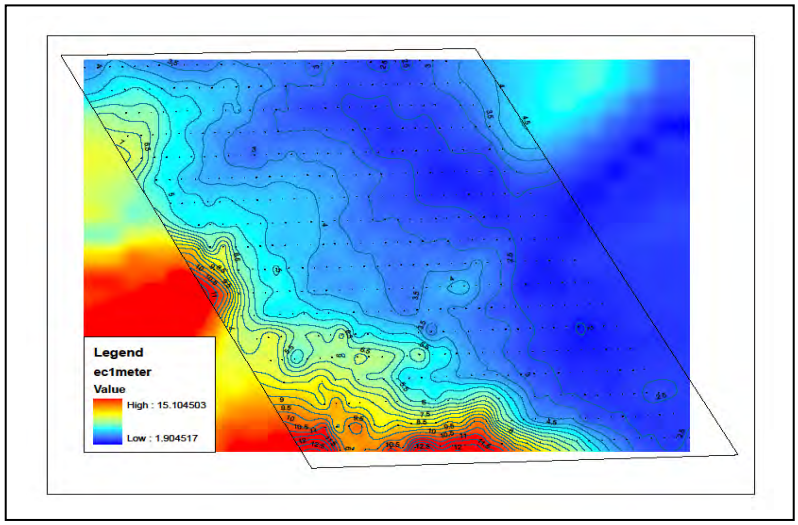


Bridger Plant Materials Center

2009 Annual Technical Report

United States
Department
Of Agriculture

Natural Resources
Conservation Service

Bridger Plant
Materials
Center
Bridger, Montana

August 2010

Helping People Help the Land

AN EQUAL OPPORTUNITY PROVIDER AND EMPLOYER

BRIDGER PLANT MATERIALS CENTER
2009

Advisory Committee

Joyce Swartzendruber, State Conservationist, Montana
Xavier Montoya, State Conservationist, Wyoming

Soil and Water Conservation Districts of Montana, Incorporated

Kenneth Borcher, Board Chairman, Wyoming
Pete Jachowski, Board Member, Wyoming
Walt Borntrager, Board Member, Montana
Shirley Parrott, Board Treasurer, Montana
Jerry Lunde, Board Member, Montana
Jean Hodges, Board Secretary

Resource Personnel

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

Plant Materials Center Cooperators

Bobbie Frank, Executive Director, Wyoming Association of Conservation Districts
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

Roger Hybner, Manager
Joseph Scianna, Horticulturist/Assistant Manager
Susan Winslow, Agronomist
Elizabeth Graham, Project Leader DATR
Darren Zentner, Farm Foreman
Ross Oyler, Biological Technician
Robert Fisher, Biological Technician
Marlene Kinney, Experience Works Assistant
Andrea Pierson, STEP Student

BRIDGER PLANT MATERIALS CENTER
2009 TECHNICAL REPORT

Correspondence to Plant Materials Center personnel may be addressed by name to:

Bridger Plant Materials Center
98 South River Road
Bridger, Montana 59014-9718
Phone: (406) 662-3579
FAX: (406) 662-3428

Correspondence to the Plant Materials Specialist may be addressed to:

Jim Jacobs
Plant Materials Specialist
Federal Building, Room 443
10 East Babcock Street
Bozeman, Montana 59715-4704
Phone: (406) 587-6995
FAX: (406) 587-6761

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.

Trade names are used solely to provide specific information. Mention of a trade name does not constitute a guarantee or endorsement by the U.S. Department of Agriculture, Natural Resources Conservation Service. No responsibility is assumed for chemical label changes. The user must check the label or contact company representatives for current restrictions.

The United States Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact the USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, 1400 independence Avenue, S.W., Washington, DC 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal employment opportunity provider and employer.

TABLE OF CONTENTS

Page No.

FOREWORD 6
TOURS, PRESENTATIONS, AND TRAINING 7
PUBLICATIONS 10
WEATHER 13
I. INITIAL EVALUATION PLANTINGS 15
PLANT MATERIALS COLLECTIONS 16
NATIVE FORBS TO REVEGETATE DISTURBANCES 19
BUR OAK SELECTION 22
II. INITIAL SEED INCREASE 61
INITIAL SEED INCREASE 62
III. SEED AND PLANT INCREASE 64
SEED PRODUCTION OF FOUNDATION SEED STOCKS 65
SEED DISTRIBUTION OF FOUNDATION SEED STOCKS 67
IV. COMPARATIVE EVALUATION PLANTINGS 69
MILL CREEK WOODY 70
STUCKY RIDGE 78
SCARLET GLOBEMALLOW 86
DRYLAND COOL-SEASON GRASSES FOR FORAGE 88
IRRIGATED COOL SEASON and ALTERNATE ROW FOR FORAGE 90
TALL WHEATGRASS FOR BIO-MASS 91
V. MANAGEMENT – CULTURAL – ESTABLISHMENT TRIALS 92
ALTERNATE ROW, COOL SEASON GRASSES AND ALFALFA 93
FIELD BINDWEED CONTROL IN WINTERFAT 94
XERISCAPE DEMONSTRATION 96
NEW CONSERVATION GRASSES 98
NEW CONSERVATION FORBS 101
SUB-IRRIGATION TUBES FOR SEMI-ARID ENVIRONMENTS 102
SALINITY TOLERANCE OF TREES AND SHRUBS 120
HERBICIDES FOR NATIVE WILDFLOWER SEED PRODUCTION 235
VI. COLLABORATIVE AND REIMBURSABLE PROJECTS 251
GLACIER NATIONAL PARK SUMMARY REPORT 252
YELLOWSTONE NATIONAL PARK SUMMARY REPORT 253
WYOMING BLM 255

TABLE OF CONTENTS – con't.

VII. PLANT MATERIALS SPECIALIST REPORT and OFF-SITE PLANTINGS and DEMONSTRATIONS …….. …… 259

REGISTER OF MONTANA HERBACEOUS FIELD PLANTINGS……. 261

REGISTER OF MONTANA WOODY FIELD PLANTINGS……. 262

REGISTER OF WYOMING HERBACEOUS FIELD PLANTINGS……. 263

REGISTER OF WYOMING WOODY FIELD PLANTINGS……. 263

REESTABLISHING GRASSES TO CHEATGRASS INFESTED RANGELAND 264

WELL-PAD RECLAMATION FIELD TRIALS…….. 265

SHELL-PINEDALE FIELD EVALUATION PLANTING…….. 267

VIII. GRADUATE PROJECTS

APRIL PEARCE 289

JESSICA WIESE..... 291

FOREWORD

The Bridger Plant Materials Center (PMC) is a federally operated faciltiy 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 conservation plant program 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 selection with the Agricultural Experiment Stations (Montana State University-Bozeman and University of Wyoming-Laramie), Montana Conservation Seedling Nursery-Missoula, United States Department of Interior-National Park Service (USDI-NPS) (Yellowstone, Glacier, and Craters of the Moon), the 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. 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 sites throughout Montana and Wyoming at conservation problem sites in cooperation with federal, state, and municipal agencies, and private individuals.

TOURS, PRESENTATIONS, AND TRAINING
Fiscal Year 2009

Date presented: 10/30/2008
Title: Revegetating Disturbance in the Pinedale Anticline
Presenter Winslow, S.R. **Location** University of Montana--Missoula

Date presented: 10/30/2008
Title: Ecological Approach to Plant Materials in the Nothern Rocky Mountains
Presenter Winslow, S.R. **Location** University of Montana--Missoula

Date presented: 11/18/2008
Title: Tree and Shrub Salinity Research
Presenter Scianna, J.D. **Location** Missoula, Montana

Date presented: 11/18/2008
Title: Plant Selection and Release for the Anaconda Superfund Site.
Presenter Graham, Elizabeth **Location** Missoula, MT

Date presented: 11/19/2008
Title: Bridger Plant Materials Center Program - 2008
Presenter Scianna, J.D. **Location** Missoula, Montana

Date presented: 11/19/2008
Title: Plant Selection and Release for the Anaconda, MT Superfund Site.
Presenter Graham, Elizabeth **Location** Missoula, MT

Date presented: 11/20/2008
Title: BPMC Update
Presenter Roger Hybner **Location** Gillette, WY

Date presented: 1/7/2009
Title: Biology and Mechanics of Transplanting Mature Trees
Presenter Scianna, J.D. **Location** Billings, MT

Date presented: 1/27/2009
Title: Horticultural Research and Projects at the BPMC.
Presenter Scianna, J.D. **Location** Bozeman, MT

Date presented: 2/21/2009
Title: Growing roses in your garden
Presenter Winslow, S.R. **Location** Bridger, MT

TOURS, PRESENTATIONS, AND TRAINING – con't.
Fiscal Year 2009

Date presented: 2/24/2009
Title: Bridger PMC 2008 Update
Presenter Winslow, S.R. **Location** Casper, WY

Date presented: 4/9/2009
Title: On The Wing: Plant Natives and They Will Come
Presenter Winslow, S.R. **Location** Billings, MT

Date presented: 4/17/2009
Title: The Road to Pre-Varietal Release
Presenter Winslow, S.R. **Location** Casper, WY

Date presented: 5/8/2009
Title: BPMC and WY BLM Cooperative Assistance
Presenter Scianna, J.D. and S.R. Winslow **Location** Bridger, PMC

Date presented: 5/11/2009
Title: PMC Seed Processing and Increase Activities
Presenter PMC Staff **Location** Bridger, MT

Date presented: 6/1/2009
Title: Comparative Evaluation of Grasses, Forbs and Seed Mixtures from "Local" Versus "Non-Local" Origins at (Stucky Ridge) Anaconda, MT
Presenter Roger Hybner **Location** Billings, MT

Date presented: 6/1/2009
Title: Selection and Release of Indigeneous Plant Materials for the Anaconda Smelter Superfund Site - 'Opportunity' Germplasm Nevada bluegrass
Presenter Graham, E.C. **Location** Billings, MT

Date presented: 6/1/2009
Title: Plant Materials Program in MT and WY
Presenter Winslow, S.R. and J.D. **Location** Bridger PMC

Date presented: 6/3/2009
Title: Effects of Sub-Irrigation Tubes and Cover Type on Woody Plant Establishment
Presenter Scianna, J.D. **Location** Billings, MT

Date presented: 6/3/2009
Title: Revegetation Trials in the Pinedale Anticline Project Area
Presenter Winslow, S.R. **Location** Billings, MT

TOURS, PRESENTATIONS, AND TRAINING – con't.
Fiscal Year 2009

Date presented: 6/23/2009
Title: Plant Materials Training
Presenter PMC Staff **Location** Bridger, Montana

Date presented: 7/14/2009
Title: Deer Lodge Valley CD Board of Directors DATR Project Overview
Presenter Elizabeth Graham **Location** Deer Lodge, Montana

Date presented: 8/12/2009
Title: Windbreak Technology Training
Presenter Scianna, J.D., Zentner, **Location** Bridger, Montana

Date presented: 8/31/2009
Title: PMC Program Overview and Tour for USFS
Presenter PMC Staff **Location** Bridger, Montana

PUBLICATIONS

Fiscal Year 2009

Zhang, Wang, Wang, Han, Mao, Majerus 2009. Plant Growth Regulator Effects on Balancing Vegetative and Reproductive Phases in Alfalfa Seed Yield. Agronomy Journal, September 101:1139-1145. 7p.

Zhang, Wang, Han, Wang, Mao, Majerus 2009. Effects of Between Row and Within Row Spacing on Alfalfa Seed Yields. Crop Science, 48:794-803.

Winslow, S.R., K.J. Clause, J.S. Jacobs, and R.M. Hybner 2009. Abstract--Revegetation Trials in the Pinedale Anticline Project Area. 26th Annual Meeting American Society of Mining and Reclamation, Lexington, KY. 11th Billings Land Reclamation Symposium. 1p.

Winslow, S.R., K.J. Clause, J.S. Jacobs, and R.M. Hybner 2009. Revegetation Trials in the Pinedale Anticline Project Area. Bridger PMC, Lexington, KY. June 2009. 35p.

Winslow, S.R. 2009. Critana Thickspike Wheatgrass--A Conservation Plant for Montana and Wyoming. Bridger, MT, Bozeman, MT. February 2009. 1p.

Winslow, S.R. 2009. IEP WY BLM 2009 Progress Report. Bridger PMC, Bridger, MT. FY 2009. 5p.

Winslow, S.R. 2009. Yellowstone National Park 2008 Annual Technical Report. Bridger PMC, Bridger, MT. 2008. 137p.

Winslow, S.R. 2009. Yellowstone National Park 2008 Summary Report. Bridger PMC, Bridger, MT. 2008. 1p.

Scianna, J.D; Graham; Kilian; Zentner and Hybner 2009. Effects of Sub-Irrigation Tubes and Cover Type on Woody Plant Establishment. ASMR-Billings Land Reclamation Symposium, Lexington, KY. 11th Annual 2009. 12p.

