre of meadow brome (3.83) and sainfoin (3.92), followed closely by 7.72 tons/acre of meadow brome (3.74) and alfalfa (3.98). The highest hay yields in the second cutting (Table 3) were 4.66 tons/acre of Russian wildrye (1.29) and alfalfa (3.37). In 2008, the greatest amount of total forage produced was 11.81 tons/acre of meadow brome (5.06) and alfalfa (6.75). The highest total annual grass forage produced was McBeth meadow brome at 5.18 tons/acre. The highest total annual legume forage produced was Dormal Plus alfalfa at 7.84 tons/acre.
In 2009, all the plots were harvested in two cuttings (Appendix tables 6A and 6B). The highest hay yields in the first cutting (Table 3) were 6.62 tons/acre of meadow brome (2.84) and sainfoin (3.78), followed by 6.45 tons/acre of pubescent wheatgrass (2.22) and sainfoin (4.23). The highest hay yields in the second cutting (Table 3) were 3.79 tons/acre of Russian wildrye (0.88) and sainfoin (2.91), followed by 3.71 tons/acre in meadow brome (0.99) and sainfoin (2.72). In 2009, the greatest amount of total forage produced was 10.33 tons/acre of meadow brome (3.83) and sainfoin (6.5). The highest total annual grass forage produced was McBeth meadow brome at 3.83 tons/acre. The highest total annual legume forage produced was Shoshone sainfoin at 7.31 tons/acre.

In 2010, all the plots were harvested in two cuttings (Appendix Tables 7A and 7B). The highest hay yields in the first cutting (Table 3) were 7.69 tons/acre of pubescent wheatgrass (4.99) and alfalfa (2.70), followed by 6.77 tons/acre of pubescent wheatgrass (4.28) and sainfoin (2.49). The highest hay yields in the second cutting (Table 3) were 3.13 tons/acre of meadow brome (1.38) and alfalfa (1.75), followed by 2.98 tons/acre of pubescent wheatgrass (0.86) and alfalfa (2.07). In 2010, the greatest amount of total forage produced was 10.62 tons/acre of pubescent wheatgrass (5.85) and alfalfa (4.77). The highest total annual grass forage produced was Manska pubescent wheatgrass at 5.85 tons/acre. The highest total annual legume forage produced was Dormal Plus at 4.78 tons/acre.

The replicated alternate-row plots will be harvested in 2011. The data will be statistically analyzed and summarized at the end of the study.

Table 3. Comparative Evaluation Planting--Powell, Wyoming. The 4-year yield summary of alternate-row grass and legume plots; planted April 28, 2006.

			2007 Harvest†			2008 Harvest†			2009 Harvest†			2010 Harvest†		
Scientific Name	Common Name	Accession	1st	2nd	total	1st	2nd	total	1st	2nd	total	1st	2nd	total
Thinopyrum intermedium	Pubescent/sainfoin	Manska	5.57	0.55	6.12	3.34	0.55	3.89	2.22	0.56	2.78	4.28	0.69	4.98
	Pubescent/alfalfa		5.33	0.44	5.76	3.04	0.78	3.82	2.51	0.50	3.02	4.99	0.86	5.85
Psathyrostachys juncea	RWR/sainfoin	Bozoisky-Select	2.48	0.52	3.00	2.59	1.03	3.63	2.24	0.88	3.12	2.58	0.97	3.56
	RWR/alfalfa		3.12	0.48	3.60	2.62	1.29	3.91	2.58	0.94	3.52	3.23	1.02	4.25
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	4.94	0.57	5.51	3.83	1.35	5.17	2.84	0.99	3.83	3.37	1.06	4.43
	Meadow brome/alfalfa		4.89	0.85	5.74	3.74	1.32	5.06	2.75	1.08	3.83	3.77	1.38	5.15
Onobrychis viciifolia	Sainfoin/pubescent	Shoshone	5.95	3.25	9.21	4.01	2.32	6.33	4.23	3.08	7.32	3.10	1.62	4.73
	Sainfoin/RWR		6.45	3.12	9.57	4.02	2.64	6.66	3.64	2.91	6.54	3.13	1.60	4.73
	Sainfoin/meadow brome		5.50	3.37	8.87	3.92	2.30	6.22	3.78	2.72	6.50	2.49	1.62	4.11
Medicago sativa	Alfalfa/pubescent	Dormal Plus	4.57	4.60	9.17	4.50	2.83	7.33	2.92	2.05	4.97	2.70	2.07	4.77
	Alfalfa/RWR		5.78	4.56	10.35	4.47	3.37	7.84	2.54	2.16	4.70	2.90	1.88	4.79
	Alfalfa/meadow brome		5.01	4.26	9.27	3.98	2.77	6.75	2.61	1.87	4.48	2.80	1.75	4.55

† Forage yield determined as hay in tons/acre at 12% moisture.

Appendix Table 1. Comparative Evaluation Planting—Powell, Wyoming. The 2007 performance of replicated monoculture grass plots; planted on April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Rep 4	Average	Total	Moisture	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*tons/acre*
Thinopyrum intermedium	pubescent wheatgrass	Luna	63.3	60.0	76.0	105.4	76.175	33517	42.0	14077.14	8.0
		Greenleaf	54.8	68.6	57.4	61.5	60.575	26653	42.5	11327.53	6.4
		Manska	81.6	61.6	54.6	71.3	67.275	29601	46.0	13616.46	7.7
	intermediate wheatgrass	Oahe	67.0	58.9	45.2	55.5	56.650	24926	45.5	11341.33	6.4
		Reliant	79.6	52.2	67.0	53.4	63.050	27742	42.8	11873.58	6.7
		Rush	73.4	70.1	39.2	76.6	64.825	28523	45.0	12835.35	7.3
Agropyron cristatum	crested wheatgrass	Hycrest	60.3	35.6	32.2	28.3	39.100	17204	49.0	8429.96	4.8
		Hycrest II	67.4	34.0	28.7	45.2	43.825	19283	52.5	10123.58	5.8
		CD II	58.3	48.9	35.4	32.0	43.650	19206	52.0	9987.12	5.7
		Douglas	32.7	30.5	27.5	31.8	30.625	13475	51.0	6872.25	3.9
Agropyron fragile	Siberian wheatgrass	P-27	54.0	49.7	27.6	31.4	40.675	17897	47.5	8501.08	4.9
		Vavilov	53.1	37.7	34.7	45.3	42.700	18788	56.5	10615.22	6.1
		Vavilov II	46.1	30.1	53.6	54.4	46.050	20262	55.0	11144.10	6.3
Pseudoroegneria spicata	bluebunch wheatgrass	Goldar	22.3	39.6	34.8	30.7	31.850	14014	56.5	7917.91	4.5
		Anatone	26.4	33.6	24.5	22.3	26.700	11748	58.0	6813.84	3.9
		P-7	26.0	28.9	18.1	22.1	23.775	10461	57.0	5962.77	3.4
		9081636	22.1	26.8	18.2	22.1	22.300	9812	50.5	4955.06	2.8
P. spicata ssp. *inermis*	beardless bluebunch	Whitmar	21.8	17.9	19.8	18.6	19.525	8591	57.5	4939.83	2.8
Elymus wawawaiensis	Snake River wheatgrass	Secar	33.0	21.9	22.0	28.1	26.250	11550	59.0	6814.50	3.9
Elymus trachycaulus	slender wheatgrass	Pryor	54.1	46.6	54.3	51.3	51.575	22693	51.5	11686.90	6.6
		San Luis	37.8	41.2	28.2	57.4	41.150	18106	51.5	9324.59	5.3
		Copperhead	36.4	32.9	38.8	24.8	33.225	14619	57.0	8332.83	4.7
		First Strike	44.5	46.4	39.2	70.7	50.200	22088	51.5	11375.32	6.5
Pascopyrum smithii	western wheatgrass	Rosana	45.2	34.8	42.6	64.4	46.750	20570	45.0	9256.50	5.3
		Rodan	40.3	29.6	33.1	46.5	37.375	16445	44.5	7318.03	4.2
		Army	34.6	35.3	47.7	30.3	36.975	16269	46.5	7565.09	4.3

Appendix Table 1. Comparative Evaluation Planting—Powell, Wyoming. The 2007 performance of replicated monoculture grass plots; planted on April 28, 2006—Continued.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Rep 4	Average	Total	Moisture	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*tons/acre*
Psathyrostachys juncea	Russian wildrye	Bozoisky-Select	16.7	28.6	28.3	27.3	25.225	11099	44.0	4883.56	2.8
		Bozoisky II	25.1	20.9	25.2	22.8	23.500	10340	48.5	5014.90	2.9
		Mankota	20.8	31.1	16.9	23.0	22.950	10098	48.5	4897.53	2.8
		Swift	13.9	16.9	21.2	11.5	15.875	6985	52.0	3632.20	2.1
Poa secunda	Sandberg bluegrass	High Plains	16.0	10.5	35.8	11.2	18.375	8085	57.5	4648.88	2.7
	big bluegrass	Sherman	19.8	14.2	13.7	12.4	15.025	6611	57.0	3768.27	2.1
		Opportunity	13.4	14.3	10.3	15.7	13.425	5907	52.0	3071.64	1.8
Poa compressa	Canada bluegrass	Foothills	39.6	23.5	23.1	11.0	24.300	10692	51.0	5452.92	3.1
		Reubens	22.9	28.5	16.5	15.2	20.775	9141	51.5	4707.62	2.7
Leymus angustus	Altai wildrye	Prairieland	41.6	29.9	30.3	48.5	37.575	16533	45.3	7489.45	4.3
		Mustang	45.5	27.9	46.5	50.4	42.575	18733	45.0	8429.85	4.8
Elymus elymoides	bottlebrush squirreltail	9019219	21.3	18.1	14.5	20.5	18.600	8184	62.5	5115.00	2.9
		Sand Hollow	18.5	22.6	23.1	24.0	22.050	9702	58.5	5675.67	3.2