Scianna, J.D; Graham; Kilian; Zentner and Hybner 2009. Effects of Sub-Irrigation Tubes and Cover Type on Woody Plant Establishment. ASSMR-Billings Land Reclamation Symposium, Lexington, KY. 11th Annual. 1p.

Scianna, J.D.; Logar, R., Zentner, D. 2009. Notice of Release of Ekalaka Germplasm Bur Oak. Bridger PMC, Bridger, Montana. 2009. 38p.

Scianna, J.D. and R. Hybner 2009. Stretchberry *Forestiera pubescens*: A Shrub for Potential Conservation Applications in Montana and Wyoming. Bridger PMC, Bozeman, MT. 2009. 4p.

Scianna, J.D. 2009. Bur oak *Quercus macrocarpa* Michx.. Bridger PMC, PLANTS. 2009. 2p.

Scianna, J.D. 2009. Glacier National Park 2008 Annual Technical Report. Bridger, Montana, 2008. 179p.

Scianna, J.D. 2009. Glacier National Park 2008 Summary Report. Bridger PMC, Bridger, Montana. 2008. 1p.

Scianna, J.D. 2009. Warren Air Force Base 2008 Summary Report. Bridger PMC, Bridger, Montana. 2008. 3p.

Scianna, Graham, Kilian, Zentner, Hybner. 2009. Effects of Water Delivery Method and Herbaceous Competition on Seedling Survival, Height Growth, and Vigor Rating: Four-Year Summary Results. Bridger PMC, Bozeman, MT. 2009. 6p.

PUBLICATIONS – con't.

Fiscal Year 2009

PMC Staff 2009. Bridger PMC Year 2008 Progress Report of Activities. Bridger PMC, Bridger, MT. 2008.

PM Staff 2009. Plant Materials Today - Spring. Bridger PMC, Bridger, MT. Vol. 16, No. 2, April 2009. 3p.

PM Staff 2008. Plant Materials Today - Summer. Bridger PMC, Bridger, MT. Vol. 14, No. 3 - July 2008. 3p.

PM Staff 2009. Plant Materials Today -- Summer 2009. Bridger PMC, Bridger PMC. Vol. 16, No. 3, July 2009. 3p.

PM Staff 2008. Plant Materials Today--Fall 2008. Bridger PMC, Bridger, MT. Vol. 15, No. 4., October 2008. 2p.

PM Staff 2009. Plant Materials Today--January 2009. Bridger PMC, Bridger, MT. Vol. 16 No. 1. 5p.

Jones, T.A., S.D.Parr, S.R.Winslow, and M.A.Rosales 2009. Notice of Release of 'Continental' Basin Wildrye. Native Plants Journal, Vol. 10, No. 1, Spring 2009. 5p.

Hybner, R.; Graham, E.; Majerus, M.; and S. Majerus 2009. Comparative Evaluation of Grasses, Forbs and Seed Mixtures from "Local" versus "Non-Local" Origins at (Stucky Ridger) Anaconda, MT.. ASMR - Billings Land Reclamation Symposium, Lexington, KY. 11th Annual 2009. 12p.

Hybner, R.; Graham, E. Majerus, M. and S. Majerus 2009. Comparative Evaluation of Grasses, Forbs, and Seed Mixtures from "Local" versus "Non-Local" Origins at (Stucky Ridge) Anaconda, MT. ASRM - Billings Land Reclamation Symposium, Lexington, KY. 11th Annual 2009. 1p.

Graham, E.;S. Majerus; M. Majerus, Scianna and Hybner 2009. Selection and Release of Indigeneous Plant Materials for the Anaconda Superfund Site - 'Opportunity' Germplasm Nevada Bluegrass. ASRM - Billings Land Reclamation Symposium, Lexington, KY. 11th Annual 2009. 12p.

Graham, E.; S. Majerus; M. Majerus; Scianna and Hybner 2009. Selection and Release of Indigeneous Plant Materials for the Anaconda Superfund Site - 'Opportunity' Germplasm Nevada Bluegrass. ASMR - Billings Land Reclamation Symposium, Lexington, KY. 11th Annual 2009. 1p.

Elizabeth Graham, Joseph Scianna 2009. Opportunity Germplasm Selected Class Nevada bluegrass Brochure. Bridger PMC, Bozeman, Montana. February 2009. 1p.

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.

2009

Precipitation	
Annual Total	7.73 inches
Long-Term Average	11.96 inches
High Monthly Total (June)	1.89 inches
Low Monthly Total (November)	0.10 inches
Temperature	
Highest Daily Temperature (July 23)	99.4°F
Lowest Daily Temperature (December 8)	-18.7°F
Highest Monthly Max. Mean Temperature (July)	70.4°F
Lowest Monthly Max. Mean Temperature (December)	15.6°F

Table 1**.** Weather Data, 2009. 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	2009	Long-Term Mean	Departure from Mean	Number Days Ppt.	Avg. Wind Speed
						in.	*in.*	*in.*		*mph*
January	37.6	16.9	27.3	22.1	+5.2	0.18	0.51	-.33	4	6.6
February	42.2	20.6	31.4	27.5	+3.9	0.14	0.34	-.20	2	3.5
March	47.7	21.9	34.8	35.2	-0.4	0.64	0.75	-.11	8	4.8
April	56.3	31.5	43.9	43.8	+0.1	1.45	1.44	+.01	11	2.2
May	73.5	40.4	56.9	53.3	+3.6	0.45	2.19	-1.74	6	2.5
June	75.3	47.3	61.3	62.1	-0.8	1.89	1.90	-.01	15	1.4
July	87.0	53.7	70.4	69.9	+0.5	0.87	0.75	+.12	10	1.0
August	85.4	54.3	69.9	67.5	+2.4	0.65	0.81	-.16	9	1.3
September	83.3	47	65.2	57.8	+7.4	0.39	1.25	-.86	8	1.6
October	50.8	30.9	40.9	46.4	-5.5	0.76	1.15	-.39	9	3.3
November	52.7	26.9	39.8	33.2	+6.6	0.10	0.49	-.39	2	6.9
December	26.3	4.8	15.6	24.7	-9.1	0.21	0.40	-.19	4	4.7
Yearly Total						7.73	11.96	-4.25	88	
Monthly Mean	59.8	33.0	46.45	45.3	1.16					3.3

† Growing Season 28°F: 166 days, April 25 to October 9.
High Temperature: 99.4°F July 23 (Record High: 110°F).
Low Temperature: -18.7°F December 8 (Record Low: -38°F on December 24, 1983).

I. INITIAL EVALUATION PLANTINGS (IEPs)

Study Title: Initial Evaluation Planting—Plant Materials Collections

Objective: Solicit seed collections of native plants identified in the PMC's Long-Range Plan as suitable candidates to solve conservation problems.

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 2009, the Center received 29 seed collections from offices in Montana totaling 0.984 kilograms (Table 1). Individuals from 18 counties contributed seed collections. There were 19 Wyoming seed collections received from 10 counties totaling 0.225 kilograms (Table 2).

Table 1. Initial Evaluation Planting. The 2009 Montana seed collections.

Accession	Genus and Species	Date Collected	County	Collector	Amount
					kg
Grasses					
9088104	*Festuca scabrella*	7/10/09	Lake, MT	Lujan, W.	0.004
9088105	*Pseudoroegneria spicata* ssp. *spicata*	7/8/09	Sanders, MT	Feist, D.	0.009
9088106	*P. spicata* ssp. *spicata*	7/9/09	Missoula, MT	Jacobs, J.	0.010
9088107	*P. spicata* ssp. *spicata*	7/10/09	Lake, MT	Lujan, W.	0.054
9088108	*P. spicata* ssp. *spicata*	7/15/09	Carbon, MT	Winslow, S. and J. Jacobs	0.039
9088109	*P. spicata* ssp. *spicata*	7/21/09	Rosebud, MT	Kilian, R., P. Hagemeister, R. Simeniuk, and K. Wickey	0.031
9088110	*P. spicata* ssp. *spicata*	7/21/09	Gallatin, MT	Ricketts, M. and B. Woodson	0.001
9088111	*P. spicata* ssp. *spicata*	7/22/09	Carbon, MT	Majerus, M.	0.526
9088112	*P. spicata* ssp. *spicata*	7/23/09	Prairie, MT	Kilian, R. and R. Simeniuk	0.014
9088113	*P. spicata* ssp. *spicata*	8/3/09	Ravalli, MT	Jacobs, J.	0.008
9088114	*P. spicata* ssp. *spicata*	8/4/09	Meagher, MT	Woodward, J.	0.004
9088115	*P. spicata* ssp. *spicata*	8/5/09	Big Horn, MT	Winslow, S.	0.070
9088116	*P. spicata* ssp. *spicata*	8/11/09	Musselshell, MT	Ricketts, M. and D. Pratt	0.010
9088117	*P. spicata* ssp. *spicata*	8/12/09	Madison, MT	Jacobs, J.	0.015
9088118	*P. spicata* ssp. *spicata*	8/12/09	Madison, MT	Jacobs, J.	0.006
9088119	*P. spicata* ssp. *spicata*	9/14/09	Wibaux, MT	Merriman, C.	0.002
Subtotal:	2 species	14 days	14 counties	15 collectors	0.803 kg
Legumes					
9088120	*Astragalus crassicarpus*	7/17/09	Gallatin, MT	Ricketts, M. and E. Suffridge	0.005
-	*Pediomelum argophylla*	9/2/09	Fallon, MT	Kilian, R.	No fill
-	*P. argophylla*	9/23/09	Treasure, MT	Gorder, M. and R. Kilian	No fill
9088121	*Thermopsis rhombifolia*	6/23/09	Rosebud, MT	Kilian, R. and R. Simeniuk	0.096
9088122	*T. rhombifolia*	8/11/09	Musselshell, MT	Ricketts, M. and D. Pratt	0.048
Subtotal:	3 species	5 days	5 counties	6 collectors	0.149 kg
Forbs					
9088123	*Agastache urticifolia*	8/11/09	Gallatin, MT	Husby, P.	Trace
9088124	*Agoseris glauca*	6/13/09	Carbon, MT	Winslow, S.	0.006
9088125	*Lomatium triternatum*	6/25/08	Sanders, MT	Jacobs, J.	0.012
9088126	*Penstemon laricifolius* ssp. *laricifolius*	8/5/09	Carbon, MT	Winslow, S. and J. Jacobs	0.003
9088127	*P. laricifolius* ssp. *laricifolius*	8/5/09	Big Horn, MT	Winslow, S.	0.007
9088128	*P. laricifolius* ssp. *laricifolius*	9/27/09	Carbon, MT	Winslow, S.	0.002
Subtotal:	4 species	5 days	4 counties	4 collectors	0.030
Shrub					
9088145	*Artemisia* sp.	2009	Custer, MT	Muscha, J.	Trace
9088129	*Artemisia tridentata wyomingensis*	11/6/09	Petroleum, MT	Rife, N.	0.002
Subtotal:	2 species	2 days	2 counties	2 collectors	0.002 kg
2009 Montana Totals:					
29 collections	11 species	23 days	18 counties	19 collectors	0.984 kg

Table 2. Initial Evaluation Planting. The 2009 Wyoming seed collections.

Accession	Genus and Species	Date Collected	County	Collector	Amount
					kg
Grasses					
9088130	*Pseudoroegneria.spicata* ssp. *spicata*	7/30/09	Hot Springs, WY	Winslow, S. and J. Jacobs	0.014
9088131	*P. spicata* ssp. *spicata*	8/3/09	Johnson, WY	Murray, R., P. Gonzales, and B. Rapp	0.009
9088132	*P. spicata* ssp. *spicata*	8/3/09	Johnson, WY	Murray, R., P. Gonzales	0.001
9088140	*P. spicata* ssp. *spicata*	7/22/09	Carbon, WY	O'Leary, E. and S. Paavola	0.002
9088141	*P. spicata* ssp. *spicata*	8/26/09	Carbon, WY	O'Leary, E. and S. Paavola	0.002
-	*P. spicata* ssp. *spicata*	8/19/09	Hot Springs, WY	Haverkamp, J. and S. Poitras	No fill
-	*P. spicata* ssp. *spicata*	8/19/09	Hot Springs, WY	Haverkamp, J. and S. Poitras	No fill
-	*P. spicata* ssp. *spicata*	9/22/09	Sublette, WY	Clause, K.	No fill
Subtotal:	1 species	6 days	4 counties	10 collectors	0.028 kg
Legumes					
-	*Astragalus convallarius*	7/16/09	Uinta, WY	Clause, K. and E. Watson	No fill
9088133	*Thermopsis rhombifolia*	7/29/09	Park, WY	Gullion, R.	0.147
9088142	*Thermopsis rhombifolia*	8/12/09	Carbon, WY	O'Leary, E. and S. Paavola	0.006
9088143	*Thermopsis rhombifolia*	8/5/09	Carbon, WY	O'Leary, E. and S. Paavola	0.008
Subtotal:	2 species	4 days	3 counties	5 collectors	0.161 kg
Forbs					
9088144	*Agoseris glauca*	6/15/09	Carbon, WY	O'Leary, E. and S. Paavola	0.001
9088005	*Penstemon* sp.	7/31/09	Sweetwater, WY	Biasotti, V.	0.020
9088134	*Penstemon laricifolius* ssp. *laricifolius*	7/30/09	Hot Springs, WY	Winslow, S. and J. Jacobs	0.005
9088135	*P. laricifolius* ssp. *laricifolius*	7/30/09	Fremont, WY	Winslow, S. and J. Jacobs	0.001
9088136	*P. laricifolius ssp. laricifolius*	9/4/09	Sublette, WY	Clause, K.	0.006
9088137	*P. laricifolius* ssp. *laricifolius*	9/30/09	Carbon, WY	Evans, M.	0.001
9088138	*Sphaeralcea coccinea*	7/29/09	Park, WY	Gullion, R.	0.002
Subtotal:	4 species	6 days	6 counties	8 collectors	0.036 kg
2009 Wyoming Totals:					
19 collections	7 species	14 days	10 counties	14 collectors	0.225 kg

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. A study plan was developed and approved to continue evaluation of native herbaceous species (Appendix Table 1).

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. 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 (Figure 1). 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. On April 22, 2009, five late-arriving entries were seeded at the end of the ninth row in plots 26 and 27, and the first three plots in the tenth row. The study area is approximately 0.41 acre.

Results*:* Plots were evaluated for plant density, height, floral phenology, and seed production characteristics. Seedling emergence was variable with 35 legume and 23 forb entries established in the study (Table 1). The best overall performers were *Thermopsis rhombifolia* (9087509), *Vicia americana* (9087855), *Allium* (9087538), *Helianthella uniflora* (9087804), *Penstemon nitidus* (9087512), and *Phacelia hastata* (9087513). The study is anticipated to remain active until 2012.

Table 1. Initial Evaluation Planting, evaluation of 83 accessions of native legumes and forbs, 2009, Bridger, MT.

Row-Position-Length†	Accession	Genus and Species	Density No. plants	Height	Comments
				cm	
East-West, Row 1		**Legumes**			
1-1	9087816	*Astragalus*	0		
1-2-2.4 ft	9087817	*Astragalus agrestis*	0		
1-3	9087741	*Astragalus bisulcatus*	4	18	first count May 28
1-4	9087818	*A. bisulcatus*	34	15	
1-5	9087401	*Astragalus canadensis*	0		
1-6	9063357	*Astragalus crassicarpus*	1	7	
1-7	9081970	*A. crassicarpus*	6	9	
1-8	9087505	*A. crassicarpus*	2	7	
1-9-2 ft	9087536	*A. crassicarpus*	0		
1-10	9087819	*A. crassicarpus*	5	12	
1-11	9087820	*Astragalus douglasii*	1	12	
1-12	9087821	*Astragalus flexuosus*	1	6	
1-13	9078644	*Thermopsis rhombifolia*	13	21	
1-14	9082253	*T. rhombifolia*	17	15	
1-15	9082291	*T. rhombifolia*	0		
1-16	9082292	*T. rhombifolia*	21	17	
1-17	9087509	*T. rhombifolia*	25	16	
1-18	9087535	*T. rhombifolia*	16	25	
1-19	9087841	*T. rhombifolia*	15	13	
West-East, Row 2	-	-			
2-1	9087842	*T. rhombifolia*	18	13	
2-2	9087843	*T. rhombifolia*	11	20	
2-3	9087844	*T. rhombifolia*	1	20	
2-4	9087845	*T. rhombifolia*	5	21	
2-5	9087846	*T. rhombifolia*	6	13	
2-6-6.7 ft	9087847	*T. rhombifolia*	1	12	
2-7-3.8 ft	9087848	*T. rhombifolia*	3	16	
2-8-13.8 ft	9087849	*T. rhombifolia*	3	15	
2-9	9087869	*T. rhombifolia*	5	13	
2-10	9087870	*T. rhombifolia*	8	17	
2-11	9087871	*T. rhombifolia*	16	19	
2-12	9087523	*Trifolium gymnocarpum*	0		
2-13-1 ft	9087525	*T. gymnocarpum*	0		
2-14	9087397	*Vicia americana*	4	8	
2-15	9087399	*V. americana*	15	10	
2-16-10 ft	9087537	*V. americana*	3	9	
2-17	9087851	*V. americana*	21	10	
2-18-7.5 ft	9087852	*V. americana*	18	12	
2-19	9087853	*V. americana*	11	11	
2-20	9087854	*V. americana*	25	12	
East-West, Row 3		-			
3-1	9087855	*Vicia americana*	69	13	
3-2	9087856	*Vicia* spp.	0		first count April 21
3-3	9087857	*V. americana*	29	12	
3-4-1.6 ft	9087858	*V. americana*	0		
3-5-10 ft	9087872	*V. americana*	8	10	

Table 1. Initial Evaluation Planting, evaluation of 83 accessions of native legumes and forbs, 2009. -cont'd.

Row-Position-Length†	Accession	Genus and Species	Density No. plants	Height	Comments
				cm	
-	-				
		Forbs			
3-6	9087527	*Agoseris glauca*	2	3	
3-7-6 ft	9087733	*A. glauca*	2	2	
3-8	9087734	*A. glauca*	2	2	
3-9	9087416	*A. textile*	30	5	
3-10-9 ft	9087538	*Allium* spp.	63	5	
3-11	9087822	*Castilleja sessiliflora*	0		
3-12-12 ft	9087873	*Echinacea angustifolia*	0		
3-13	9087874	*Helianthella uniflora*	68	9	
3-14	9058079	*Liatris punctata*	3	4	
3-15	9076006	*L. punctata*	8	6	
3-16	9082127	*L. punctata*	0		
3-17	9087575	*L. punctata*	0		
3-18	9087576	*L. punctata*	0		
3-19	9087577	*L. punctata*	0		
West-East, Row 4	-	-			
4-1	9087823	*Lomatium macrocarpum*	0		
4-2	9087824	*Lomatium dissectum*	0		
4-3	9087831	*Penstemon* spp.	12	5	
4-4	9087510	*Penstemon eriantherus*	27	4	
4-5	9087511	*P. eriantherus*	9	5	
4-6	9087529	*P. eriantherus*	15	4	
44-7	9087875	*P. eriantherus*	30	4	
4-8	9087876	*P. eriantherus*	3	4	
4-9	9087832	*Penstemon grandiflorus*	3	7	
4-10	9087512	*Penstemon nitidus*	39	7	
4-11	9082252	*Perideridia gairdnerii*	0		
4-12	9087513	*Phacelia hastata*	100	12	sdhd 16 cm
4-13	9087514	*P. hastata*	75	15	sdhd 26 cm
4-14	9087530	*P. hastata*	85	11	sdhd 25 cm
4-15	9087531	*P. hastata*	25	13	sdhd 22 cm
4-16	9087532	*P. hastata*	40	16	sdhd 23 cm
4-17	9087833	*P. hastata*	45	18	sdhd 25 cm
4-18	9087515	*Platyschkuhria integrifolia*	1	10	sdhd 28 cm
East-West, Row 5	-	-			
5-1	9087744	*Pulsatilla occidentalis*	0		
5-2	9087850	*Tradescantia* spp.	0		
5-3-6 ft	9087570	*Sphaeralcea coccinea*	0		
Move to Row 9 Plot 26	-	-			
Cont East-West Forbs	-	-			
R9P26	9087999	*Allium*	0		
R9P27	9088000	*Allium acuminatus*	0		
West-East, Row 10					
R10P1	9088001	*Allium textile*	0		
R10P2	9088003	*Lomatium foeniculaceum*	0		
R10P3	9088004	*Thelypodium*	0		

Study Title: Bur Oak Provenance Study

Study Number: MT-94-0011

Objective: To select superior seed sources of bur oak for use in windbreaks and shelterbelts in Montana and Wyoming.

Project Description: For project description and history, reference the attached final release notice for Ekalaka Germplasm bur oak.

Results: For project results, reference the attached final release notice for Ekalaka Germplasm bur oak.

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

NOTICE OF RELEASE OF EKALAKA GERMPLASM BUR OAK 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, announce the Selected Class pre-varietal release of Ekalaka Germplasm bur oak *Quercus macrocarpa* Michx. for the northern Great Plains and valleys of the Intermountain West. This selection was evaluated and selected by the staff from the USDA-NRCS Plant Materials Center, Bridger, Montana.

As a Selected Class release, this selection will be referred to as Ekalaka Germplasm bur oak, NRCS accession number 9087732.

Justification for alternative release is based on a critical need for well-adapted plant materials for windbreaks, shelterbelts, riparian forest buffers, and wildlife plantings in the northern Great Plains and Intermountain West. In addition, the emergence of the emerald ash borer *Agrilus planipennis* will create an urgent demand for medium-stature deciduous trees to replace green ash *Fraxinus pennsylvanica* Marsh in numerous conservation practices. Discontinuation of Russian olive *Elaeagnus angustifolia* as a conservation species, as well as its removal and control from existing plantings and habitats, will create a need for well-adapted alternatives. A lack of tested and adapted germplasm and the potential use of nonadapted seed sources further support Selected Class release. Given this selection originates from a bulk of several northern Great Plains seed sources, it should prove well adapted to the conditions in the intended geographic area of use. Ekalaka Germplasm bur oak was selected for superior seedling survival, rate of height growth, and vigor rating, relative to other bur oak individual trees and seed sources tested. Ekalaka Germplasm bur oak can also be used in other conservation applications such as reforestation, Xeriscaping®, and woody draw restoration.

Collection Site/Seed Source Information: The original Ekalaka Germplasm bur oak (accession number 9087732) seed collections were made in various locations across the Great Plains (see Table 1). In 1991, the Bridger PMC

entered into a cooperative bur oak study initiated by the GP-13 Improved Trees Task Force and organized by W. R. Schroeder of the Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Centre at Indian Head, Saskatchewan, and Richard Cunningham of the ARS-Northern Great Plains Research Lab at Mandan, North Dakota. The goals of the study include the following:

Table 1. Bur oak seed source origin, Bridger PMC, Bridger, MT.

Accession Number	Seed Source Identification	County of Origin	State
9076042	103	McKenzie	ND
9076043	106	Griggs	ND
9076044	111	Burleigh	ND
9076045	112	Pennington	SD
9076046	122	Bottineau	ND
9076047	128	Oliver	ND
9076048	139	Dunn	ND
9076049	142	Carter	MT
9076050	151	Emmons	ND
9076051	209	Bottineau	ND
9076052	211	Stark	ND
9076053	218	Oliver	ND
9076054	219	McKenzie	ND
9076055	226	Burleigh	ND
9076056	227	Burleigh	ND
9076057	228	Sioux	ND
9076058	236	Morton	ND
9076059	237	Morton	ND
9076060	250	Emmons	ND
9076061	Tree A	Carter	MT
9076062	ETTII	Carter	MT
9076063	Tree B	Carter	MT
9076064	144	Carter	MT
9076065	Tree 3	Carter	MT

1. To identify the nature and extent of genetic variation among selected sources of bur oak,

2. To provide genetically improved bur oak seed for shelterbelt plantings, and

3. To provide germplasm for selection and trait improvement research and advanced generation breeding.

In conjunction with the GP-13 goals, the MITOSIS (Montana Interagency Tree and/or Shrub Improvement Study) program seeks to improve the quality and diversity of the nursery stock produced by the Montana Conservation Seedling Nursery for windbreak and shelterbelt applications. After data was collected for the GP-13 study, selections of individual trees and families with superior traits were retained and used to establish a foundation seed orchard for the production of superior germplasm for release to cooperating agencies and the commercial nursery industry.

Wildland bur oak seed collections were made in 1991 and 1992 from individual trees demonstrating superior phenotypic characteristics. These characteristics included single, straight stems with strong apical dominance, well-formed crowns, at least 30 years of age, and the production of abundant crops of sound acorns. Acorns were shipped to study cooperators in 1992 and 1993 for propagation.

Propagation of test plants for this study began in late fall of 1991 when five Montana sources were collected and sown in the greenhouse at the PMC. These collections were not all original GP-13 test accessions, but were included in the Bridger planting in order to generate more information about the performance of Montana sources of bur oak. On February 25, 1992, the Bridger PMC received 468 acorns representing 16 additional accessions collected from sites in Montana, North Dakota, Oklahoma, and South Dakota.

On February 3, 1993, the Bridger PMC received a second shipment of 300 acorns, representing 10 additional accessions. These accessions were from different trees in the same counties as those received in 1992. All counties represented in the second group of collections were also represented in the first group.