Appendix Table 2. Comparative Evaluation Planting—Powell, Wyoming. The 2008 performance of replicated monoculture grass plots; planted on April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Rep 4	Average	Total	Moisture	Dry Matter	Hay Yield @12% Moisture
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*
Thinopyrum intermedium	pubescent wheatgrass	Luna	73.6	67	63.4	59	65.8	28930	37	10704.1	6.1
		Greenleaf	62.1	46.8	56	57.2	55.5	24431	33	8062.2	4.6
		Manska	56.4	61.5	51.5	66.9	59.1	25993	31	8057.8	4.6
	intermediate wheatgrass	Oahe	48.2	44	48.6	46	46.7	20548	35	7191.8	4.1
		Reliant	65	60	51	63	59.8	26290	33	8675.7	4.9
		Rush	59.7	63.5	38	60	55.3	24332	32	7786.2	4.4
Agropyron cristatum	crested wheatgrass	Hycrest	43.7	41	43.2	37.3	41.3	18172	40	7268.8	4.1
		Hycrest II	41.1	32.3	40.1	50	40.9	17985	44	7913.4	4.5
		CD II	45.9	36.9	39.5	47.4	42.4	18667	41	7653.5	4.3
		Douglas	36.1	37.3	37.5	42.3	38.3	16852	39	6572.3	3.7
Agropyron fragile	Siberian wheatgrass	P-27	40.7	52.3	39.5	30	40.6	17875	40	7150.0	4.1
		Vavilov	48.5	45	40.5	35.2	42.3	18612	41	7630.9	4.3
		Vavilov II	33.9	39.6	42	53	42.1	18535	43	7970.1	4.5
Pseudoroegneria spicata	bluebunch wheatgrass	Goldar	33.9	31	22	31	29.5	12969	46	5965.7	3.4
		Anatone	26.5	54	24	20	31.1	13695	46	6299.7	3.6
		P-7	35.6	28	23.4	25	28.0	12320	46	5667.2	3.2
		9081636	42.7†	39†	34†	32†	36.9	16247	49	7961.0	4.5
P. spicata ssp. *inermis*	beardless bluebunch	Whitmar	33.5†	21†	24.6†	20†	24.8	10901	43	4687.4	2.7
Elymus wawawaiensis	Snake River wheatgrass	Secar	40.1	25	34	38	34.3	15081	33	4976.7	2.8
Elymus trachycaulus	slender wheatgrass	Pryor	59.2	36.8	38.5	46.2	45.2	19877	40	7950.8	4.5
		San Luis	47.8	40.5	35	39.9	40.8	17952	41	7360.3	4.2
		Copperhead	42.5†	25.1†	24.5†	12.1†	26.1	11462	37	4240.9	2.4
		First Strike	57.8	44	41.5	42.8	46.5	20471	42	8597.8	4.9
Pascopyrum smithii	western wheatgrass	Rosana	43.9	45.5	40.5	60	47.5	20889	39	8146.7	4.6
		Rodan	63.3	52.4	41.5	47.6	51.2	22528	33	7434.2	4.2
		Army	53.7	43	49.5	41	46.8	20592	39	8030.9	4.6

† Replicated plots 1-4 weed infested.

Appendix Table 2. Comparative Evaluation Planting—Powell, Wyoming. The 2008 performance of replicated monoculture grass plots; planted on April 28, 2006--Continued.

Genus & Species	Common Name	Accession	Harvested Weights						Moisture	Dry Matter	Hay Yield @12% Moisture
			Rep 1	Rep 2	Rep 3	Rep 4	Average	Total			
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*
Psathyrostachys juncea	Russian wildrye	Bozoisky-Select	46	30.5	35.6	36.6	37.2	16357	42	6869.9	3.9
		Bozoisky II	37	32.3	43.2	36.8	37.3	16423	41	6733.4	3.8
		Mankota	32.6	36.9	35.1	36.7	35.3	15543	37	5750.9	3.3
		Swift	31.9	36.1	20.5	19	26.9	11825	37	4375.3	2.5
Poa secunda	Sandberg bluegrass	High Plains	24.6†	26†	26.6†	41†	29.6	13002	45	5850.9	3.3
	big bluegrass	Sherman	30.9†	28.7†	17.4†	19†	24.0	10560	46	4857.6	2.8
		Opportunity	34.2†	33.2†	31†	26.4†	31.2	13728	48	6589.4	3.7
Poa compressa	Canada bluegrass	Foothills	38.2	30.5	28.4	32.4	32.4	14245	39	5555.6	3.2
		Ruebens	27.7†	43.4†	27.6†	27.1†	31.5	13838	40	5535.2	3.1
Leymus angustus	Altai wildrye	Prairieland	29	56.5	40	43	42.1	18535	41	7599.4	4.3
		Mustang	45.2	40	47	56.7	47.2	20779	40	8311.6	4.7
Elymus elymoides	bottlebrush squirreltail	9019219	53.2†	27†	18.8†	28†	31.8	13970	40	5588.0	3.2
		Sand Hollow	34.4†	20†	34.6†	25†	28.5	12540	40	5016.0	2.8

† Replicated plots 1-4 weed infested.

Appendix Table 3. Comparative Evaluation Planting—Powell, Wyoming. The 2009 performance of replicated monoculture grass plots; planted on April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Rep 4	Average	Total	Moisture	Dry Matter	Hay Yield @12% Moisture
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*
Thinopyrum intermedium	pubescent wheatgrass	Luna	63.8	63.8	50.6	63.8	60.5	23171.5	30	6951.5	3.9
		Greenleaf	41.8	50.6	66	59.4	54.5	20854.4	31	6464.8	3.7
		Manska	63.8	50.6	59.4	46.2	55.0	21065.0	33	6951.5	3.9
	intermediate wheatgrass	Oahe	52.8	41.8	46.2	101.2	60.5	23171.5	32	7414.9	4.2
		Reliant	79.2	41.8	50.6	72.6	61.1	23382.2	30	7014.6	4.0
		Rush	63.8	68.2	59.4	57.2	62.2	23803.5	36	8569.2	4.9
Agropyron cristatum	crested wheatgrass	Hycrest	50.6	39.6	52.8	39.6	45.7	17484.0	44	7692.9	4.4
		Hycrest II	59.4	74.8	57.2	41.8	58.3	22328.9	41	9154.8	5.2
		CD II	46.2	41.8	37.4	50.6	44.0	16852.0	40	6740.8	3.8
		Douglas	35.2	35.2	41.8	37.4	37.4	14324.2	41	5872.9	3.3
Agropyron fragile	Siberian wheatgrass	P-27	68.2	61.6	37.4	44	52.8	20222.4	38	7684.5	4.4
		Vavilov	48.4	44	48.4	55	49.0	18747.9	42	7874.1	4.5
		Vavilov II	41.8	44	50.6	66	50.6	19379.8	39	7558.1	4.3
Pseudoroegneria spicata	bluebunch wheatgrass	Goldar	35.2	33	46.2	44	39.6	15166.8	41	6218.4	3.5
		Anatone	35.2	57.2	33	35.2	40.2	15377.5	41	6304.8	3.6
		P-7	46.2	61.6	30.8	33	42.9	16430.7	42	6900.9	3.9
		9081636†	41.8	37.4	28.6	37.4	36.3	13902.9	42	5839.2	3.3
P. spicata ssp. *inermis*	beardless bluebunch	Whitmar	37.4	28.6	28.6	46.2	35.2	13481.6	36	4853.4	2.8
Elymus wawawaiensis	Snake River wheatgrass	Secar	52.8	24.2	44	57.2	44.6	17062.7	30	5118.8	2.9
Elymus trachycaulus	slender wheatgrass	Pryor	66	44	70.4	66	61.6	23592.8	36	8493.4	4.8
		San Luis	37.4	48.4	39.6	48.4	43.5	16641.4	38	6323.7	3.6
		Copperhead†	59.4	37.4	59.4	28.6	46.2	17694.6	41	7254.8	4.1
		First Strike	52.8	59.4	48.4	61.6	55.6	21275.7	32	6808.2	3.9
Pascopyrum smithii	western wheatgrass	Rosana	46.2	41.8	50.6	46.2	46.2	17694.6	33	5839.2	3.3
		Rodan	44	26.4	26.4	46.2	35.8	13692.3	36	4929.2	2.8
		Army	39.6	52.8	41.8	30.8	41.3	15798.8	33	5213.6	3.0

† Replicated plots 1-4 weed infested

Appendix Table 3. Comparative Evaluation Planting—Powell, Wyoming. The 2009 performance of replicated monoculture grass plots; planted on April 28, 2006--Continued.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Rep 4	Average	Total	Moisture	Dry Matter	Hay Yield @12% Moisture
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*
Psathyrostachyus juncea	Russian wildrye	Bozoisky-Select	24.2	33	46.2	35.2	34.7	13271.0	40	5308.4	3.0
		Bozoisky II	30.8	41.8	61.6	44	44.6	17062.7	41	6995.7	4.0
		Mankota	35.2	57.2	35.2	52.8	45.1	17273.3	38	6563.9	3.7
		Swift	30.8	41.8	33	30.8	34.1	13060.3	40	5224.1	3.0
Poa secunda	Sandberg bluegrass	High Plains†	30.8	28.6	37.4	46.2	35.8	13692.3	41	5613.8	3.2
	big bluegrass	Sherman†	37.4	41.8	33	37.4	37.4	14324.2	42	6016.2	3.4
		Opportunity†	30.8	37.4	28.6	44	35.2	13481.6	41	5527.5	3.1
Poa compressa	Canada bluegrass	Foothills†	41.8	48.4	41.8	35.2	41.8	16009.4	36	5763.4	3.3
		Ruebens†	39.6	55	57.2	55	51.7	19801.1	38	7524.4	4.3
Leymus angustus	Altai wildrye	Prairieland	44	59.4	61.6	61.6	56.7	21697.0	38	8244.8	4.7
		Mustang	66	46.2	63.8	50.6	56.7	21697.0	36	7810.9	4.4
Elymus elymoides	bottlebrush squirreltail	9019219†	55	41.8	26.4	33	39.1	14956.2	42	6281.6	3.6
		Sand Hollow†	30.8	46.2	39.6	26.4	35.8	13692.3	44	6024.6	3.4

† Replicated plots 1-4 weed infested

Appendix Table 4A. Comparative Evaluation Planting—Powell, Wyoming. The 2007 1st cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights						Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			Rep 1	Rep 2	Rep 3	Matter	Average	Total				
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*tons/acre*	*tons/acre*
Thinopyrum intermedium	pubescent /sainfoin	Manska	29.1	29.4	29.0	30.3	29.450	25916	43	11143.9	5.6	6.3
	pubescent/alfalfa		31.6	34.8	23.4	22.8	28.150	24772	43	10652.0	5.3	6.1
Psathyrostachys juncea	RWR/sainfoin	Bozoisky-Select	12.8	13.6	13.6	11.2	12.800	11264	44	4956.2	2.5	2.8
	RWR/alfalfa		25.7	14.3	13.6	10.8	16.100	14168	44	6233.9	3.1	3.5
Bromus biebersteinii	meadow brome/sainfoin	McBeth	20.9	19.2	19.8	28.2	22.025	19382	51	9884.8	4.9	5.6
	meadow brome/alfalfa		22.9	19.4	24.9	19.9	21.775	19162	51	9772.6	4.9	5.6
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	44.4	38.5	32.9	30.5	36.575	32186	37	11908.8	6.0	6.8
	sainfoin/RWR		42.2	40.8	33.6	41.8	39.600	34848	37	12893.8	6.4	7.3
	sainfoin/meadow brome		37.1	37.1	30.3	30.6	33.775	29722	37	10997.1	5.5	6.2
Medicago sativa	alfalfa/pubescent	Dormal Plus	33.9	25.1	28.6	27.8	28.850	25388	36	9139.7	4.6	5.2
	alfalfa/RWR		30.0	40.5	41.1	34.4	36.500	32120	36	11563.2	5.8	6.6
	alfalfa/meadow brome		31.9	28.6	37.2	28.9	31.650	27852	36	10026.7	5.0	5.7