Description: Bur oak or mossycup oak is a medium- to tall-stature deciduous tree widely distributed across the US and native to limited areas in Montana and Wyoming. The bur oak has several desirable attributes including strong branches, drought tolerance, winter hardiness, and freedom from serious insect or disease problems. Acceptance of bur oak for use in windbreaks and shelterbelts has been limited due to a reputation for slow growth and a multi-stemmed habit of seed sources at the western edge of its natural range. The goal of this study was to assemble, evaluate, select, and release a population of bur oak demonstrating superior seedling survival, sustained rate of adequate height growth, superior overall plant vigor rating, as well as good overall form.

Bur oak is a hardy, drought-tolerant tree capable of growing over a wide range of soil conditions. A combination of high water use efficiency and a fast growing tap root enable this species to withstand the dry, windy conditions characteristic of the northern plains. Bur oak has a large, native range extending from Nova Scotia, west to Manitoba, south through Kansas to Texas, east to Alabama, and northeast to Virginia and New England. In Montana, it occurs only in Carter County (which is in the extreme southeastern corner of the state) in uncultivated, natural stands. Landscape specimens can be found in many Montana communities over much of the state. Most references list bur oak as hardy in USDA Winter Hardiness Zones 4 to 8, although Zone 2 is given in at least one source. Bur oak is considered only moderately shade tolerant.

Although it favors rich alluvial bottomland, bur oak can grow well on rocky hillsides, limestone soils, droughty soils, clayey sites, and other marginal locations -- given full sun conditions. This species even performed better than most others tested on coal-mine spoils of pH 5.6 in eastern Kansas. In the western United States bur oak is considered a pioneer species and is capable of invading prairie grasslands. In the eastern Great Plains it occurs primarily along stream bottoms and stream terraces in association with green ash (*Fraxinus pennsylvanica*), boxelder (*Acer negundo*), and cottonwood (*Populus sp.*). Bur oak is, however, intolerant of flooding.

On good sites, bur oak has a spreading habit with a broad crown; massive bole; and low, large branches. It is capable of reaching heights of 25 to 28 meters (82.0 to 91.9 ft.), and individual trees up to 30.5 meters (100 ft.) are common on good sites. An individual tree with a height of 51 meters (170 ft.) and a d.b.h. (diameter breast high) of 213 centimeters (84 inches) has been reported in the lower Ohio Valley. In Montana, heights of 15 meters (49.2 ft.) can be considered about the upper limits of growth.

Although bur oak is monoecious, with both male and female flowers on the same plant, cross pollination between individual trees appears to be favored. Acorns ripen in 1 year and can fall as early as August or as late as November depending on the tree and location. Acorns can usually germinate immediately without pretreatment, but may require some cold stratification when collected from sources in northern climates. The average minimum seed-bearing age of forest trees is approximately 35 years with best production typically between 75 to 150 years. Good crops usually occur every 2 to 3 years. It may be necessary to check seed-bearing trees regularly in order to assure harvesting the acorns before the wildlife do.

Serious insect and disease problems are relatively limited for bur oak in the western United States. Reported insect problems include oak webworm, oak skeletonizer, leaf miner, variable oakleaf caterpillar, oak lacebug, and June beetles. Oak lacebug can be a serious problem in shelterbelt plantings, especially during drought conditions. Fungal pathogens are also known to occur, but disease does not appear to be a major problem with this species.

In addition to its windbreak and shelterbelt applications, bur oak has several other positive attributes and uses. This species makes an impressive street tree and large landscape plant. The wood of bur oak is quite valuable and is often marketed as white oak. Bur oak acorns are a favored food for numerous wildlife species deer, turkeys, rabbits, and squirrels.

Despite its tolerance of a wide range of site conditions, bur oak has not been widely used in conservation plantings. The primary limiting factor for lack of acceptance has been its reputation for slow rate of height growth, which is approximately 4.6 to 6.1 meters (15 to 20 ft.) per 20 years. In addition, seed sources at the western edge of its natural range tend to have poor form. There appears to be much opportunity for selecting a genetically improved strain capable of sustaining greater rates of height growth and improved form.

Method of Selection: Ekalaka Germplasm bur oak is being released as a ‘Natural–Track’ germplasm, i.e., it is being increased without purposeful manipulation. This selection was based on a comparison of 24 seed sources of bur oak from the northern Great Plains. Selection was based on a combination of sustained rate of annual height growth, seedling survival, and plant vigor rating. Final selections appear in Table 2.

Table 2. Bur oak provenance study, mean performance data, final selections (bold), Bridger, Montana, 2003.

Accession Number	Study I.D.	County	State	Original Number Planted	2003 Number Selected	2003 Percent Survival	2003 Mean Height	2003 Mean Basal Caliper	2003 Mean DBH	2003 Mean Vigor Rating
						%	*cm*	*mm*	*mm*	*(1-9)*
9076042	103	McKenzie	ND	12		66.7	218.5	48.0	20.6	4.4
9076043	106	Griggs	ND	16		87.5	227.1	53.0	25.2	4.5
9076044	**111**	**Burleigh**	**ND**	**15**	**6**	**93.3**	**275.2**	**68.3**	**31.2**	**3.6**
9076045	**112**	**Pennington**	**SD**	**14**	**5**	**92.9**	**285.7**	**67.8**	**35.6**	**3.7**
9076046	122	Bottineau	ND	15		80.0	248.8	54.5	27.6	3.9
9076047	128	Oliver	ND	16		87.5	258.7	68.2	30.4	3.4
9076048	139	Dunn	ND	14		71.4	289.2	70.1	37.0	3.9
9076049	142	Carter	MT	16		68.7	188.5	54.6	19.6	4.2
9076050	**151**	**Emmons**	**ND**	**14**	**7**	**92.9**	**279.4**	**69.0**	**37.9**	**3.9**
9076051	209	Bottineau	ND	16		100.0	150.3	41.9	13.2	4.9
9076052	211	Stark	ND	16		87.5	229.5	54.8	24.7	4.1
9076053	**218**	**Oliver**	**ND**	**16**	**9**	**93.8**	**300.6**	**76.5**	**37.8**	**3.5**
9076054	219	McKenzie	ND	14		57.1	191.1	48.3	17.4	4.4
9076055	**226**	**Burleigh**	**ND**	**16**	**11**	**93.8**	**311.6**	**75.0**	**37.4**	**3.5**
9076056	227	Burleigh	ND	16		81.2	284.0	65.2	30.1	3.5
9076057	**228**	**Sioux**	**ND**	**16**	**9**	**93.8**	**310.0**	**76.0**	**42.7**	**3.1**
9076058	236	Morton	ND	16		75.0	223.8	59.6	24.5	4.3
9076059	237	Morton	ND	16		81.2	235.4	62.4	30.3	3.8
9076060	250	Emmons	ND	16		93.8	243.3	58.5	26.3	3.9
9076061	**Tree A**	**Carter**	**MT**	**16**	**6**	**75.0**	**279.6**	**71.8**	**34.1**	**3.3**
9076062	**ETTII**	**Carter**	**MT**	**16**	**7**	**87.5**	**289.6**	**66.7**	**31.4**	**3.3**
9076063	**Tree B**	**Carter**	**MT**	**16**	**7**	**87.5**	**254.7**	**67.2**	**32.4**	**3.4**
9076064	144	Carter	MT	16		81.2	218.2	52.0	22.3	4.5
9076065	Tree 3	Carter	MT	16		81.2	244.4	68.7	32.0	3.6
Grand Mean:						**84.1**	**253.2**	**62.9**	**29.6**	**3.8**
	Grand Total:			**370**	**67**					

Testing: Field testing was conducted at the Plant Materials Center at Bridger, Montana. The test site was located at an elevation of 1,128 m (3,700 ft.) in a 254- to 330-mm (10- to 13-in.) annual precipitation zone. Bridger falls in USDA Winter Hardiness Zone 4b, with annual minimum temperatures of -20 to -25°F (-28.9 to -31.6°C). The site was located in Major Land Resource Area (MLRA) 32, Northern Intermountain Desertic Basin. This classification consists of sites in Montana and Wyoming ranging in elevation from 1,100 to 1,800 m (3,609 to 5,905 ft.). The climate averages 125 to 225 mm (4.9 to 8.9 in.) of annual precipitation with most precipitation in the spring and fall. Precipitation is low and erratic. The average annual temperature is about 7°C (44.6°F) with an average frost-free period of 120 to 140 days.

The 3.0-acre planting site gradually slopes from east to west and north to south. The planting site soil is a 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 cm (18 in.) of the profile are characterized as mildly alkaline, whereas the lower 46 to 152 cm (18 to 60 in.) 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°C (48 to 51°F) and the frost-free period is 120 to 130 days. This soil falls in the Windbreak Group 1 suitability group; and is characterized by deep, friable, nearly level to steep, well-drained soils on stream terraces and fans. Soils in this group are well suited to caragana (*Caragana arborescens* Lam.), honeysuckle (*Lonicera* sp.), lilac (*Syringa* sp.), chokecherry (*Prunus virginiana* L.), American plum (*Prunus americana* Marsh), skunkbush sumac (*Rhus trilobata* Nutt.), silver buffaloberry (*Shepherdia argentea* [Pursh] Nutt.), sand cherry (*Prunus pumila* var. *besseyi* [Bailey] Gleason), red-osier dogwood (*Cornus sericea* L.), and Russian olive (*Elaeagnus angustifolia* L.). Natural vegetation

is mixed mid- and short grasses, forbs, shrubs, and cottonwoods along the streams. The dominant vegetation in uncultivated areas adjacent to the site includes bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Love), needle and thread (*Hesperostipa comata* Trin. and Rupr.), prairie junegrass (*Koeleria macrantha* [Ledeb.] J.A.Schultes), big sagebrush (*Artemisia tridentata* ssp. *spiciformis* [Osterhout] Kartesz and Gandhi), ponderosa pine (*Pinus ponderosa*), Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), and limber pine (*Pinus flexilis* James). The planting site at Bridger was located at an elevation of 1,128 m (3,700 ft.) in a 254- to 330-mm (10- to 13-in.) annual precipitation zone.

Propagation of test plants for this study began in fall 1991 when five Montana sources were collected and sown in the PMC greenhouse. These collections were not all original GP-13 test accessions, but were included in the Bridger planting in order to generate more information about the performance of Montana sources of bur oak. On February 25, 1992, the Bridger PMC received 468 acorns representing 16 additional accessions collected from sites in Montana, North Dakota, Oklahoma, and South Dakota. The collections, shipped in zip-lock bags, were immediately stored in a 37°F walk-in cooler. From February 26 through March 2, 1992, the acorns were planted in 40-cubic-inch Deepots® in Fison's #3® potting mix, watered, and then placed in the greenhouse at 80°F days and 65°F nights under 62 percent shade. Germination and height data were recorded on July 30, 1992.

The oaks were moved outdoors in early August, under the partial shade of a green ash windbreak, for the remainder of the summer. Although generally not severe, some plants did develop symptoms of sunscald. After their leaves had abscised in October, all plants were moved into a temporary, overwintering structure. Plants were periodically watered until the propagation media had frozen. In mid-January 1993, a check of the seedlings revealed rodents had chewed most stems down to the media surface. All accessions were brought into the greenhouse and allowed to break bud. Survival data were taken in April.

On February 3, 1993, the Bridger PMC received a second shipment of 300 acorns, representing 10 additional accessions. These accessions were from different trees in the same counties as those received in 1992. All counties represented in the second group of collections were also represented in the first group. The acorns were handled and processed identically as the initial group, being removed from the cooler and planted in Fisons #4® in Deepots® on March 12, 1993. The plants were watered and placed in the headhouse to germinate. After germination was complete, data were collected on each accession. All plants were fertigated periodically with 125 ppm N-P-K. Gnatrol® at a rate of 4 teaspoons-per-gallon was used on two occasions to control fungus gnat larva.

An evaluation of all trees was conducted on March 29, 1994, and April 4, 1994, in order to record preplanting height. On June 17, 1994, a 24 accession RCB (Randomized Complete Block) design planting was installed in Field 23 at the Bridger PMC with collections from Montana, North Dakota, and South Dakota represented. Only accessions containing 12 or more surviving trees were included in the study as test plants. The RCB consisted of 8 blocks, each block consisting of three rows of 16 test positions each. This resulted in a total of 384 RCB planting locations. When available, two trees of each accession were randomized in each block resulting in the planting of 16 trees per accession (see Appendix 1). Trees were planted on 14-foot centers between rows and 18 feet within rows occupying an area of approximately 3.0 acres. Holes were drilled with an 8-inch auger to a depth of 24 to 30 inches. Each tree was hand planted and then irrigated with approximately 2 gallons of water. Most plants were produced in containers; however, a small number of additional plants were shipped to Bridger in early 1994 as bareroot stock. Bareroot stock has been identified on the layout and evaluation forms in case performance differences appear over time.

The entire oak study was flood irrigated four times over the course of the 1994 growing season because of exceptionally hot, dry, windy conditions. The planting continues to be maintained in a fallow condition by a combination of roto-mowing, mechanical cultivation, and spot spraying of noxious weeds. Each tree was evaluated on October 12, 1994, for survival, height, and animal damage.

On July 18, 1995, extra seedlings held in containers were used to replace dead trees and blanks within the RCB, and to establish a border row around the perimeter of the entire planting. Each replacement was given approximately 2 gallons of water at planting and then twice more over the course of the 1995 growing season. No additional irrigation was supplied to any of the 1994 planted trees. As in 1994, mechanical cultivation and spot spraying were used to maintain the planting. On October 9, 1995, all bur oak were evaluated for survival, height, and animal damage.

Although a three-wire electric fence was installed around the perimeter of the field prior to planting in 1994, deer browsing was fairly high in 1994 and 1995. A combination of inadequate electrical grounding and poor design was

the probable cause of failure. To correct this problem, Vexar® seedling protectors were placed over each tree on October 25, 1995, to deter rabbit and deer predation. A PVC (polyvinyl chloride) sleeve was first placed over each tree and then the seedling protector placed over the tube. The PVC sleeve was then pulled upward leaving the protector in place. This technique prevented branch damage and greatly reduced installation time. The seedling protectors worked well to prevent serious stem and terminal bud damage although browsing of foliage continued over time. In 2000, evidence of girdling from the protectors resulted in their removal from all trees. The fence, which had been inoperative since 1996, was removed in 2001 to facilitate cultivation operations. Final selections were made in March 2004 and all non-selected trees were removed in April. The lower limbs on all selected trees were pruned in July 2004 to facilitate cultivation and seed collection. In August and September 2004, a 6-foot high welded-wire fence was constructed around the entire seed orchard to exclude deer. In 2007, a two-wire electric fence was attached to the existing welded-wire fence at 6 inches and 3 feet above the ground. Evidence of animal predation of the 2007 crop was minimal. The planting continues to be maintained fallow by a combination of hand, mechanical, and chemical cultivation. The only herbicide used in this study has been 2 to 4 percent glyphosate solutions to control field bindweed (*Convolvulus arvensis*) and Canada thistle (*Cirsium arvense*). No other herbicides, fertilizers, or fungicides have been used to date. Since 2001, fairly high numbers of aphids have warranted the use of insecticidal soap and paraffinic oil for control. For seed collection information, see Seed Increase.

Results and Discussion

Data has been collected annually since 1999. For mean results and other descriptive statistics, reference the Bridger Plant Materials Center 1996-2003 and 2004-2005 Technical Reports.

Final selections in 2004 were based on data from the fall 2003 evaluation. Raw data from the 2003 evaluation appears in Appendix 2.

Selection was based on a combination of descriptive statistics (mean height growth, percentage survival, and vigor rating at or above the overall population mean), a visual (subjective) field review of each tree within a family (seed source), and statistical analyses. In general, seed sources with mean survival, height growth, and vigor rating at or above overall population means were selected. Additionally, individual trees within a selected seed source that did not meet established mean criteria or that did not appear suitable based on the field inspection were omitted. A total of 67 trees from 9 seed sources from three states (Montana, North Dakota, and South Dakota) were selected (see Table 3). Selected seed sources maintained 89.9 percentage survival until 2003, whereas non-selected and all seed sources maintained 80.5 and 84.1 percentage survival, respectively. Percentage survival among selected seed sources ranged from 75.0 to 94.0 percent. Selected trees averaged 28.8 cm (11.3 inches) of height growth in 2003, with individual tree annual growth as high as 84.8 cm (33.4 inches). Mean annual height growth by seed source ranged from 7.2 cm (2.8 inches) to 37.1 cm (14.6 inches). Selected trees averaged 339.1 cm (133.5 inches) in height in 2003, whereas non-selected and all trees measured 229.6 cm (90.4 inches) and 253.2 cm (99.7 inches), respectively. Plant vigor rating of selected trees in 2003 averaged 2.9, whereas non-selected and all trees averaged 4.1 and 3.8, respectively. The basal caliper of selected trees averaged 84.1 mm (3.3 inches), whereas the basal caliper of non-selected and all trees averaged 57.0 mm (2.25 inches) and 62.9 mm (2.5 inches), respectively. The D.B.H. (diameter breast high) of selected trees averaged 45.6 mm (1.8 inches), whereas the D.B.H. of non-selected and all trees averaged 25.2 mm (1 inch) and 29.6 mm (1.2 inches), respectively.

Table 3. Bur oak provenance study, “selected” versus “non-selected” versus “all” mean performance data, Bridger, Montana, 2003.

Original Number Planted	2003 Number	2003 Percent Survival	2003 Mean Height	2003 Mean Basal Caliper	2003 Mean D.B.H.	2003 Mean Vigor Rating
		%	*cm*	*mm*	*mm*	*(1-9)*
Selected Seed Sources	67	89.9	339.1	84.1	45.6	2.9
Non-Selected Seed Sources	244	80.5	229.6	57.0	25.2	4.1
All Seed Sources	311	84.1	253.2	62.9	29.6	3.8

As previously noted, a statistical analysis of pseudo-replicates by ANOVA was conducted (see Appendix 3), but was not the sole basis for selection.

Seed Increase: A total of 67 trees selected in 2004 were retained to create an open-pollinated seed orchard. All non-selected trees were mechanically removed and sprouts sprayed with glyphosate. Seed production and data collection from the test plot actually began in 1999 when seedlings were 7 or 8 years of age. Two studies were developed to track seed production by individual tree and seed source (MT-02-0008) and to determine if seed production correlated with one or more plant growth factors (MT-02-0009). Reference the Bridger Plant Materials Center 1996-2003 Technical Report, Volume 2 – Woody Plant, Propagation, and Germination Research; and the Bridger Plant Materials Center 2003-2005 Technical Report for more information.

Annual evaluations for seed production by individual tree began in 1999 with the first evidence of flowering and fruit production. Each evaluation consisted of counting the number of seeds and caps produced by an individual tree in order to estimate total seed production. Seed weight data was also collected and summarized depending on the year.

In 1999, only one tree from Stark, North Dakota, (211-08), produced one acorn. In 2000, a total of 48 test trees representing 20 of the 24 seed sources tested produced at least one acorn. A total of 588 acorns were produced in 2000 when the trees were 8 or 9 years old. A formal evaluation of bur oak seed production was not possible in 2001 because most acorns were lost to animal predation. It was noted that of the 48 trees producing acorns in 2000, 47 trees (98 percent) produced evidence of acorns in 2001. An additional 75 trees produced acorns in 2001 for a total of 122 acorn-producing trees in 2001.

There was substantial evidence of seed predation throughout the study again in 2002.

In 2002, a total of 165 test trees representing all 24 tested seed sources produced at least one acorn. An estimated 39,060 acorns were produced in 2002. The highest number of acorns produced by an individual tree was 1,336 by Carter, Montana -Tree B II-46. The overall mean number of acorns produced per acorn-producing tree was 236.7 in 2002. In 2002 and 2003, correlation analyses were conducted to determine if plant height, basal caliper, diameter breast high, or vigor rating could be used as indices of seed production and productivity.

In 2003, a total of 188 test trees representing all 24 tested seed sources produced at least one acorn, an increase of 23 trees from the 2002 level. An estimated 9,768 acorns were produced in 2003, a substantial decrease from the 39,060 acorns produced in 2002. The highest number of acorns produced by an individual tree was 610 by Emmons, North Dakota -151-8. The overall mean number of acorns produced per acorn-producing tree was 52.0 in 2003.

In 2004, a total of 144 test trees representing 10 tested seed sources produced at least one acorn. An estimated 6,684 acorns were produced in 2004, a decrease from the 9,768 acorns produced in 2002. The highest number of acorns produced by an individual tree was 586 by Oliver, ND-218-13. The overall estimated mean number of acorns produced per acorn-producing tree was 46.4 in 2004.

As a result of severe late spring frosts in 2005 and 2006, seed production was very low each year and no seed was collected.

Data was again collected on individual tree seed production in 2007. A total of 723.3 pounds (328 kg) of bulk seed representing 201,613 seeds with a grand mean viability of 77 percent was collected from the orchard and stored in a walk-in cooler for conservation seedling production. Reference MT-07-0002 Bur Oak Seed Production and Germination by Individual Selected Tree, Bridger Plant Materials Center 2006-2007 Technical Report for detailed information.

Seed was collected for production purposes in 2008, but no production data was recorded.

Ekalaka Germplasm bur oak averages 614 seeds-per-kilogram (279 seeds-per-pound). Average date of harvest of Ekalaka Germplasm bur oak at the Plant Materials Center, Bridger, Montana, ranges from late August to early October each year with peak production in mid- to late-September.

Ecological Considerations and Evaluation: Bur oak is a long-lived deciduous tree native to Montana and Wyoming. At reproductive maturity it is a prolific seed producer, but is not weedy. Bur oak stands readily perpetuate themselves through seed shatter, but the seedlings are sensitive to grazing, flooding, and fire. The species is very tolerant to cold temperatures. Ekalaka Germplasm bur oak passes the NRCS Plant Materials Program, Environmental Evaluation of Plant Materials Releases (attached) for potential invasiveness.

Anticipated Conservation Use: Ekalaka Germplasm bur oak is intended primarily for use in windbreaks, shelterbelts, and riparian forest buffers. This selection may also be used for other conservation practices including woody draw restoration, wildlife habitat, Xeriscaping®, and reforestation projects.

Anticipated Area of Adaptation: Ekalaka Germplasm bur oak is a bulk of multiple seed sources originating in the northern Great Plains. Although testing of this selection has been limited to the Bridger, Montana, test site, it should perform well across broad areas of eastern Montana and Wyoming, as well as western North Dakota and western South Dakota. Based on the performance data in Bridger, Montana, and in its native range, Ekalaka Germplasm bur oak is best adapted to elevations of 2,000 to 4,000 feet, performing more favorably on lower elevation (valley) sites.

Ekalaka Germplasm bur oak will continue to be field tested across its geographic range to assess its performance and adaptation.

Increase and Distribution: Generation G_1 (equivalent to Foundation) seed of Ekalaka Germplasm bur oak will be 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. Foundation Class seed stock will be available in the spring of 2010. Commercial production of two generations (G_2 and G_3) beyond G_1 is allowed.

Prepared by: Joseph D. Scianna, Research Horticulturist, USDA-NRCS, Plant Materials Center, 98 South River Road, Bridger, MT 59014; Robert Logar, State Staff Forester, USDA-NRCS, Federal Building, Room 443, 10 East Babcock Street, Bozeman, MT 59715-4704; and Darren Zentner, Biological Technician, USDA-NRCS, Plant Materials Center, 98 South River Road, Bridger, MT 59014.

Signatures for release of:
Ekalaka Germplasm bur oak

State Conservationist NRCS Bozeman, Montana	Date
State Conservationist NRCS Casper, Wyoming	Date
Director Montana Agricultural Experiment Station Montana State University Bozeman, Montana	Date
Director Wyoming Agricultural Experiment Station University of Wyoming Laramie, Wyoming	Date
Director Ecological Sciences Division NRCS Washington, DC	Date

Appendix 1. Bur oak seed source study, RCB design and test plant location, Bridger, Montana.