Appendix Table 4B. Comparative Evaluation Planting—Powell, Wyoming. The 2007 2nd cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Rep 4	Average	Total	Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*lb*	*lb*	*lb/acre*	*%*	*lb/acre*	*tons/acre*	*tons/acre*
Thinopyrum intermedium	pubescent/sainfoin	Manska	6.1	4.2	3.6	5.3	4.8	4224	26	1098.24	0.5	0.6
	pubescent/alfalfa		3	4.8	3.3	4.2	3.825	3366	26	875.16	0.4	0.5
Psathyrostachys juncea	RWR/sainfoin	Bozoisky-Select	5.4	4.6	4.9	1	3.975	3498	30	1049.4	0.5	0.6
	RWR/alfalfa		5.8	2	2	4.8	3.65	3212	30	963.6	0.5	0.5
Bromus biebersteinii	meadow brome/sainfoin	McBeth	3.2	4.8	2.1	2.5	3.15	2772	41	1136.52	0.6	0.6
	meadow brome/alfalfa		5.2	3.6	4.7	5.4	4.725	4158	41	1704.78	0.9	1.0
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	43	30.7	28.6	32.1	33.6	29568	22	6504.96	3.3	3.7
	sainfoin/RWR		30.2	34.1	33.2	31.6	32.275	28402	22	6248.44	3.1	3.5
	sainfoin/meadow brome		37	39.4	28.8	34.2	34.85	30668	22	6746.96	3.4	3.8
Medicago sativa	Alfalfa/pubescent	Dormal Plus	43.4	47.5	39.8	30.2	40.225	35398	26	9203.48	4.6	5.2
	Alfalfa/RWR		38.6	39.9	44.5	36.6	39.9	35112	26	9129.12	4.6	5.2
	Alfalfa/Meadow brome		37.7	47	30.4	33.7	37.2	32736	26	8511.36	4.3	4.8

Appendix Table 5A. Comparative Evaluation Planting—Powell, Wyoming. The 2008 1st cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights						Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			Rep 1	Rep 2	Matter	Moisture	Average	Total				
			lb	*lb*	*lb*	*tons/acre*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*	
Thinopyrum intermedium	Pubescent /sainfoin	Manska	28.6	27.6	31.2	25.1	28.1	24750	27	6682.5	3.3	3.8
	pubescent/alfalfa		27.4	25.5	30.7	18.8	25.6	22528	27	6082.6	3.0	3.5
Psathyrostachys juncea	RWR/sainfoin	Bozoisky-Select	20.3	14.9	18.7	11.6	16.4	14410	36	5187.6	2.6	2.9
	RWR/alfalfa		13.9	19	12.8	20.4	16.5	14542	36	5235.1	2.6	3.0
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	23.4	31.2	24.3	23.4	25.6	22506	34	7652.0	3.8	4.3
	Meadow brome/alfalfa		24.8	21.6	26.6	27	25.0	22000	34	7480.0	3.7	4.2
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	37.5	43.1	36.3	41.6	39.6	34870	23	8020.1	4.0	4.6
	sainfoin/RWR		39	38.9	41.6	39.2	39.7	34914	23	8030.2	4.0	4.6
	sainfoin/Meadow brome		42.1	34.3	35.7	43	38.8	34122	23	7848.1	3.9	4.5
Medicago sativa	Alfalfa/pubescent	Dormal Plus	44	47	34.6	45	42.7	37532	24	9007.7	4.5	5.1
	Alfalfa/RWR		44	45	38.8	41.5	42.3	37246	24	8939.0	4.5	5.1
	Alfalfa/Meadow brome		34	46	38.8	32	37.7	33176	24	7962.2	4.0	4.5

Appendix Table 5B. Comparative Evaluation Planting—Powell, Wyoming. The 2008 2nd cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Moisture	Average	Total	Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*tons/acre*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*	*ton/acre*
Thinopyrum intermedium	Pubescent /sainfoin	Manska	4.8	3	4	3.3	3.8	3322	33	1096.3	0.5	0.6
	pubescent/alfalfa		5.2	5	5.4	5.9	5.4	4730	33	1560.9	0.8	0.9
Psathyrostachys juncea	RWR/sainfoin	Bozoisky-Select	4.5	4	8.6	8.3	6.4	5588	37	2067.6	1.0	1.2
	RWR/alfalfa		7.8	4.1	7.3	12.5	7.9	6974	37	2580.4	1.3	1.5
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	9.6	5.4	10.3	9.7	8.8	7700	35	2695.0	1.5	1.5
	Meadow brome/alfalfa		9.5	6.2	5	13.5	8.6	7524	35	2633.4	1.5	1.5
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	27.6	21	25.6	21.5	23.9	21054	22	4631.9	2.3	2.6
	sainfoin/RWR		26.6	23	30.1	29.4	27.3	24002	22	5280.4	2.6	3.0
	sainfoin/Meadow brome		19.7	28.6	24.6	22.1	23.8	20900	22	4598.0	2.3	2.6
Medicago sativa	Alfalfa/pubescent	Dormal Plus	25.3	24.6	28.8	33.1	28.0	24596	23	5657.1	2.8	3.2
	Alfalfa/RWR		30.5	32.7	30.9	39.1	33.3	29304	23	6739.9	3.4	3.8
	Alfalfa/Meadow brome		29.8	25.7	27.6	26.2	27.3	24046	23	5530.6	2.8	3.1

Appendix Table 6A. Comparative Evaluation Planting—Powell, Wyoming. The 2009 1st cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights						Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			Rep 1	Rep 2	Rep 3	Moisture	Average	Total				
			lb	*lb*	*lb*	*tons/acre*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*	*ton/acre*
Thinopyrum intermedium	Pubescent /sainfoin	Manska	19.6	17.2	24.6	21.6	20.8	15853.0	28	4438.8	2.2	2.5
	pubescent/alfalfa		23.6	19.8	24.7	25.9	23.5	17954.0	28	5027.1	2.5	2.9
Psathyrostachyus juncea	RWR / sainfoin	Bozoisky-Select	18.4	10	17.9	13.9	15.1	11498.2	39	4484.3	2.2	2.5
	RWR / alfalfa		11.3	17.6	15.7	24.8	17.4	13255.4	39	5169.6	2.6	2.9
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	24.8	23.4	25.6	22.2	24.0	18336.0	31	5684.2	2.8	3.2
	Meadow brome/alfalfa		23.7	24.7	20	24.4	23.2	17724.8	31	5494.7	2.7	3.1
Onobrychis vicieaefolia	sainfoin/pubescent	Shoshone	48.2	53.1	49	51.1	50.4	38467.4	22	8462.8	4.2	4.8
	sainfoin/RWR		41.1	46.4	44.5	41.1	43.3	33062.1	22	7273.7	3.6	4.1
	sainfoin/Meadow brome		43.4	51.2	37.3	48.1	45.0	34380.0	22	7563.6	3.8	4.3
Medicago sativa	Alfalfa/pubescent	Dormal Plus	29.7	31.8	41.5	29.8	33.2	25364.8	23	5833.9	2.9	3.3
	Alfalfa/RWR		26.4	29.1	28.8	31.3	28.9	22079.6	23	5078.3	2.5	2.9
	Alfalfa/Meadow brome		26.8	29.8	40.5	21.9	29.8	22729.0	23	5227.7	2.6	3.0

Appendix Table 6B. Comparative Evaluation Planting—Powell, Wyoming. The 2009 2nd cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Moisture	Average	Total	Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*tons/acre*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*	*ton/acre*
Thinopyrum intermedium	Pubescent /sainfoin	Manska	3	5.5	4.7	6.4	4.9	4116	27	1111.3	0.6	0.6
	pubescent/alfalfa		6	3	3.8	5	4.5	3738	27	1009.3	0.5	0.6
Psathyrostachys juncea	RWR / sainfoin	Bozoisky-Select	6	4	10.8	7	7.0	5838	30	1751.4	0.9	1.0
	RWR / alfalfa		6.3	4.5	11	8	7.5	6258	30	1877.4	0.9	1.1
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	8.5	9.4	10	7	8.7	7329	27	1978.8	1.0	1.1
	Meadow brome/alfalfa		9.7	10	6.4	12.1	9.6	8022	27	2165.9	1.1	1.2
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	29	31	27	26	28.3	23730	26	6169.8	3.1	3.5
	sainfoin/RWR		28	23	30	25.5	26.6	22365	26	5814.9	2.9	3.3
	sainfoin/Meadow brome		28	24	25.5	22	24.9	20895	26	5432.7	2.7	3.1
Medicago sativa	Alfalfa/pubescent	Dormal Plus	17.5	19	27.5	21	21.3	17850	23	4105.5	2.1	2.3
	Alfalfa/RWR		18	20	24.4	27	22.4	18774	23	4318.0	2.2	2.5
	Alfalfa/Meadow brome		15	20	24.3	18	19.3	16233	23	3733.6	1.9	2.1

Appendix Table 7A. Comparative Evaluation Planting—Powell, Wyoming. The 2010 1st cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Moisture	Average	Total	Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*tons/acre*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*	*ton/acre*
Thinopyrum intermedium	Pubescent /sainfoin	Manska	38.9	37.5	31.9	27.6	34.0	28539	30	8561.7	4.3	4.9
	pubescent/alfalfa		45.3	41.2	37.7	34.2	39.6	33264	30	9979.2	5.0	5.7
Psathyrostachys juncea	RWR / sainfoin	Bozoisky-Select	24.2	16.6	20.8	17.8	19.9	16674	31	5168.9	2.6	2.9
	RWR / alfalfa		29.8	25.7	21.7	22	24.8	20832	31	6457.9	3.2	3.7
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	28	28.5	21	22.8	25.1	21063	32	6740.2	3.4	3.8
	Meadow brome/alfalfa		26.8	33.4	25.7	26.3	28.1	23562	32	7539.8	3.8	4.3
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	29.5	26.7	28.1	29.4	28.4	23877	26	6208.0	3.1	3.5
	sainfoin/RWR		27.8	37.2	22.8	27	28.7	24108	26	6268.1	3.1	3.6
	sainfoin/Meadow brome		29.5	25.4	20.6	15.8	22.8	19173	26	4985.0	2.5	2.8
Medicago sativa	Alfalfa/pubescent	Dormal Plus	19.1	26	31.4	22.5	24.8	20790	26	5405.4	2.7	3.1
	Alfalfa/RWR	Manska	29.9	22.6	26.4	27.4	26.6	22323	26	5804.0	2.9	3.3
	Alfalfa/Meadow brome		25.3	24.8	35	17.4	25.6	21525	26	5596.5	2.8	3.2

Appendix Table 7B. Comparative Evaluation Planting—Powell, Wyoming. The 2010 2ndt cut performance of alternate-row grass and legume plots; planted April 28, 2006.