		Block 1			Block 2			Block 3			Block 4	
	Row 1	Row 2	Row 3	Row 1	Row 2	Row 3	Row 1	Row 2	Row 3	Row 1	Row 2	Row 3
142-21	**142-22**	**142-24**	**142-25**	**142-26**	**142-27**	**142-28**	**142-31**	**142-33**	**209-01**	**209-05**	**209-18**	**209-19**
	9076043-09	9076051-08	9076060-19	9076049-10	9076061-30	9076057-11	9076060-22	9076058-02	9076059-03	(9076051-03)	9076058-15	9076049-05
142-20	106-09	209-08	250-19	142-10-br	T ASII-30	228-11	250-22	236-02	237-03	(209-03)	236-15NT	142-05-br
	9076053-16	9076063-10	9076051-06	9076045-10	9076062-27	9076063-13	9076045-02	9076046-13	9076065-10	(9076051-21)	9076053-18	9076061-24
142-17	218-16	T BII-10	209-06	112-10	ETT II-27	T B II-13	112-02	122-13	T #3-10	(209-21)	218-18	T ASII-24
	9076064-16	9076058-25	9076046-10	9076042-05	9076050-02	9076055-05	9076047-05	9076053-04	9076049-12	9076063-03	9076060-13	9076062-12
136-03	13-1-16	236-25	122-10	103-05	151-02	226-05	128-05	218-04	142-12-br	T B II-03	250-13	ETT II-12
	9076054-03	9076059-24	(9076049-06	9076048-04	9076046-09	9076061-39	9076048-05	9076054-02	9076049-07	9076064-29	9076044-10	9076058-16
136-02	219-03	237-24	142-06-br	139-04	122-09	T AS II-39	139-05	219-02	142-07-br	T #1-10	111-10	236-16
	9076050-08	9076054-13	9076042-11	9076059-22	9076051-10	9076056-20	9076054-08	9076055-02	9076042-10	9076045-15	9076049-09	9076062-39
136-01	151-08	219-13	103-11	237-22	209-10	227-20	219-08	226-02	103-10	112-15	142-09-br	ETT II-39
	9076052-11	9076047-01	9076045-13	9076065-40	9076047-02	9076043-16	9076044-08	9076056-15	9076052-12	9076065-11	9076048-06	9076050-14
130-02	211-11	128-01	112-13	1 1/4-3-22	128-02	106-16	111-08	227-15	211-12	T #3-11	139-06	151-14
	9076061-17	9076064-02	9076053-05	9076047-11	9076053-03	9076052-06	9076063-11	9076050-05	9076061-18	9076055-13	9076047-22	9076044-12
130-01	T ASII-17	13-1-02	218-05	128-11	218-03	211-06	T B II-11	151-05	T ASII-18	226-13	128-22	111-12
	9076045-07	9076059-28	9076062-24	9076062-08	9076055-08	9076046-15	9076058-09	9076059-15	9076064-18	9076060-03	9076042-09	9076046-12
128-23	112-07	237-28	ETT II-24	ETT II-08	226-08	122-15	236-09	237-15	13-1-18	250-03	103-09	122-12
	9076058-18	9076055-01	9076057-17	9076059-17	9076064-12	9076058-13	9076052-02	9076057-07	9076063-41	9076063-46	9076058-24	9076057-03
128-20	236-18	226-01	228-17	237-17	13-1-12	236-13	211-02	228-07	T B II-41	T B II-46	236-24	228-03
	9076043-18	9076048-08	9076062-41	9076051-11	9076060-09	9076053-06	9076050-09	9076043-04	9076056-28	9076059-19	9076045-18	9076057-04
128-17	106-18	139-08	ETT II-41	209-11	250-09	218-06	151-09	106-04	227-28	237-19	112-18	228-04
	9076055-18	9076065-45	9076063-07	9076048-10	9076064-30	9076042-03	9076062-11	9076064-14	9076048-01	9076064-13	9076065-01	9076046-08
128-09	226-18	1 1/4-3-27	T B II-07	139-10	T #1-11	103-03	ETT II-11	13-1-14	139-01	13-1-13	T #3-01	122-08
	9076071-2	9076050-01	9076047-04	9076060-05	9076057-05	9076044-03	9076061-16	9076057-16	9076045-21	9076055-15	9076043-19	9076047-14
127-06	567-02	151-01	128-04	250-05	228-05	111-03	T ASII-16	228-16	112-21	226-15	106-19	128-14
	9076056-08	9076065-16	9076060-01	9076058-21	9076052-07	9076049-11	9076065-06	9076046-01	9076055-11	9076043-10	9076061-21	9076048-09
126-08	227-08	T #3-16	MT-250-01	236-21	211-07	142-11-br	T #3-06	122-01	226-11	106-10	T ASII-21	139-09
	9076046-05	9076057-01	9076049-08	9076056-22	9076065-47	9076044-11	9076062-10	9076044-09	9076042-04	9076056-16	9076053-13	9076059-27
126-07	122-05	228-01	142-08-br	227-22	1 1/4-3-29	111-11	ETT II-10	111-09	103-04	227-16	218-13	237-27
	9076052-22	9076044-05	9076056-04	9076054-11	9076045-04	9076054-06	9076060-08	9076047-03	9076053-09	9076054-14	9076056-17	9076050-03
106-27	211-22	111-05	227-04	219-11	112-04	219-06	250-08	128-03	218-09	219-14	227-17	151-03
	9076042-7	9076048-02	9076044-04	9076050-12	9076063-15	9076043-06	9076051-23	9076051-16	9076043-14	9076052-03	9076052-04	9076042-08
106-26	103-07	139-02	111-04	151-12	T B II-15	106-06	209-23	209-16	106-14	211-03	211-04	103-08
ETT-30	**EKTII-22**	**EKTII-21**	**EKTII-20**	**EKTII-18**	**EKTII-15**	**TASII-33**	**TASII-29**	**TASII-26**	**TASII-25**	**TASII-15**	**TASII-12**	**TASII-11**

Appendix 1. Bur oak seed source study, RCB design and test plant location, Bridger, Montana - (continued).

	Block 5			Block 6			Block 7			Block 8		Border
Row 1	Row 2	Row 3	Row 1	Row 2	Row 3	Row 1	Row 2	Row 3	Row 1	Row 2	Row 3	
218-01	**218-02**	**218-11**	**218-17**	**218-23**	**218-26**	**218-27**	**226-03**	**226-07**	**226-09**	**226-10**	**226-14**	**226-23**
9076048-19	9076066-02	9076042-13	9076053-22	9076063-01	9076044-14	9076065-17	9076055-16	9076056-25	9076060-10	9076051-04	Blank	
139-19-br	126-02	103-13-br	218-22	T B II-01	111-14	T #3-17	226-16	227-25	250-10	209-04		**226-24**
9076050-11	9076051-12	9076057-22	9076064-23	9076059-26	9076042-12	9076065-08	9076049-16	9076062-32	Blank	Blank	9076053-12	
151-11	209-12	228-22	T #1-04	237-26	103-12-br	T #3-08	142-16-br	ETT II-32			218-12	**227-01**
9076059-04	9076053-10	9076055-19	9076052-08	9076043-17	9076052-01	9076048-17	9076053-07	9076051-09	9076043-22	9076051-13	9076049-15	
237-04	218-10	226-19	211-08	106-17	211-01	139-17-br	218-07	209-09	106-22-br	209-13	142-15-br	**227-03**
9076064-26	9076059-02	9076044-01	9076051-17	9076062-23	9076057-12	9076064-28	9076052-18	9076055-04	9076043-23	9076057-27	9076065-09	
T #1-07	237-02	111-01	209-17	ETT II-23	228-12	T #1-09	211-18	226-04	106-23-br	228-27	T #3-09	**227-05**
9076049-02	9076055-12	9076044-13	9076048-15	9076051-02	9076058-20	9076056-12	9076071-03	Blank	9076055-17	9076061-13	9076059-10	
142-02-br	226-12	111-13	139-15-br	209-02	236-20	227-12	567-03		226-17	T ASII-13	237-10	**227-07**
9076049-04	9076053-14	9076065-44	9076063-49	9076061-37	9076060-12	9076048-18	9076047-08	9076063-43	9076046-22	Blank	Blank	
142-04-br	218-14	1 1/4-3-26	T B II-49	T ASII-37	250-12	139-18-br	128-08	T B II-43	122-22-br			**227-09**
9076048-14	9076062-07	9076047-16	9076055-06	9076056-27	9076050-04	9076064-21	9076045-12	9076043-21	9076058-14	9076065-07	9076052-20	
139-14-br	ETT II-07	128-16	226-06	227-27	151-04	T #1-02	112-12	106-21-br	236-14	T #3-07	211-20	**227-14**
9076042-14	9076052-15	9076058-05	9076055-20	9076058-22	9076049-01	9076044-06	9076061-42	9076045-16	Blank	9076060-20	9076056-02	
103-14-br	211-15	236-05	226-20	236-22	142-01-br	111-06	T ASII-42	112-16		250-20	227-02	**227-18**
9076045-06	9076045-14	9076054-01	9076064-11	9076048-16	9076065-39	9076054-12	9076053-21	9076060-14	9076044-15	Blank	9076057-21	
112-06	112-14	219-01	13-1-11	139-16-br	1 1/4-3-21	219-12	218-21	250-14	111-15		228-21	**227-19**
9076065-43	9076046-04	9076043-11	9076054-07	9076060-21	9076054-05	9076043-20	9076062-04	9076052-23	9076056-24	9076055-22	9076052-10	
1 1/4-3-25	122-04	106-11	219-07	250-21	219-05	106-20-br	ETT II-04	211-23	227-24	226-22	211-10	**227-21**
9076056-13	9076063-05	9076051-07	9076057-08	9076047-13	9076061-23	9076057-14	9076047-15	9076059-08	Blank	9076053-19	9076062-06	
227-13	T B II-05	209-07	228-08	128-13	T ASII-23	228-14	128-15	237-08		218-19	ETT II-06	**227-23**
9076061-01	9076064-24	9076060-25	9076045-05	9076043-07	9076053-25	9076051-20	9076059-06	9076049-14	9076059-09	Blank	9076047-21	
T ASII-01	T #1-05	250-25	112-05	106-07	218-25	209-20	237-06	142-14-br	237-09		128-21	**227-29**
9076046-11	9076062-13	9076056-11	9076062-14	9076044-07	9076042-15	9076060-23	9076046-20	9076063-04	9076047-10	9076062-09	9076063-54	
122-11	ETT II-13	227-11	ETT II-14	111-07	103-15-br	250-23	122-20-br	T B II-04	128-10	ETT II-09	T B II-54	**142-19**
9076058-23	9076057-02	9076050-15	9076050-13	9076056-10	9076045-01	9076066-03	9076050-16	9076046-21	9076058-10	Blank	9076049-13	
236-23	228-02	151-15	151-13	227-10	112-01	126-03	151-16	122-21-br	236-10		142-13-br	**237-05**
9076043-08	9076054-09	9076047-07	9076059-01	9076046-18	9076065-18	9076057-23	9076044-02	9076058-17	Blank	9076063-06	9076061-02	
106-08	219-09	128-07	237-01	122-18-br	T #3-18	228-23	111-02	236-17		T B II-06	T ASII-02	**237-07**
9076063-02	9076060-15	9076061-43	9076049-03	9076047-18	9076046-19	9076061-14	9076058-19	Blank	Blank	9076064-37	9076064-36	
T B II-02	250-15	T ASII-43	142-03-br	128-18	122-19-br	T ASII-14	236-19			T #1-04	T #1-03	**237-11**
TASII-10	**TASII-09**	**TASII-08**	**TASII-06**	**TASII-05**	**TASII-04**	**250-26**	**250-18**	**250-17**	**250-06**	**237-23**	**237-16**	**237-12**

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
1	1	1	nt	9076038	130-R97	1	165.0	1997
1	1	2	t	9076052-22	211-22	1	62.0	
1	1	3	t	9076046-05	122-5	1	255.0	
1	1	4	nt	9076056-26	227-26-R97	1	230.0	1997
1	1	5	nt	9076045	112-R97	1	195.0	1995;1997; low fork
1	1	6	t	9076055-18	226-18	1	360.0	
1	1	7	t	9076043-18	106-18	0		dead
1	1	8	t	9076058-6	236-6-R96	1	162.0	1996
1	1	9	t	9076045-07	112-7	1	460.0	leaves 11/14/03
1	1	10	nt	9076043-25	106-25-R97	1	176.0	1997
1	1	11	t	9076052-11	211-11	1	190.0	
1	1	12	t	9076050-08	151-8	1	250.0	
1	1	13	t	9076054-03	219-3	1	187.0	
1	1	14	t	9076064-16	13-1-16	1	290.0	
1	1	15	t	9076053-16	218-16	1	270.0	
1	1	16	t	9076043-09	106-9	1	215.0	
1	2	1	t	9076048-02	139-2	1	330.0	
1	2	2	t	9076044-05	111-5	0		weed badger blight 2003
1	2	3	t	9076057-01	228-1	1	370.0	
1	2	4	nt	9076065-13	T#3-13-R97	1	185.0	1997,etiolated+M52
1	2	5	t	9076050-01	151-1	1	230.0	
1	2	6	t	9076065-45	1 1/4-3-27	1	370.0	
1	2	7	t	9076048-08	139-8	1	270.0	
1	2	8	t	9076055-01	MT-226-1	1	435.0	
1	2	9	t	9076059-28	237-28	1	225.0	
1	2	10	t	9076064-02	13-1-2	1	62.0	
1	2	11	t	9076047-01	128-1	1	140.0	
1	2	12	t	9076054-13	219-13	0		dead
1	2	13	t	9076059-24	237-24	1	190.0	
1	2	14	t	9076058-25	236-25	1	270.0	
1	2	15	t	9076063-10	Tree B II-10	0		dead
1	2	16	t	9076051-08	209-8	1	175.0	
1	3	1	t	9076044-04	111-4	1	180.0	
1	3	2	t	9076056-04	227-4	1	240.0	corky
1	3	3	t	9076049-08	142-8	1	120.0	bareroot;corky
1	3	4	nt	9076060-24	MT-250-24-R97	1	262.0	1997
1	3	5	t	9076047-04	128-4	1	290.0	low fork