Genus & Species	Common Name	Accession	Harvested Weights Rep 1	Rep 2	Rep 3	Moisture	Average	Total	Moisture	Dry Matter	Dry Matter	Hay Yield @ 12% Moisture
			lb	*lb*	*lb*	*tons/acre*	*lb*	*lb/acre*	*%*	*lb/acre*	*ton/acre*	*ton/acre*
Thinopyrum intermedium	Pubescent /sainfoin	Manska	7.5	5.8	5.9	3.3	6.3	5555	25	1388.75	0.69	0.8
	pubescent/alfalfa		4.8	6.9	9	7.3	7.9	6908	25	1727	0.86	1.0
Psathyrostachys juncea	RWR / sainfoin	Bozoisky-Select	9.3	4.2	10.7	10.6	9.2	8107	24	1945.68	0.97	1.1
	RWR / alfalfa		7.5	10.8	9.4	11.2	9.6	8481	24	2035.44	1.02	1.2
Bromus biebersteinii	Meadow brome/sainfoin	McBeth	7.2	9.1	10.5	11.4	9.6	8481	25	2120.25	1.06	1.2
	Meadow brome/alfalfa		11.8	8.9	5.2	13	12.6	11044	25	2761	1.38	1.6
Onobrychis viciifolia	sainfoin/pubescent	Shoshone	21	13	16.5	11	16.8	14740	22	3242.8	1.62	1.8
	sainfoin/RWR		19.4	12.8	22.1	18.2	16.5	14553	22	3201.66	1.60	1.8
	sainfoin/Meadow brome		15.6	10.9	17.4	15.9	16.7	14729	22	3240.38	1.62	1.8
Medicago sativa	Alfalfa/pubescent	Dormal Plus	11.4	16.4	30.4	15.9	18.1	15928	26	4141.28	2.07	2.4
	Alfalfa/RWR	Manska	18.3	13.6	23.4	15.4	16.5	14498	26	3769.48	1.88	2.1
	Alfalfa/Meadow brome		16.4	9.4	23.3	12	15.3	13442	26	3494.92	1.75	2.0

VIII. OUTREACH PROJECTS

Title: Bur oak seed germination study.

Study Number: MT-10-008

Introduction: This trial is part of the Bridger PMC Outreach efforts designed to introduce natural resource conservation to elementary school children. The student conducted this experiment at the PMC under the direction of staff as part of their science curriculum and Science Fair project. Project selection was based on the ability of the student, as well as an identified conservation issue at the Center.

Objective: Bur oak is a native Montana tree used with increasing frequency for landscaping and conservation applications. There is conflicting information regarding the optimum storage and handling of bur oak seed. Some information indicates bur oak seeds lose viability after a year in storage. There are some suggestions bur oak seeds need a cold:moist chilling treatment to increase total germination and germination rate. No information was found indicating whether bur oak seeds with emerging radicles can be held in cold storage for extended periods of time and then grow when planted, or if cap retention is an indicator of seed maturity and/or viability.

Methods and Materials: One 2008 bur oak seed with an emerged radicle was sown in each of 98, 10-cubic-inch containers. These acorns had begun germination in late 2008 while in cold, humid storage in a walk-in cooler (34^0 to 36^0F; 95% relative humidity). The study design consists of 14 containers per replication, seven replications (98 seeds total) per treatment. All seeds were watered and placed in a greenhouse maintained at 75^0 to 80^0F days, and 65^0 to 70^0F nights. All containers were kept moist and watered over time as needed. The same procedure was repeated using 98 seeds of 2008 bur oak with caps, 98 seeds of 2008 bur oak without caps, and 98 seeds of 2009 bur oak without a cold:moist chilling treatment. The last treatment involved cold chilling 98 seeds of the 2009 lot of bur oak. The seeds were watered, allowed to drain, and then placed in a walk-in cooler at 34^0 to 36^0F and 95% relative humidity for 50 days. After 50 days, the containers with the seeds were removed from the cooler and placed in the greenhouse.

From late October until mid February, data was collected at 2 to 3 day intervals.

Results: Tabular results of these trials are given in Table 1 and Appendix 1. Graphic results are shown in Chart 1 and Graph 1. All averages are corrected for actual seed lot viability. Approximately 94% of the 2008 acorns with emerged radicles survived and grew into healthy plants. Acorns from 2008 without caps germinated at 89.7%, whereas acorns with caps germinated at 87.2%. Of the 2009 seeds, 93.7% germinated without a cold chilling (stratification) period, and 70.3% germinated when given a 50 day cold chill, although a environmental control failure in the greenhouse ended the study prematurely, resulting in incomplete data for the 50-day cold chill treatment.

Rates of growth appear in Graph 1. The greatest (fastest) rate of growth occurred with the 2008 acorns with radicles treatment. Rates of growth of the other 2008 treatments (with and without caps) were approximately the same. With the 2009 seed treatments, cold chilled seeds germinated sooner than the un-chilled lot. Again, incomplete data for the 50-day cold chill treatment did not allow completion of the growth rate graph for this treatment.

Table 1. Mean percentage survival and percentage germination of bur oak seed, Bridger, MT 2010.

	Number of Surviving 2008 Acorns With Emerged Radicle	Number of Germinated 2008 Acorns Without a Cap	Number of Germinating 2008 Acorns With a Cap	Number of Germinating 2009 Acorns No Cold Chill	Number of Germinating 2009 Acorns 50-Day Chill
Total Number:	94.0	70.0	68.0	60.0	45.0
Percent:	95.9	71.4	69.4	61.2	45.9
Corrected %:*	**94.0**	**89.7**	**87.2**	**93.7**	**70.3**

* 2008 seeds were 78% viable and 2009 seeds were 64% viable.

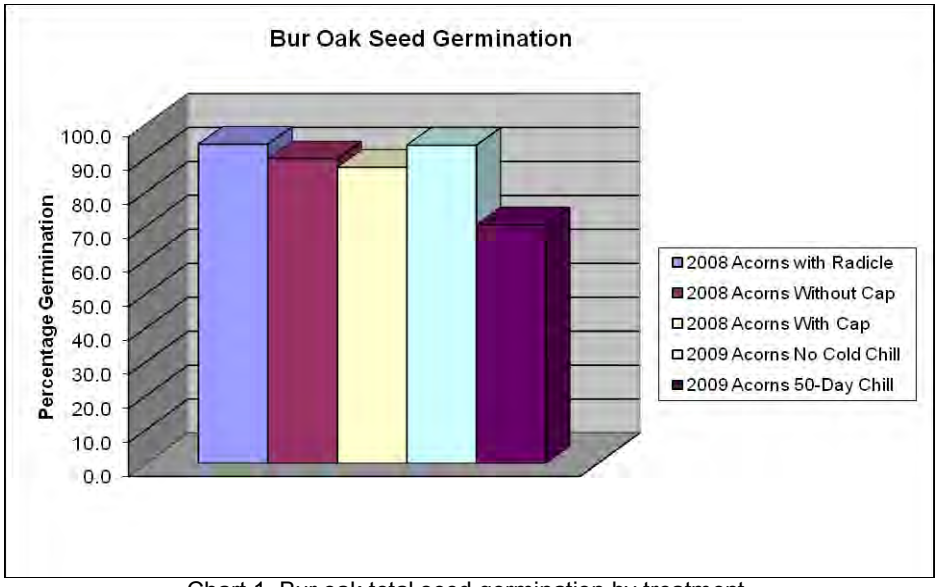
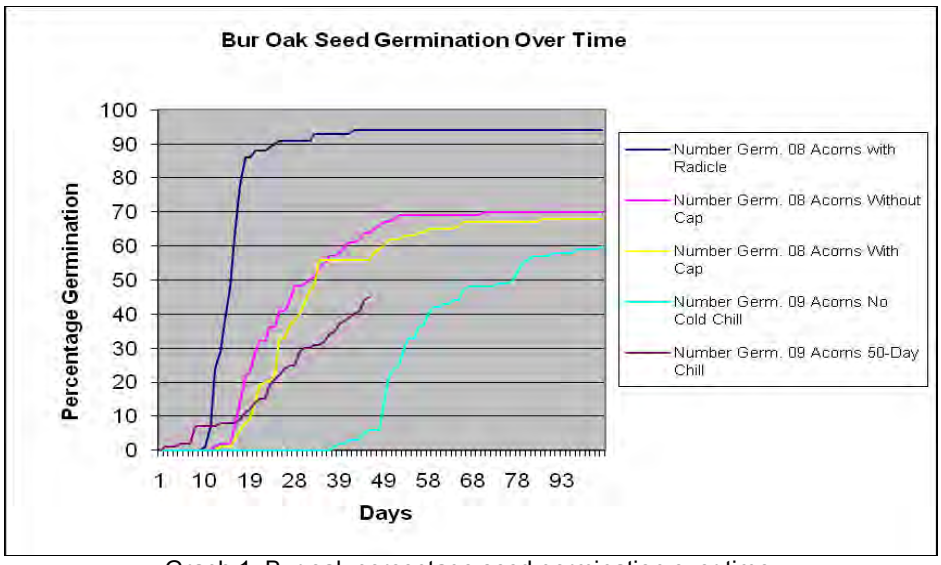


Chart 1. Bur oak total seed germination by treatment.



Graph 1. Bur oak percentage seed germination over time.

Conclusions: Bur oak seeds that begin germination by producing a radicle and are then subsequently stored under cool, humid conditions in a quiescent state can retain viability and grow properly even after a year in storage. Similarly, the 2008 seed lots germinated faster and had greater total germination than the 2009 lots even after a year of storage under cool, humid conditions. There did not appear to be a significant difference in percentage germination between seeds with and without caps, suggesting that cap retention is not necessarily an indicator of immature seed. Chilled seeds initially germinated faster than seeds without cold chill treatment, but there was not enough data to complete the trend.

Bur oak seeds can be used for at least one year and perhaps longer if stored properly. Seeds with caps appear to germinate and grow as well as seeds without caps. Cold treatment seems to improve bur oak germination rate, although more tests are needed to determine if longer cold treatment will continue to increase germination rate and total germination.

Appendix 1. Bur oak seed germination study raw evaluation data, Bridger, PMC, 2010.

Day No. In Greenhouse	Number of Surviving 2008 Acorns with Radicle	Number of Germinated 2008 Acorns Without a Cap	Number of Germinated 2008 Acorns With a Cap	Number of Germinated 2009 Acorns No Cold Chill	Day No. After Removal From Cooler	Number of Germinated 2009 Acorns 50-Day Chill
1						
2						
3						
4						
5						
6						
7						
8						
9						
10	1	0	0	0		
11	7	0	0	0		
12	24	1	0	0		
13	29	2	1	0		
14	38	2	1	0		
15	48	2	1	0		
16	63	7	3	0		
17	78	14	6	0		
18	86	22	8	0		
19	86	23	9	0		
20	88	29	14	0		
21	88	32	19	0		
22	88	32	20	0		
23	89	36	20	0		
24	90	36	22	0		
25	91	41	33	0		
26	91	41	33	0		
27	91	44	37	0		
28	91	48	38	0		
29	91	48	40	0		
30	91	49	43	0		
31	91	50	47	0		
32	93	51	48	0		
33	93	54	56	0		
34	93	55	56	0		
35	93	57	56	0		
38	93	57	56	1		
39	93	58	56	2		
40	93	60	56	2		
41	93	61	56	3		
42	94	61	56	3		
43	94	62	56	3		
44	94	64	56	5		
45	94	64	56	6		
46	94	65	58	6		
47	94	66	59	6		
49	94	67	60	13		
50	94	67	62	22		

Appendix 1. Bur oak seed germination study raw evaluation data, Bridger, PMC, 2010 (continued).