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
1	3	6	t	9076063-07	Tree B II-7	1	285.0	low fork
1	3	7	nt	9076043-24	106-24-R97	1	310.0	1997
1	3	8	t	9076057-17	228-17	1	237.0	
1	3	9	t	9076062-24	E.T.T.II-24	1	345.0	
1	3	10	t	9076053-05	218-5	1	390.0	
1	3	11	t	9076045-13	112-13	1	50.0	
1	3	12	t	9076042-11	103-11	1	278.0	
1	3	13	t	9076049-18	142-18-R95	1	212.0	1995
1	3	14	t	9076046-10	122-10	1	225.0	low fork,corky
1	3	15	t	9076051-06	209-6	1	120.0	
1	3	16	t	9076060-19	250-19	1	165.0	etiolated
2	1	1	t	9076050-12	151-12	1	345.0	
2	1	2	t	9076054-11	219-11	1	87.0	
2	1	3	t	9076056-22	227-22	1	390.0	corky
2	1	4	t	9076058-21	236-21	1	255.0	corky
2	1	5	t	9076060-05	250-5	1	335.0	
2	1	6	t	9076048-10	139-10	1	270.0	corky
2	1	7	t	9076051-11	209-11	1	287.0	
2	1	8	t	9076059-17	237-17	1	290.0	corky,*Vexar branch problem
2	1	9	t	9076062-08	E.T.T.II-8	1	100.0	poorly planted
2	1	10	t	9076047-11	128-11	1	285.0	
2	1	11	t	9076065-40	1 1/4-3-22	1	305.0	
2	1	12	nt	9076063-35	T.BII-35-R97	1	275.0	1997;forked low
2	1	13	t	9076048-04	139-4	1	310.0	
2	1	14	t	9076042-05	103-5	1	137.0	
2	1	15	t	9076045-10	112-10	1	362.0	
2	1	16	t	9076049-10	142-10	1	135.0	barer;corky
2	2	1	t	9076063-15	Tree B II-15	1	330.0	exc. form, but low fork?
2	2	2	t	9076045-04	112-4	1	325.0	leaf retention 11/14/03
2	2	3	nt	Blank	Blank	0		dead 1998
2	2	4	t	9076052-07	211-7	1	310.0	
2	2	5	t	9076057-05	228-5	1	320.0	
2	2	6	nt	9076072-4	3/4-C-4-R97	1	242.0	1997;low fork
2	2	7	t	9076060-09	250-9	1	200.0	etiolated
2	2	8	t	9076064-12	13-1-12	1	135.0	
2	2	9	t	9076055-08	226-8	1	290.0	

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
2	2	10	t	9076053-03	218-3	1	450.0	
2	2	11	t	9076047-02	128-2	1	60.0	
2	2	12	t	9076051-10	209-10	1	25.0	
2	2	13	t	9076046-09	122-9	1	152.0	etiolated
2	2	14	t	9076050-02	151-2	1	420.0	bean pole shape
2	2	15	nt	9076063-39	T.B.II-39-R97	1	200.0	1997
2	2	16	t	9076061-30	Tree AS II-30	1	320.0	
2	3	1	t	9076043-06	106-6	1	300.0	
2	3	2	nt	9076063-37	T.BII-37-R97	1	212.0	1997
2	3	3	t	9076044-11	111-11	1	265.0	forked low
2	3	4	t	9076049-11	142-11	0		bareroot;dead
2	3	5	t	9076044-03	111-3	1	330.0	
2	3	6	t	9076042-03	103-3	1	218.0	narrow
2	3	7	t	9076053-06	218-6	1	250.0	
2	3	8	t	9076058-13	236-13	0		dead
2	3	9	t	9076046-15	122-15	1	227.0	
2	3	10	t	9076052-06	211-6	1	245.0	
2	3	11	t	9076043-16	106-16	1	25.0	barely alive
2	3	12	t	9076056-20	227-20	1	190.0	
2	3	13	t	9076061-39	Tree AS II-39	1	180.0	
2	3	14	t	9076055-05	226-5	1	377.0	narrow
2	3	15	t	9076063-13	Tree B II-13	0		dead
2	3	16	t	9076057-11	228-11	1	287.0	
3	1	1	t	9076051-23	209-23	1	68.0	deer broke leader
3	1	2	t	9076060-08	250-8	1	55.0	
3	1	3	t	9076062-10	E.T.T.II-10	1	270.0	low fork
3	1	4	t	9076065-06	Tree #3-6	1	227.0	
3	1	5	t	9076061-16	Tree AS II-16	1	315.0	
3	1	6	t	9076062-11	E.T.T.II-11	1	278.0	low fork
3	1	7	t	9076050-09	151-9	1	80.0	
3	1	8	t	9076052-02	211-2	1	226.0	
3	1	9	t	9076058-09	236-9	1	365.0	
3	1	10	t	9076063-11	Tree B II-11	1	160.0	etiolated
3	1	11	t	9076044-08	111-8	1	352.0	
3	1	12	t	9076054-08	219-8	0		dead
3	1	13	t	9076048-05	139-5	1	322.0	
3	1	14	t	9076047-05	128-5	1	280.0	low fork

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
3	1	15	t	9076045-02	112-2	1	330.0	low fork,*87.98 w/o swell
3	1	16	t	9076060-22	250-22	1	302.0	
3	2	1	t	9076051-16	209-16	1	62.0	deer broke leader
3	2	2	t	9076047-03	128-3	0		dead
3	2	3	t	9076044-09	111-9	1	430.0	
3	2	4	t	9076046-?	122-?-R96	1	175.0	1996
3	2	5	t	9076057-16	228-16	1	376.0	*Vexar branch problem
3	2	6	t	9076064-14	13-1-14	1	334.0	
3	2	7	t	9076043-04	106-4	1	385.0	low fork
3	2	8	t	9076057-07	228-7	1	248.0	
3	2	9	t	9076059-15	237-15	1	248.0	
3	2	10	t	9076050-05	151-5	1	255.0	
3	2	11	t	9076056-15	227-15	1	250.0	
3	2	12	t	9076055-02	226-2	1	280.0	
3	2	13	t	9076054-02	219-2	1	175.0	etiolated
3	2	14	t	9076053-04	218-4	1	215.0	low forks
3	2	15	t	9076046-13	122-13	0		dead
3	2	16	t	9076058-02	236-2	1	200.0	
3	3	1	t	9076043-14	106-14	1	155.0	
3	3	2	nt	9076053-20	218-20-R97	1	290.0	1997
3	3	3	t	9076042-04	103-4	1	220.0	
3	3	4	nt	9076063-24	T.BII-24-R97	1	124.0	1997
3	3	5	t	9076045-21	112-21	1	227.0	
3	3	6	t	9076048-01	139-1	0		dead
3	3	7	t	9076056-28	227-28	0		dead
3	3	8	t	9076063-41	Tree B II-41	1	65.0	
3	3	9	t	9076064-18	13-1-18	0		dead 2003
3	3	10	nt	Blank	Blank	0		dead 1998
3	3	11	t	9076052-12	211-12	1	183.0	
3	3	12	t	9076042-10	103-10	1	110.0	heavy deer damage
3	3	13	**nt**	9076049-29	*142-29-R97*	1	187.0	bareroot;1997
3	3	14	t	9076049-12	142-12	1	100.0	bareroot
3	3	15	nt	9076049-3	11/2-2-3-R97	1	295.0	1997
3	3	16	t	9076059-03	237-3	0		dead
4	1	1	t	9076052-03	211-3	1	155.0	
4	1	2	t	9076054-14	219-14	1	326.0	
4	1	3	t	9076056-16	227-16	1	450.0	low fork

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
4	1	4	t	9076043-10	106-10	0		dead 2003
4	1	5	t	9076055-15	226-15	1	425.0	*Vexar branch problem
4	1	6	t	9076064-13	13-1-13	1	385.0	
4	1	7	t	9076059-19	237-19	1	352.0	low fork
4	1	8	t	9076063-46	Tree B II-46	1	377.0	
4	1	9	t	9076060-03	250-3	1	252.0	
4	1	10	t	9076055-13	226-13	1	440.0	corky
4	1	11	t	9076065-11	Tree #3-11	1	210.0	
4	1	12	t	9076045-15	112-15	1	290.0	
4	1	13	t	9076064-29	Tree #1-10	1	130.0	
4	1	14	t	9076063-03	Tree B II-3	1	305.0	small dead leaves??
4	1	15	t	9076051-21	209-21-R95	1	148.0	1995
4	1	16	t	9076051-03	209-3-R95	1	185.0	1995
4	2	1	t	9076052-04	211-4	0		dead
4	2	2	t	9076056-17	227-17	0		dead
4	2	3	t	9076053-13	218-13	1	350.0	
4	2	4	t	9076061-21	Tree AS II-21	1	380.0	high fork
4	2	5	t	9076043-19	106-19	1	33.0	
4	2	6	t	9076065-01	Tree #3-1	1	196.0	
4	2	7	t	9076045-18	112-18	0		dead
4	2	8	t	9076058-24	236-24	1	47.0	barely alive
4	2	9	t	9076042-09	103-09	1	335.0	
4	2	10	t	9076047-22	128-22	1	300.0	
4	2	11	t	9076048-06	139-6	1	220.0	
4	2	12	**nt**	9076065-24	1/4-3-24-R97	1	300.0	1996;1997
4	2	13	t	9076044-10	111-10	1	376.0	
4	2	14	t	9076060-13	250-13	1	225.0	
4	2	15	t	9076053-18	218-18	1	190.0	
4	2	16	nt	9076058-15	236-15NT-R95	1	245.0	1995;nontest;
4	3	1	t	9076042-08	103-8	1	302.0	
4	3	2	t	9076050-03	151-3	1	285.0	low fork
4	3	3	t	9076059-27	237-27	1	105.0	
4	3	4	t	9076048-09	139-9	1	407.0	low fork
4	3	5	t	9076047-14	128-14	1	303.0	low fork
4	3	6	t	9076046-08	122-8	1	268.0	
4	3	7	t	9076057-04	228-4	1	302.0	
4	3	8	t	9076057-03	228-3	1	175.0	low fork

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
4	3	9	t	9076046-12	122-12	1	260.0	
4	3	10	t	9076044-12	111-12	1	100.0	
4	3	11	t	9076050-14	151-14	1	425.0	
4	3	12	t	9076062-39	E.T.T.II-39	1	287.0	
4	3	13	t	9076058-16	236-16	1	55.0	
4	3	14	t	9076062-12	E.T.T.II-12	1	280.0	
4	3	15	t	9076061-24	Tree AS II-24	1	280.0	low fork
4	3	16	t	9076049-05	142-5	1	224.0	bareroot
5	1	1	t	9076063-02	Tree B II-2	1	296.0	low fork
5	1	2	t	9076043-08	106-8	1	276.0	
5	1	3	t	9076058-23	236-23	1	262.0	low fork
5	1	4	nt	9076060-11	250-11-R97	1	170.0	1997
5	1	5	t	9076061-14	Tree AS II-14	1	240.0	
5	1	6	t	9076056-13	227-13	1	390.0	low fork
5	1	7	t	9076065-43	1 1/4-3-25	1	95.0	
5	1	8	t	9076045-06	112-6	1	400.0	low fork
5	1	9	nt	Blank	Blank	0		1995, dead
5	1	10	t	9076048-14	139-14	1	177.0	bareroot
5	1	11	t	9076049-04	142-04	1	220.0	bareroot
5	1	12	nt	Blank	Blank	1	37.0	bareroot;alive
5	1	13	t	9076064-26	Tree #1-7	1	360.0	
5	1	14	t	9076059-04	237-4	1	360.0	
5	1	15	t	9076050-11	151-11	1	249.0	
5	1	16	nt	9076066-01	126-1-R95	1	277.0	1995
5	2	1	t	9076060-15	250-15	1	348.0	
5	2	2	t	9076054-09	219-9	1	280.0	low fork
5	2	3	t	9076057-02	228-2	1	258.0	
5	2	4	t	9076062-13	E.T.T.II-13	1	390.0	
5	2	5	t	9076064-24	Tree #1-5	1	326.0	
5	2	6	t	9076063-05	Tree B II-5	1	227.0	
5	2	7	t	9076046-04	122-4	1	287.0	
5	2	8	t	9076045-14	112-14	1	199.0	
5	2	9	t	9076052-15	211-15	1	235.0	
5	2	10	t	9076062-07	E.T.T.II-7	1	307.0	low fork
5	2	11	t	9076053-14	218-14	1	310.0	low fork
5	2	12	t	9076055-12	226-12	1	290.0	
5	2	13	nt	Blank	Blank	0		dead