Day No. In Greenhouse	Number of Surviving 2008 Acorns with Radicle	Number of Germinated 2008 Acorns Without a Cap	Number of Germinated 2008 Acorns With a Cap	Number of Germinated 2009 Acorns No Cold Chill	Day No. After Removal From Cooler	Number of Germinated 2009 Acorns 50-Day Chill
51	94	68	62	24		
52	94	69	62	25	2	1
53	94	69	63	30	3	1
54	94	69	63	33	4	1
55	94	69	63	33	5	2
56	94	69	64	36	6	2
57	94	69	64	37	7	2
58	94	69	65	40	8	7
60	94	69	65	42	10	7
61	94	69	65	42	11	7
62	94	69	65	43	12	7
63	94	69	65	43	13	7
64	94	69	65	44	14	8
65	94	69	66	44	15	8
66	94	69	67	47	16	8
67	94	69	67	48	17	8
68	94	69	67	48	18	9
69	94	69	67	48	19	11
70	94	70	67	48	20	12
71	94	70	67	48	21	14
72	94	70	67	48	22	15
74	94	70	67	49	24	15
75	94	70	67	49	25	19
76	94	70	67	49	26	21
77	94	70	67	50	27	22
78	94	70	67	53	28	24
80	94	70	67	55	30	25
81	94	70	67	56	31	25
82	94	70	67	57	32	29
83	94	70	67	57	33	30
85	94	70	68	57	35	30
86	94	70	68	57	36	31
89	94	70	68	58	39	31
90	94	70	68	58	40	32
93	94	70	68	58	43	34
95	94	70	68	58	45	35
100	94	70	68	58	50	37
102	94	70	68	59	52	38
103	94	70	68	59	53	39
104	94	70	68	59	54	40
106	94	70	68	59	56	41
107	94	70	68	59	57	44
109	94	70	68	60	59	45

Study Title: Weed Seed Viability at Different Soil Depths

Study Number: MT-10-007

Introduction: This project is part of the Bridger PMC Outreach efforts designed to introduce natural resource conservation to elementary school children. The student conducted this experiment at the PMC under the direction of staff as part of their science curriculum and Science Fair project. Project selection was based on the ability of the student, as well as an identified conservation issue at the Center.

Objective: The objective of this study is to estimate the number of viable weeds seeds at different soil depths in a selected seed production field at the Bridger PMC. Information on the number of viable (germinating) seeds and whether they are monocots or dicots, will be collected in order to determine the suitability of the field for Foundation seed production, as well identify appropriate management and cultural practices.

Materials and Methods: In October 2009, five sampling locations were marked in Field 15 at the Bridger PMC. Soil samples were taken from the surface at each sampling location measuring 12 inches by 12 inches by less than 1 inch deep. This represented the surface sample. This sampling procedure was repeated at three additional soil depths (1 to 2 inches deep, 6 to 12 inches deep, greater than 12 inches deep) at each of the four remaining sample locations. The soil samples were placed in trays and placed in a greenhouse maintained at 75^0 to 80^0F day temperatures and 65^0 to 70^0F night temperatures. Each tray was watered approximately every other day. After the weeds were growing for about 3 months in the greenhouse, number of monocots and dicots were recorded and green biomass weighed.

Results: Tabular results of this experiment appear Table 1 and Appendix 1. Graphic results appear in Charts 1 and 2. The soil surface layer had the highest mean number of germinating monocot seeds, close to the highest mean number of germinating dicot seeds, and the greatest mean green biomass. The 0 to 2 inch treatment had the second highest mean number of monocots, the highest mean number of dicots, and the second greatest mean green biomass. The 6 to 12 inch treatment had the third highest mean number of monocots, the lowest mean number of dicots (tied with the >12 inch treatment), and the second lowest mean green biomass. The >12 inch treatment had the lowest mean number of monocots, the lowest mean number of dicots, and the lowest mean green biomass.

Table 1. Weed seed viability at different soil depths, mean results, Bridger PMC, Bridger, MT, 2010.

Soil Depth	Average Number of Monocots	Average Number of Dicots	Average Green Biomass
inches			*grams*
surface	168.2	1.3	8.8537
0 to 2	100.6	1.5	4.9148
6 to 12	6.7	0.1	0.7000
>12	1.6	0.1	0.2215

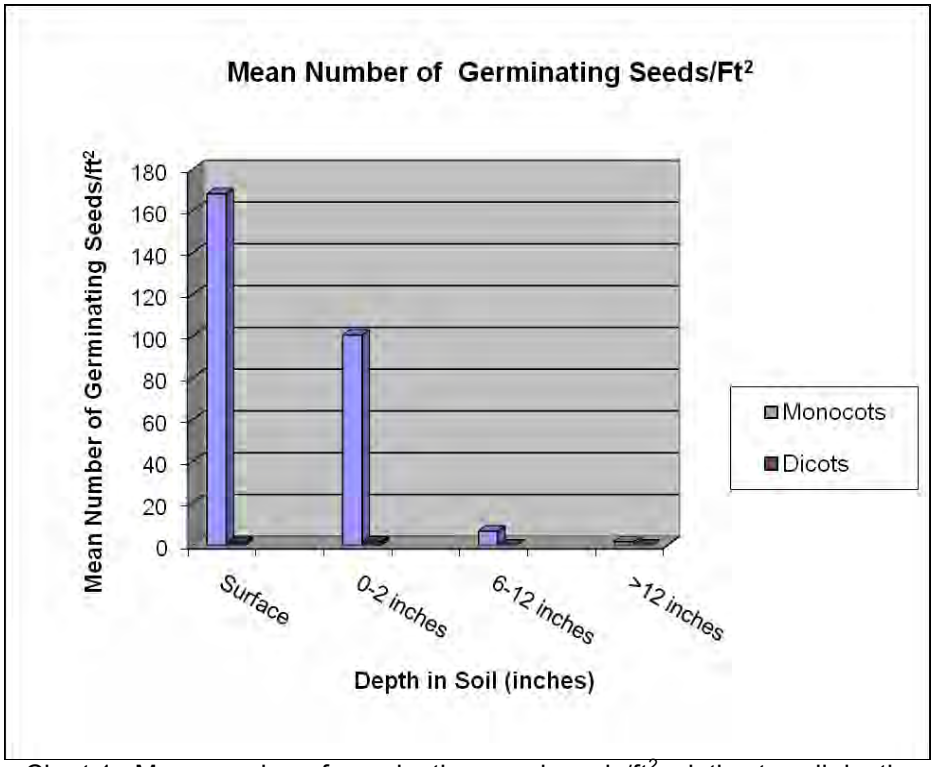


Chart 1. Mean number of germinating weed seeds/ft^2 relative to soil depth.

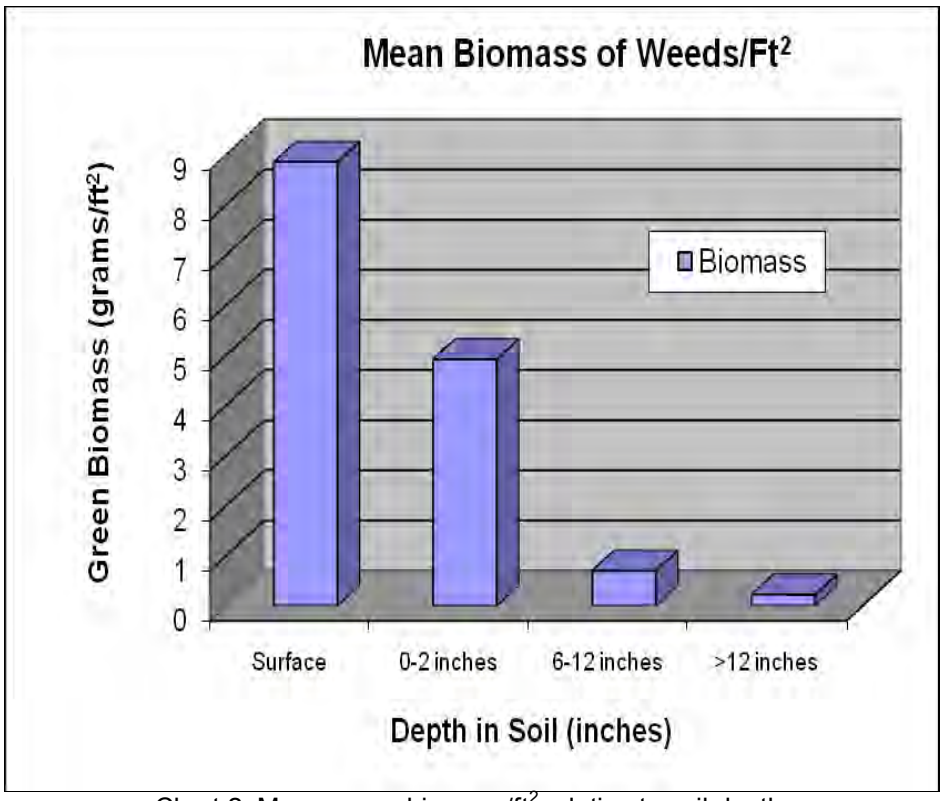


Chart 2. Mean green biomass/ft^2 relative to soil depth.

Conclusions: As anticipated, the greatest number of germinating seeds was found on the surface and shallow soil layers. The loss of seed viability with increasing depth reflects increasing age and other unfavorable conditions with increasing depth within the soil profile. High incidence of warm season annual grasses result from grass seed production systems where weedy grass control within grass crops is limited to hand removal and mechanical cultivation. The study did not consider dormant weed seed requiring one or more dormancy-breaking treatments, such as cold:moist chilling, and seeds were not screened from the soil and tested for viability utilizing non-germination techniques.

Appendix 1. Weed seed viability at different soil depths, raw evaluation data, Bridger, MT, 2010.

Site Number	Soil Depth	Rep	Total No. of Monocots	Total No. of Dicots	Total Green Biomass
	inches				*grams*
1	surface	I	132	4	5.66
1	surface	II	151	2	7.17
1	surface	III	156	3	10.81
1	0-2	I	25	0	0.00
1	0-2	II	31	0	0.23
1	0-2	III	101	0	0.03
1	6-12	I	10	0	0.52
1	6-12	II	11	0	0.51
1	6-12	III	24	0	0.34
1	>12	I	0	0	0.00
1	>12	II	0	0	0.00
1	>12	III	5	0	0.63
2	surface	I	21	0	1.03
2	surface	II	76	0	4.84
2	surface	III	71	1	3.01
2	0-2	I	142	0	5.66
2	0-2	II	84	0	5.33
2	0-2	III	86	0	7.16
2	6-12	I	9	0	0.23
2	6-12	II	6	0	0.21
2	6-12	III	1	0	0.00
2	>12	I	5	0	0.22
2	>12	II	5	1	0.44
2	>12	III	4	0	0.31
3	surface	I	254	3	23.74
3	surface	II	317	0	16.40
3	surface	III	329	0	17.87
3	0-2	I	15	0	0.07
3	0-2	II	29	1	4.87
3	0-2	III	130	1	28.17
3	6-12	I	1	0	0.04
3	6-12	II	0	0	0.00
3	6-12	III	13	2	4.21
3	>12	I	1	0	0.25
3	>12	II	0	0	0.00
3	>12	III	1	0	0.25
4	surface	I	257	1	7.60
4	surface	II	401	0	11.84
4	surface	III	277	0	10.07
4	0-2	I	165	1	2.32
4	0-2	II	263	0	3.36
4	0-2	III	257	2	2.83
4	6-12	I	6	0	0.23
4	6-12	II	2	0	0.36
4	6-12	III	3	0	1.35
4	>12	I	0	0	0.00
4	>12	II	0	0	0.00
4	>12	III	0	0	0.00
5	surface	I	15	1	1.72
5	surface	II	39	5	6.58
5	surface	III	27	0	4.48

Appendix 1. Weed seed viability at different soil depths, raw evaluation data, Bridger, MT, 2010.

Site Number	Soil Depth	Rep	Total No. of Monocots	Total No. of Dicots	Total Green Biomass
	inches				*grams*
5	0-2	I	54	8	1.93
5	0-2	II	70	5	3.66
5	0-2	III	57	5	8.11
5	6-12	I	4	0	0.53
5	6-12	II	5	0	0.73
5	6-12	III	5	0	1.25
5	>12	I	0	0	0.00
5	>12	II	3	0	1.22
5	>12	III	0	0	0.00

VIII. APPENDIX

THE
UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
WASHINGTON, D.C.

and

MONTANA AGRICULTURAL EXPERIMENT STATIONS
MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA
and
WYOMING AGRICULTURAL EXPERIMENT STATIONS
UNIVERSITY OF WYOMING
LARAMIE, WYOMING

in cooperation with the

DEER LODGE VALLEY CONSERVATION DISTRICT
DEER LODGE, MONTANA

NOTICE OF RELEASE OF MILL CREEK GERMPLASM SILVER BUFFALOBERRY SELECTED CLASS OF NATURAL GERMPLASM

The U.S. Department of Agriculture, Natural Resources Conservation Service-Bridger Plant Materials Center, Montana Agricultural Experiment Stations-Montana State University, and Wyoming Agricultural Experiment Stations-University of Wyoming in cooperation with the Deer Lodge Valley Conservation District, announce the Selected Class pre-varietal release of Mill Creek Germplasm silver buffaloberry *Shepherdia argentea* (Pursh) Nutt. for use in the intermountain foothills and mountains of Montana and Wyoming, with particular emphasis on areas characterized by soils with low pH and contamination by heavy metals. This release was evaluated and jointly selected by staff from the Deer Lodge Valley Conservation District and USDA/NRCS Plant Materials Center, Bridger, Montana.

As a pre-varietal release, this selection will be referred to as Mill Creek Germplasm silver buffaloberry, NRCS accession number 9081334.

Justification for alternative release is based on a critical need for well-adapted plant materials for non-amended, as well as lime-amended, acidic and heavy-metal contaminated sites in low- to mid-mountain elevations in the foothills of central Montana and Wyoming. A lack of tested and adapted germplasm and the potential use of non-adapted seed sources further support Selected Class release. Additionally, the selection originates from a northern Rocky Mountain seed source that should prove well-adapted to the conditions in the intended geographic area of use. Mill Creek Germplasm silver buffaloberry was selected for superior seedling survival, vigor rating, and mean height growth relative to other *Shepherdia argentea* accessions tested. Mill Creek Germplasm silver buffaloberry can also be used in other conservation applications such as saline reclamation, riparian and woody draw restoration, wildlife habitat enhancement, and mined land reclamation.

Collection Site Information: The original Mill Creek Germplasm silver buffaloberry (accession number 9081334) seed collection was made in September 1995 by Matthew Marsh, then DATC Project Leader, on the east side of "B" Hill near Radio Hill Road, south of Anaconda, Montana. The "B" Hill designation was described only for purposes of locating the seed collection site, and referred to a hill situated south of Anaconda, between two hills commonly referred to as "A" and "C" Hills. The area was contaminated with mine waste and smelter fallout and was severely impacted by surface wind and water erosion. Seed was collected from between two and six individual plants. The surface pH of the soil in this area ranges from 4.5 to 6.0, as reported in field data throughout Anaconda and nearby locations (Deer Lodge Valley Conservation District 2008, USDA-NRCS 1998).

Description: Silver buffaloberry, (Elaeagnaceae [Oleaster]) is a deciduous thorny, thicket-forming, long-lived woody perennial. It is a native shrub to small tree that is drought and winter hardy, with a mature height ranging from 91 to 610 meters (3 to 20 feet) (Laursen and Hunter 1986, Montana State 1990, Knudson 2006). The branches of silver buffaloberry often terminate in thorns, with silvery gray leaves both top and bottom, 2 to 5 centimeters (1 to 2 inches) in length (Booth and Wright 1959). Fruits are reddish, globe-shaped (drupes) 1/8 to 1/4 inch across. *Shepherdia argentea* is dioeceous, meaning male and female flowers are found on separate plants. The seed is a small, very-hard shiny-brown achene. This accession is a red-fruited variety, although *Shepherdia argentea* can produce orange berries (Herman 1996, Knudson 2006, Schopmeyer 1974, USDA-NRCS 2009). It is assumed Mill Creek Germplasm traits are heritable and the progeny from the selection will appear and perform in a similar manner as the species. Mill Creek Germplasm silver buffaloberry reached a mean plant height of 85 centimeters (33.5 inches) on a tilled and fertilized test site in a 355-millimeter (14-inch) annual precipitation zone 8 years after planting without supplemental irrigation. Plant height in the Bridger Plant Materials Center orchard averaged 200 to 300 centimeters (6.6 to 10 feet) in the fall of 2009. It appears this selection of silver buffaloberry has the same general botanical attributes as „Sakakawea', a Bismarck Plant Materials Center release of silver buffaloberry (seed source of Canadian origin) (USDA-SCS 1984, USDA-SCS 1985).

Method of Selection: Mill Creek Germplasm silver buffaloberry is being released as a „Natural–Track' germplasm, i.e., it has been selected and increased without purposeful manipulation. This selection was compared to two nonlocal sources of *Shepherdia argentea* in a Woody Comparative Evaluation Planting (CEP) installed near Anaconda, Montana, in the fall of 2000. The two nonlocal seed sources consisted of one Utah and one Sweetwater County, Wyoming, source. Both seed sources were reportedly from lands not impacted by mining activities. The goal of the Woody Comparative Evaluation Planting was to compare the performance of local, indigenous seed sources of woody plants to nonlocal sources of the same species. Numerous demonstration projects over the last 50 years have tested the performance of several woody plant species at the Anaconda Smelter Superfund Site. Species were identified with tolerance and/or adaptation to low soil pH and elevated heavy metals levels in woody plants. The Mill Creek CEP built on the former research to identify superior accessions within species that would handle the edaphic soil conditions, and provide erosion control and wildlife habitat. This study was part of a more comprehensive effort, the Development of Acid/Heavy-Metal Tolerant Cultivars (DATC) project, a collaborative effort between Deer Lodge Valley Conservation District and the Bridger Plant Materials Center in Bridger, Montana, initiated in 1995 and supported over various grant cycles by the Environmental Protection Agency, and Montana Natural Resource Damage Program (Deer Lodge Valley Conservation District 2008).

All three collections were field planted in 2000 at the Mill Creek site near Anaconda, Montana, tested and evaluated annually for 8 years from 2002 and 2009. Mill Creek Germplasm silver buffaloberry exhibited superior seedling survival, vigor rating, and mean plant height on a tilled but otherwise non-amended acidic/heavy-metal impacted site under the ambient climatic conditions of the Upper Clark Fork Watershed (Deer Lodge County, Montana). In addition, over 350 Mill Creek Germplasm silver buffaloberry seedlings were transplanted to Field 30 at the Plant Materials Center, Bridger, Montana, in order to create a seed orchard that could become a

Foundation seed supply. Mill Creek Germplasm silver buffaloberry has also performed well on soils classified as “Very Slightly Saline” and “Slightly Saline” by the USDA.

Testing: The 0.16-hectare (0.4-acre) Woody Comparative Evaluation Planting site, located approximately 6.4 kilometers (4 miles) southeast of Anaconda, Montana, has been impacted by emission fallout from the Upper and Lower Works, as well as the Washoe smelter. The Upper and Lower Works smelters were in operation from 1884 to 1902, after which the Washoe smelter assumed smelting operations until 1980. The study site lies approximately 183 meters (200 yards) east of Mill Creek at an elevation of 1,567 meters (5,140 feet) in USDA Winter Hardiness Zone 4a. Soils at the site are in the Haploboroll’s Family and consist of deep, well-drained soils formed in mixed alluvium composed of granitic, meta-sedimentary, and volcanic rocks. The alluvium is derived from the Mill Creek drainage. Cobbles and stones commonly occur on the soil surface. In 1999, the site was plowed to a depth of 15.25 centimeters (6 inches), rototilled, and packed. Laboratory analysis of four, 0- to 15.25-centimeter (0- to 6-inch) composite soil samples taken after tilling to 15.25 centimeters (6 inches) indicated an average pH of 4.53. Average arsenic, cadmium, copper, lead, and zinc concentrations in the four soil samples were 423 milligrams per kilogram (parts per million), 6 milligrams per kilogram, 510 milligrams per kilogram, 233 milligrams per kilogram, and 308 milligrams per kilogram, respectively (Table 1) (Deer Lodge Valley Conservation District 2008).

Table 1. Acid extractable heavy-metal levels (EPA method 3050) and pH of 0- to 6-inch composite soil samples taken from the Woody Comparative Evaluation Planting site.

Sample No.	pH	As	Cd	Cu	Pb	Zn
	s.u.	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
A.T. 0-6” NE	4.0	610	7	620	320	370
A.T. 0-6” NW	4.9	360	5	340	120	222
A.T. 0-6” SE	4.6	530	5	340	150	200
A.T. 0-6” SW	4.6	190	7	740	340	440
Mean:	4.53	422.5	6	510	232.5	308
Phytotoxic Criteria†	< 5.0	136-315	5.1-20	236-750	94-250	196-240

† EPA phytotoxicity standards (CDM Federal 1997).

The Mill Creek Germplasm silver buffaloberry orchard at the Bridger Plant Materials Center receives approximately 254 to 305 millimeters (10 to 12 inches) of average annual precipitation plus limited and infrequent supplemental irrigation during droughty periods of the growing season. The Plant Materials Center is located in south-central Montana at an elevation of 1,128 meters (3,700 feet) with soils classified as Heldt silty clay loam. The Heldt soil series is classified as a fine, montmorillonitic, mesic, Ustetric, Camborthid, on 4 to 8 percent slopes. The upper 46 centimeters (18 inches) of the profile are characterized as mildly alkaline, whereas the lower 46 to 152 centimeters (18 to 60 inches) are strongly alkaline. These soils are formed in deep alluvium and have moderate shrink-swell potential, but high frost-action potential. Although permeability is slow, these soils are well-drained and runoff is considered medium with only a slight risk of erosion. The mean annual soil temperature is 8.9 to 10.6^{o}C (48 to 51°F) and the frost-free period ranges from 120 to 130 days. This soil falls in Windbreak Suitability Group 1, and is characterized by deep, friable, nearly level to steep, well-drained soils on stream terraces and fans. Soils in this group are reported well suited for silver buffaloberry.

Methods and Materials: The study tested 19 accessions consisting of two or three accessions each of seven shrub/tree species (Table 2). The 1-0 and 2-0 seedlings were transplanted in a Randomized Complete Block Design replicated 20 times on October 18, 2000. An individual

plant of each accession is represented in each replication. The seedlings were spaced 1.4 meters (4.5 feet) apart within rows and 2.75 meters (9 feet) apart between rows. The plot received no supplemental irrigation. Vispore™ (0.9-meter x 0.9-meter; 3-feet x 3-feet) tree mats were installed the spring following planting on all entries to suppress weeds and retard soil moisture evaporation.

Table 2. Seed origin and elevation of entries in the Woody Comparative Evaluation Planting.

Family/Species	Seed Origin	Elevation
	county/state	*feet*
Caprifoliaceae:		
Symphoricarpos albus (L.) Blake	Deer Lodge Co., MT	6000
S. albus (L.) Blake	Ravalli Co., MT	3500
S. occidentalis Hook.	Deer Lodge Co., MT	5559
S. occidentalis Hook	CO Seed Source	unknown
S. occidentalis Hook	Weston Co., WY	5000
Elaeagnaceae:		
Mill Creek *Shepherdia argentea* (Pursh) Nutt.	Deer Lodge Co., MT	6000
S. argentea (Pursh) Nutt.	UT Seed Source	unknown
S. argentea (Pursh) Nutt.	Sweetwater Co., WY	6000
Grossulariaceae:		
Ribes cereum Dougl.	Deer Lodge Co., MT	5700
R. cereum Dougl.	Chaffee Co., CO	8000
Pinaceae:		
Pinus contorta Dougl. ex Loud.	Deer Lodge Co., MT	6400
P. contorta Dougl. ex Loud.	Albany Co., WY	9500
P. contorta Dougl. ex Loud.	Custer Co., ID	6300
Pinus ponderosa P. & C. Lawson	Deer Lodge Co., MT	5850
P. ponderosa P. & C. Lawson	Lawrence Co., SD	5500
P. ponderosa P. & C. Lawson	San Juan Co., CO	8000
Rosaceae:		
Rosa woodsii	Deer Lodge Co., MT	5168
R. woodsii	Ravalli Co., MT	3400
R. woodsii	Pueblo Co., CO	6000

Plant survival, height, and vigor were assessed in 2001 (May 21 and August 14), 2002 (May 20 and August 20), 2003 (May 28 and August 26), 2004 (June 30), 2005 (August 29), 2006 (August 28), 2007 (August 21), 2008 (August 24) and 2009 (September 7). Plant height was recorded in centimeters and measured from ground to uppermost live foliage. Vigor rating was measured on a scale of 1 to 9, with 1 representing excellent vigor and 9 representing plant mortality.

Results and Discussion:

Survival

Mean percentage survival of the Mill Creek Germplasm silver buffaloberry after 8 years of evaluation at the Woody Comparative Evaluation Planting was 55 percent, versus 10 percent for each of the other two silver buffaloberry accessions tested. Table 3 presents percentage survival data for each year between 2002 and 2009. In cases of increasing percentage survival over time, seedlings appearing dead at evaluation time produced a sucker or latent bud the following year. Environmental stresses from edaphic and climatic conditions resulted in decreasing survival for all species and seed sources tested over the course of the study. It should be noted the test site was exceptionally dry the year of establishment (9.57 inches), but subsequent years were near or above the long-term average (13.93 inches) (Table 4). Fluctuating annual precipitation did not appear to be a major factor in seedling survival.

Table 3. Mean percentage survival, Woody Comparative Evaluation Planting, 2002 through 2009, Anaconda, Montana.

Species & Seed Source	**2002 %**	**2003 %**	**2004 %**	**2005 %**	**2006 %**	**2007 %**	**2008 %**	**2009 %**
Pinus contorta 9078320	85	40	25	25	25	20	10	15
Pinus contorta m039ID0002	30	15	10	10	10	0	0	0
Pinus contorta m038WY0002	20	15	5	10	10	10	10	10
Pinus ponderosa 9081318	100	100	95	95	95	80	80	75
Pinus ponderosa m04CO0002	85	85	85	75	50	30	25	20
Pinus ponderosa m020SD9903	100	100	95	95	95	90	75	70
Ribes cereum 9081329	75	65	70	60	60	60	60	65
Ribes cereum m024CO0003	65	50	50	40	40	45	40	40
Rosa woodsii 9081638	75	65	65	55	50	50	50	50
Rosa woodsii m076CO0003	15	5	5	0	0	0	0	0
Rosa woodsii m07MT0003	20	10	15	10	10	10	10	10
Mill Creek Shepherdia argentea 9081334	80	80	80	75	75	70	65	55
Shepherdia argentea m022WY0005	60	35	30	35	20	15	15	10
Shepherdia argentea m015UT9901	25	20	10	10	10	10	10	10
Symphoricarpos albus 9078388	90	85	95	90	85	90	90	75
Symphoricarpos albus m045MT003	30	30	30	30	30	25	25	25
Symphoricarpos occidentalis 9081639	85	80	65	30	20	20	20	25
Symphoricarpos occidentalis m021WY0004	90	75	70	65	55	50	55	50
Symphoricarpos occidentalis m018CO9904	90	85	75	70	65	65	55	50

Table 4. Annual precipitation and mean percentage survival, of silver buffaloberry seed sources, Woody Comparative Evaluation Planting, 2000 through 2009, Anaconda, Montana.

Year	Annual Precipitation	Mill Creek Germplasm	Wyoming	Utah	All Sources Local	All Sources Non-Local
	inches	*%*	*%*	*%*	*%*	*%*
2000	9.57					
2001	13.99					
2002	16.23	80 (-20)[a]	60 (-40)	25 (-75)	84.3 (-15.7)	52.5 (-47.5)
2003	15.42	80 (0)	35 (-25)	20 (-5)	73.6 (-10.7)	43.8 (-8.7)
2004	13.37	80 (0)	(35) (0)	10 (-10)	70.7 (-2.9)	40.0 (-3.8)
2005	15.75	75 (-5)	35 (0)	10 (0)	61.4 (-9.3)	37.5 (-2.5)
2006	19.03	75 (0)	20 (-15)	10 (0)	58.6 (-2.8)	32.9 (-4.6)
2007	16.47	70 (-5)	15 (-5)	10 (0)	55.7 (-2.9)	29.2 (-3.7)
2008	16.89	65 (-5)	15 (0)	10 (0)	53.6 (-2.1)	26.7 (-2.5)
2009	18.79	55 (-10)	10 (-5)	10 (0)	51.4 (-2.2)	24.6 (-2.1)

[a] – Numbers in parentheses represent change in mean percentage survival from the previous year to the current year.

Plant Height and Growth

The mean height over time of surviving plants of silver buffaloberry appears in Table 5. Mill Creek Germplasm had the greatest mean height of the three seed sources tested each year for the 8-year evaluation period. By 2009, Mill Creek Germplasm silver buffaloberry had reached a mean height of 85.36 cm, a decrease from 2008 caused by deer browsing and breakage.

Table 5. Mean plant height of silver buffaloberry accessions, Woody Comparative Evaluation Planting, 2002 through 2009, Anaconda, Montana.

Seed Source	2002 Mean Height	2003 Mean Height	2004 Mean Height	2005 Mean Height	2006 Mean Height	2007 Mean Height	2008 Mean Height	2009 Mean Height
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
Mill Creek	**29.88**	**37.94**	**41.69**	**73.93**	**79.93**	**84.18**	**98.31**	**85.36**
m022WY0005	5.58	7.79	12.67	20.14	33.25	44.00	46.00	40.00
m015UT9901	9.20	13.25	15.00	31.50	24.00	38.10	57.50	67.00

Mill Creek Germplasm silver buffaloberry had the greatest mean annual height growth of the three seed sources tested in 2003 and 2005, as well as the greatest single season height growth in 2005 (Table 6). Mean annual height growth of Mill Creek was, however, less than one or both other accessions the remainder of the study. Annual growth was presumably the result of various factors including response to climatic conditions, animal predation, and plant mortality as it influenced the mean height of surviving test plants.

Table 6. Mean height growth of silver buffaloberry accessions, Woody Comparative Evaluation Planting, 2002 through 2009, Anaconda, Montana.

Seed Source	2002 Mean Growth	2003 Mean Growth	2004 Mean Growth	2005 Mean Growth	2006 Mean Growth	2007 Mean Growth	2008 Mean Growth	2009 Mean Growth
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
Mill Creek	**NA**	**8.06**	**3.75**	**32.24**	**6.00**	**4.25**	**14.13**	**-12.95**
m022WY0005	NA	2.21	4.88	7.47	13.11	10.75	2.00	-6.00
m015UT9901	NA	4.05	1.75	16.5	-7.5	14.1	19.4	9.5

Vigor Rating

The mean vigor rating of surviving plants was rated on a scale from 1 to 9 (1=most vigorous) based on a visual assessment of their vigor or robustness. Dead plants were entered as missing values. As seen in Table 7, Mill Creek Germplasm silver buffaloberry exhibited significantly better vigor than the other two silver buffaloberry accessions from 2002 through 2007. In 2008 and 2009, the vigor of two surviving Utah plants was relatively high (4.0), whereas the vigor of two surviving Wyoming plants remained substantially lower (6.5). Mill Creek Germplasm silver buffaloberry retained a relatively high vigor rating (4.91) in 2008 and 2009 when compared to all other species and accessions tested.

Table 7. Mean plant vigor rating, Woody Comparative Evaluation Planting. 2002 through 2009, Anaconda, Montana,

Species & Seed Source	2002 Vigor Rating (1-9)	2003 Vigor Rating (1-9)	2004 Vigor Rating (1-9)	2005 Vigor Rating (1-9)	2006 Vigor Rating (1-9)	2007 Vigor Rating (1-9)	2008 Vigor Rating (1-9)	2009 Vigor Rating (1-9)
Pinus contorta 9078320	5.80	5.10	6.50	7.60	7.40	7.25	5.5	5.67
P. contorta m039ID0002	5.00	5.00	7.00	8.00	8.00	0.00	0.00	0.00
P. contorta m038WY0002	4.00	4.50	5.50	6.00	6.50	7.50	7.00	7.00
Pinus ponderosa 9081318	2.10	3.40	5.63	5.74	5.84	5.94	5.63	5.47
P. ponderosa m04CO0002	4.20	4.80	7.29	8.00	7.90	8.67	7.40	7.00
P. ponderosa m020SD9903	3.20	2.70	4.84	5.26	5.37	4.67	4.53	4.14
Ribes cereum 9081329	4.80	2.80	3.86	3.25	3.42	3.58	3.25	4.08
R. cereum m024CO0003	5.40	5.10	5.90	5.38	5.13	5.78	4.50	5.00
R. woodsii 9081638	4.20	4.50	4.54	4.36	5.00	5.00	5.10	5.00
R. woodsii m076CO0003	7.00	7.00	8.00	0.00	0.00	0.00	0.00	0.00
R. woodsii m07MT0003	5.00	4.00	6.00	4.00	7.00	7.00	5.50	6.50
Shepherdia argentea Mill Creek	2.50	2.50	3.94	4.00	3.67	3.57	4.39	4.91
S. argentea m022WY0005	6.60	5.20	6.67	7.29	6.25	6.33	5.33	6.50
S. argentea m015UT9901	5.80	5.00	5.50	6.00	5.50	5.00	4.50	4.00
Symphoricarpos albus 9078388	3.60	4.00	4.53	5.67	6.24	6.28	6.33	7.13
S. albus m045MT003	3.60	3.00	4.17	4.83	4.83	3.60	3.80	4.80
Symphoricarpos occidentalis 9081639	4.60	5.20	6.85	6.50	6.00	4.75	5.00	6.20
S. occidentalis m021WY0004	3.80	2.80	4.57	4.39	4.09	4.00	4.18	3.90
S. occidentalis m018CO9904	4.00	4.50	4.80	5.36	5.39	4.85	5.36	5.60

Ecological Considerations and Evaluation: Mill Creek Germplasm silver buffaloberry is a native, drought- and winter-hardy shrub that prefers moist, well-drained soils. However, silver buffaloberry grows and survives well on dry sites, as noted in the literature and evidenced in Mill Creek's collection site in Anaconda (Montana State University 1990). It is tolerant of "Nonsaline" to "Slightly Saline" soils, and can be found in varied habitat, at elevations 4,000 to 6,900 feet, including stream sides, coulees, and on exposed moist hillsides (Knudson 2006, Hoag, Tilley, Darris and Pendergrass 2008). It suckers and forms thickets, but is not considered invasive. There is currently a strong preference and resultant demand in the restoration and reclamation communities for using local ecotypes. Mill Creek Germplasm silver buffaloberry passes the NRCS Plant Materials Program, Environmental Evaluation of Plant Materials Releases (attached) for potential invasiveness.

Anticipated Conservation Use: Mill Creek Germplasm silver buffaloberry has exhibited superior survival, height, and vigor rating on severely impacted mine land sites with acidic and heavy-metal containing soils (Deer Lodge Valley Conservation District 2008, Thornburg 1982). The selection has also performed well at the Bridger Plant Materials Center. The species is common in native landscapes across the northern Great Plains: Montana, North Dakota, South Dakota, Wyoming, Nebraska, and Minnesota. It is assumed Mill Creek Germplasm silver buffaloberry exhibits the same level of soil salinity tolerance as the species and selections from the species. In unpublished tests at the Bridger Plant Materials Center, Bridger, Montana, silver buffaloberry exhibited relatively good seedling survival, rates of height growth, and vigor rating when grown on soils classified as "Very Slightly Saline" (electrical conductivity values ranging from 2 to <4 dS/m) and some tolerance to soils classified as "Slightly Saline" (4 to <8 dS/m). Silver buffaloberry is tolerant of full sun and alkali soils (Hoag, Tilley, Darris and Pendergrass 2008).

Although silver buffaloberry is not considered a favored browse of livestock or wildlife, it can be heavily browsed when seedlings are young, and is frequently damaged from antler rubbing by deer.

Mill Creek Germplasm silver buffaloberry, like the species, can be used in a variety of conservation applications in addition to mine land reclamation including windbreaks, shelterbelts, riparian restoration projects, living snow fences, low maintenance landscapes, and wildlife enhancement plantings. Silver buffaloberry provides ideal cover and nesting sites for a variety of birds, and is a favored food for sharp-tailed grouse and songbirds. It provides browsing and shelter for large and small wildlife and is considered important browse for big game animals (Hansen, Pfister, Boggs, Cook, Joy and Hinkley 1995). With its low, dense stature, silver buffaloberry is well suited for outer rows of windbreaks and shelterbelts (Laursen and Hunter 1986). This species is reportedly capable of fixing nitrogen in root nodules containing bacteria, and therefore may be an important nitrogen source for other species in adjacent plantings or islands (USDA-SCS 1985). Silver buffaloberry provides excellent bank stabilization once established and, although it grows well on well-drained sites, can tolerate some period of saturated soil conditions. This species prefers full sun. Common diseases include branch canker and white heart rot on older plants, however pruning will prolong the life of the plants (Herman, Stange and Quam 1996, USDA-NRCS 2006, Montana State University 1990).

Anticipated Area of Adaptation: Mill Creek Germplasm silver buffaloberry originated as a wildland collection in the upper Clark Fork River basin of western Montana where a native population was found growing on soil impacted by acid and heavy-metal contamination, and where effects of wind and surface water erosion were widespread. The testing of this selection has been limited to the immediate area of its origin and the Bridger Plant Materials Center in south-central Montana where it has performed well. Mill Creek Germplasm silver buffaloberry appears best adapted to low- to mid-elevations ranging from 915 to 2,300 meters (3,000 to 7,500 feet). This selection should prove well adapted for use on many drastically disturbed acidic and heavy metal impacted areas of low- to mid-mountain elevations in the northern Rocky Mountain region, given other favorable environmental conditions. As a seed source found growing naturally in the northern Rocky Mountains, it is assumed this selection will perform well in other mountainous regions of the Intermountain West with similar environments and climates. Refer to Figure 1 (Addendum) for anticipated area of adaptation.

Seed Increase: A seed orchard of Mill Creek Germplasm silver buffaloberry was established at the Plant Materials Center, Bridger, Montana, in 2000. Wildland seeds were container grown and transplanted as 1-0 and 2-0 stock to create a seed production orchard. Mechanical and chemical cultivation is used to manage weeds and other competing vegetation in the orchard. Fruit production of Mill Creek Germplasm silver buffaloberry in Bridger, Montana, began in 2007, however, seed fill that year was negligible. Viable seed was harvested in 2008 and 2009, with production increasing significantly in 2009. Although ease of harvest and seed ripeness improve with time, the risk to losses from birds and deer also increases. Mill Creek Germplasm silver

buffaloberry averages between approximately 83,700 and 92,511 seeds per kilogram (38,000 and 42,000 seeds per pound). The Montana Conservation Seedling Nursery reports the average germination of silver buffaloberry as approximately 50 percent. Average date of harvest of Mill Creek Germplasm silver buffaloberry at the Plant Materials Center, in Bridger, Montana, ranges from late August through October each year. Ripe berries remain on the shrubs, and if not consumed by wildlife, may persist until spring (Bismarck Plant Guide, revised 2006). Hand picking of fruit is difficult due to the presence of thorns. An alternative and preferred collection method is to shake the limbs to cause the fruit to drop onto tarps. Harvested fruit is kept cool and moist until processing. The fruit is macerated in order to remove the seeds from the pulp.

Increase and Distribution: Generation G_1 (equivalent to Foundation) seed of Mill Creek Germplasm silver buffaloberry is available from the USDA-Natural Resources Conservation Service (NRCS), Plant Materials Center in Bridger, Montana, through the Foundation Seed Stocks Program at Montana State University-Bozeman or the University of Wyoming. Limited G_1 seed stock will be available in the spring of 2011. Commercial production of two generations (G_2 and G_3) beyond G_1 is allowed.

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Signatures for release of:
9081334 Germplasm Silver buffaloberry *Shepherdea argentea*

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Date

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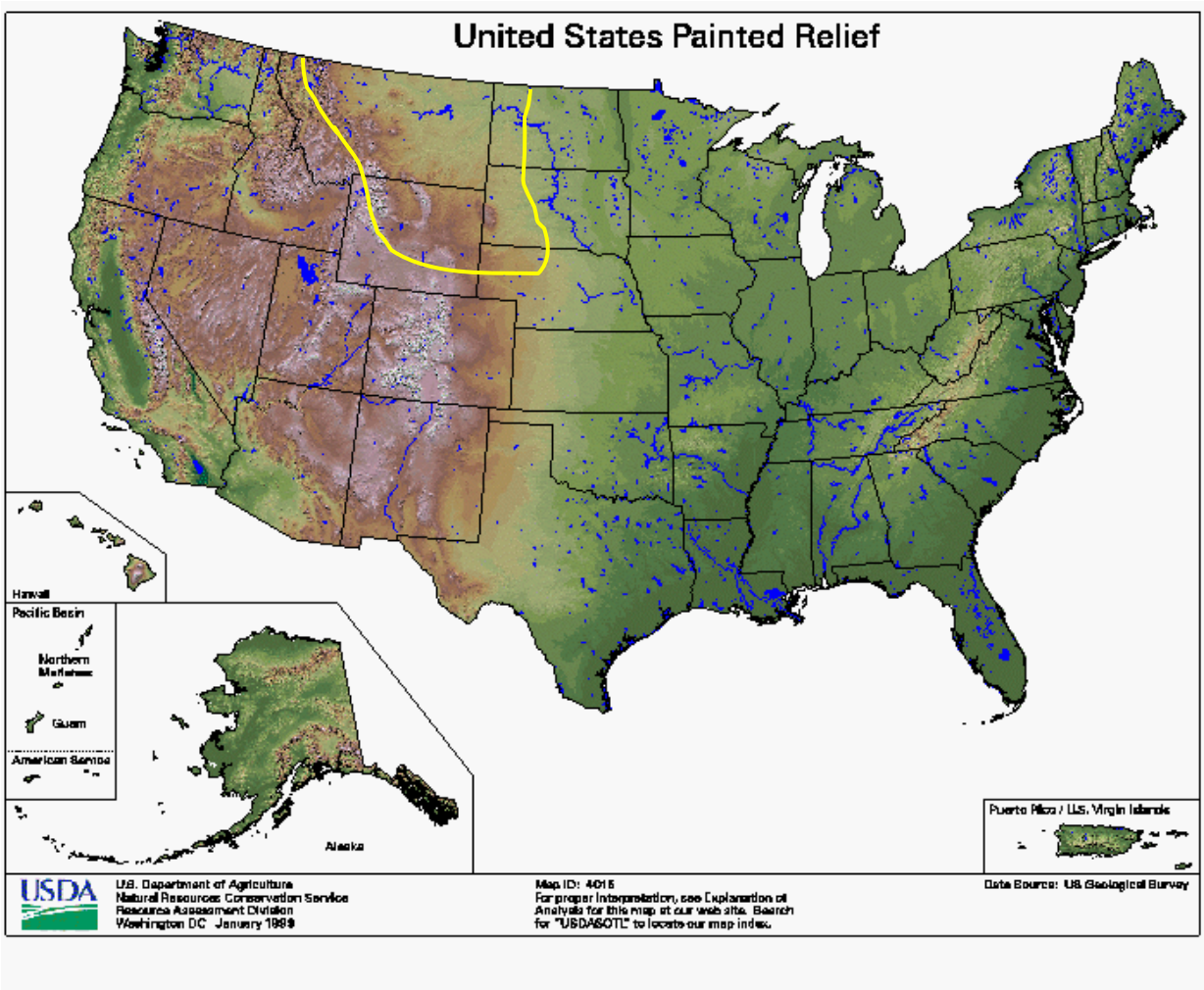

Figure 1. Anticipated area of adaptation of Mill Creek silver buffaloberry

Signatures for release of:
9081334 Germplasm Silver buffaloberry *Shepherdea argentea*

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