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
5	2	14	t	9076053-10	218-10	1	300.0	
5	2	15	t	9076051-12	209-12	1	145.0	etiolated
5	2	16	nt	9076066-02	126-2-R95	1	80.0	1995
5	3	1	t	9076061-43	Tree AS II-43	1	325.0	low fork
5	3	2	t	9076047-07	128-7	1	397.0	
5	3	3	t	9076050-15	151-15	1	328.0	
5	3	4	t	9076056-11	227-11	1	271.0	
5	3	5	t	9076060-25	250-25	1	342.0	
5	3	6	t	9076051-07	209-7	1	132.0	
5	3	7	t	9076043-11	106-11	1	220.0	
5	3	8	nt	Blank	Blank	0		dead
5	3	9	t	9076058-05	236-5	0		dead
5	3	10	t	9076047-16	128-16	1	351.0	low fork
5	3	11	t	9076065-44	1 1/4-3-26	1	202.0	
5	3	12	t	9076044-13	111-13	1	370.0	
5	3	13	t	9076044-01	111-1	1	52.0	
5	3	14	t	9076055-19	226-19	1	85.0	
5	3	15	nt	Blank	Blank	0		dead 1998
5	3	16	nt	9076067-01	127-1-R95	1	230.0	1995
6	1	1	t	9076049-03	142-3	1	228.0	barer;dk bark, v. corky
6	1	2	t	9076059-01	237-1	1	237.0	low fork
6	1	3	t	9076050-13	151-13	1	370.0	
6	1	4	t	9076062-14	E.T.T.II-14	1	310.0	v. corky
6	1	5	t	9076045-05	112-5	1	226.0	
6	1	6	t	9076057-08	228-8	1	412.0	exceptionally nice
6	1	7	t	9076054-07	219-7	1	299.0	
6	1	8	t	Blank	Blank	0		dead 1998
6	1	9	t	9076055-20	226-20	1	302.0	
6	1	10	t	9076055-06	226-6	1	290.0	
6	1	11	t	9076063-49	Tree B II-49	1	349.0	low fork
6	1	12	t	9076048-15	139-15	1	280.0	bareroot
6	1	13	t	9076051-17	209-17	1	130.0	rub, *dead leader
6	1	14	t	9076052-08	211-8	1	260.0	
6	1	15	t	9076064-23	Tree #1-4	1	137.0	
6	1	16	t	9076053-22	218-22	1	222.0	low fork
6	2	1	t	9076047-18	128-18	1	275.0	
6	2	2	t	9076046-18	122-18	1	309.0	bareroot;dk, corky bark

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
6	2	3	t	9076056-10	227-10	1	269.0	
6	2	4	t	9076044-07	111-7	1	352.0	low forks
6	2	5	t	9076043-07	106-7	1	355.0	
6	2	6	t	9076047-13	128-13	1	138.0	low fork
6	2	7	t	9076060-21	250-21	1	306.0	low fork
6	2	8	t	9076048-16	139-16	1	306.0	bareroot;corky, low fork
6	2	9	t	9076058-22	236-22	1	307.0	
6	2	10	t	9076056-27	227-27	1	212.0	
6	2	11	t	9076061-37	Tree AS II-37	1	313.0	
6	2	12	t	9076051-02	209-2	1	276.0	corky
6	2	13	t	9076062-23	E.T.T.II-23	1	423.0	
6	2	14	t	9076043-17	106-17	1	248.0	
6	2	15	t	9076059-26	237-26	1	225.0	
6	2	16	t	9076063-01	Tree B II-1	1	227.0	
6	3	1	t	9076046-19	122-19	1	277.0	
6	3	2	t	9076065-18	Tree #3-18	1	229.0	low fork
6	3	3	t	9076045-01	112-1	1	337.0	
6	3	4	t	9076042-15	103-15	1	148.0	bareroot;low fork,etiolated
6	3	5	t	9076053-25	218-25	1	362.0	
6	3	6	t	9076061-23	Tree AS II-23	1	297.0	low forks
6	3	7	t	9076054-05	219-5	1		v. small
6	3	8	t	9076065-39	1 1/4-3-21	1	303.0	
6	3	9	t	9076049-01	142-1	0		bareroot; dead
6	3	10	t	9076050-04	151-4	1	345.0	high fork
6	3	11	t	9076060-12	250-12	1	141.0	etiolated
6	3	12	t	*9076058-20*	*236-20*	0		dead
6	3	13	t	9076057-12	228-12	1	382.0	
6	3	14	t	9076052-01	211-01	1	378.0	3-4 caps
6	3	15	nt	Blank	Blank	0		1995;nontest;dead
6	3	16	t	9076044-14	111-14	1	273.0	
7	1	1	nt	Blank	Blank	0		dead
7	1	2	t	9076057-23	228-23	1	324.0	low fork
7	1	3	nt	Blank	Blank	0		1995
7	1	4	t	9076060-23	250-23	1	269.0	
7	1	5	t	9076051-20	209-20	1	177.0	low fork
7	1	6	t	9076057-14	228-14	1	406.0	
7	1	7	t	9076043-20	106-20	1	405.0	bareroot

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
7	1	8	t	9076054-12	219-12	1	150.0	*dead leader
7	1	9	t	9076044-06	111-6	1	285.0	
7	1	10	t	9076064-21	Tree #1-2	1	176.0	low fork, etiolated
7	1	11	nt	9076066-06	126-6	1	262.0	1995,*vexar problem
7	1	12	t	9076056-12	227-12	1	345.0	
7	1	13	t	9076064-28	Tree #1-9	1	92.0	low fork, short
7	1	14	nt	Blank	Blank	0		1996; dead
7	1	15	t	9076065-08	Tree #3-8	1	400.0	
7	1	16	t	9076065-17	Tree #3-17	1	260.0	few
7	2	1	nt	Blank	Blank	0		dead
7	2	2	t	9076044-02	111-2	1	350.0	*vexar
7	2	3	t	9076050-16	151-16	1	50.0	
7	2	4	t	9076046-20	122-20	1	239.0	bareroot
7	2	5	t	9076059-06	237-6	1	151.0	*dead leader
7	2	6	t	9076047-15	120-15	1	332.0	low fork
7	2	7	t	9076062-04	E.T.T.II-42	1	172.0	
7	2	8	t	9076053-21	218-21	1	294.0	high fork
7	2	9	t	9076061-42	Tree AS II-42	1	162.0	etiolated
7	2	10	t	9076045-12	112-12	1	473.0	
7	2	11	t	9076047-08	128-8	1	251.0	
7	2	12	nt	Blank	Blank	0		1995
7	2	13	t	9076052-18	211-18	1	345.0	dark, corky
7	2	14	t	9076053-07	218-7	1	362.0	
7	2	15	t	9076049-16	142-16	1	180.0	bareroot; lo fork,etiolated
7	2	16	t	9076055-16	226-16	1	177.0	etiolated
7	3	1	nt	9076067-04	127-4	1	216.0	1995; low fork
7	3	2	t	9076058-17	236-17	1	302.0	narrow,*vexar problem
7	3	3	t	9076046-21	122-21	1	311.0	bareroot
7	3	4	t	9076063-04	Tree B II-4	1	215.0	
7	3	5	t	9076049-14	142-14	1	234.0	very corky
7	3	6	t	9076059-08	237-8	1	306.0	
7	3	7	t	*9076052-23*	*211-23*	1	91.0	low fork
7	3	8	t	9076060-14	250-14	1	270.0	*vexar problem
7	3	9	t	9076045-16	112-16	1	35.0	
7	3	10	t	9076043-21	106-21	1	222.0	bareroot
7	3	11	t	9076063-43	Tree B II-43	1	202.0	
7	3	12	nt	9076067-02	127-2	1	230.0	1995

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
7	3	13	t	9076055-04	226-4	1	373.0	high fork
7	3	14	t	9076051-09	209-9	1	295.0	
7	3	15	t	9076062-32	E.T.T.II-32	1	187.0	low fork, etiolated
7	3	16	t	9076056-25	227-25	1	108.0	
8	1	1	nt	9076057-15	228-15NT	1	190.0	1995nontest
8	1	2	nt	9076057-06	228-6NT	1	226.0	1995;nontest
8	1	3	t	9076058-10	236-10	1	320.0	
8	1	4	nt	9076047-12	128-12-R97	1	165.0	1997
8	1	5	t	9076059-09	237-9	1	141.0	low fork
8	1	6	nt	9076066-05	126-5	1	324.0	1995
8	1	7	t	9076056-24	227-24	1	331.0	
8	1	8	t	9076044-15	111-15	1	138.0	
8	1	9	nt	9076067-07	127-7	1	251.0	1995
8	1	10	t	9076058-14	236-14	1	140.0	ornamntl;multi.leaders
8	1	11	nt	Blank	Blank	1	63.0	bareroot; alive
8	1	12	t	9076055-17	226-17	1	270.0	high fork
8	1	13	t	9076043-23	106-23	1	182.0	bareroot
8	1	14	t	9076043-22	106-22	1	159.0	bareroot
8	1	15	nt	Blank	Blank	0		1995, dead
8	1	16	t	9076060-10	250-10	1	139.0	deer killed leader
8	2	1	t	9076064-37	*13-1-37*	1	270.0	high fork
8	2	2	t	9076063-06	Tree B II-6	1	280.0	low fork*vexar
8	2	3	nt	9076057-29	228-29NT	1	356.0	1995;nontest
8	2	4	t	9076062-09	E.T.T.II-9	1	260.0	
8	2	5	nt	9076057-24	228-24NT	1	312.0	1995;nontest;low fork
8	2	6	t	9076053-19	218-19	1	362.0	
8	2	7	t	9076055-22	226-22	1	280.0	
8	2	8	nt	9076057-20	228-20NT	1	326.0	1995;nontest
8	2	9	t	9076060-20	250-20	1	300.0	
8	2	10	t	9076065-07	Tree #3-7	1	193.0	leaf retention 11/17/03
8	2	11	nt	9076057-19	228-19NT	1	301.0	1995;nontest
8	2	12	t	9076061-13	Tree AS II-13	1	300.0	*vexar problem
8	2	13	t	9076057-27	228-27	1	295.0	
8	2	14	t	9076051-13	209-13	1	135.0	
8	2	15	nt	9076057-18	228-18NT	1	176.0	1995;nontest
8	2	16	t	9076051-04	209-4	1	44.0	
8	3	1	t	9076064-36	*13-1-36*	1	139.0	

Appendix 2. Bur oak evaluation data, Bridger, Montana, 2003.

Block	Row	Position	Test Plant	Accession Number	Previous ID Number	Plant Survival	Height	Comments
			(t,nt)			*(0,1)*	*cm*	
8	3	2	t	9076061-02	Tree AS II-2	1	243.0	
8	3	3	t	9076049-13	142-13	1	251.0	bareroot
8	3	4	t	9076063-54	Tree B II-54	1	248.0	
8	3	5	t	9076047-21	128-21	1	220.0	
8	3	6	t	9076062-06	E.T.T.II-6	1	445.0	low fork
8	3	7	t	9076052-10	211-10	1	209.0	
8	3	8	t	9076057-21	228-21	1	258.0	low fork
8	3	9	t	9076056-02	227-2	1	246.0	
8	3	10	t	9076052-20	211-20	1	324.0	dk,corky bark; low fork
8	3	11	nt	9076057-28	228-28NT	1	258.0	1995;nontest
8	3	12	t	9076059-10	237-10	1	230.0	
8	3	13	t	9076065-09	Tree #3-9	1	187.0	deer
8	3	14	t	9076049-15	142-15	1	170.0	bareroot
8	3	15	t	9076053-12	218-12	1	182.0	
8	3	16	nt	9076057-26	228-26NT	1	140.0	1995;nontest

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

The ANOVA Procedure

Class Level Information

Class	Levels	Values
Accession	24	42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65

Data for Analysis of **Percentage Survival**

Number of Observations Read	196
Number of Observations Used	186

Data for Analysis of Height Vigor
Seed_Num Seed_Percent Caliper DBH

Number of Observations Read	196
Number of Observations Used	182

NOTE: Variables in each group are consistent with respect to the presence or absence of missing values.

The ANOVA Procedure

Dependent Variable: Survival **Percentage Survival**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	1.87514401	0.08152800	1.27	0.1933
Error	162	10.37351190	0.06403402		
Corrected Total	185	12.24865591			

R-Square	Coeff Var	Root MSE	Survival Mean
0.153090	30.26829	0.253049	0.836022

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	1.87514401	0.08152800	1.27	0.1933

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Student-Newman-Keuls Test for **Percentage Survival**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	162
Error Mean Square	0.064034
Harmonic Mean of Cell Sizes	7.709369

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6	7	8	9
Critical Range	0.2545163	0.3048832	0.3345804	0.3555682	0.3717289	0.3848258	0.3958091	0.4052492

Number of Means	10	11	12	13	14	15	16	17
Critical Range	0.4135145	0.4208568	0.4274556	0.433443	0.4389193	0.4439622	0.448633	0.4529812

Number of Means	18	19	20	21	22	23	24
Critical Range	0.4570471	0.4608639	0.4644594	0.467857	0.4710766	0.4741355	0.4770483

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	Accession
A	1.0000	8	51
A			
A	0.9375	8	60
A			
A	0.9375	8	53
A			
A	0.9375	8	55
A			
A	0.9375	8	57
A			
A	0.9286	7	50
A			
A	0.9286	7	45
A			
A	0.8750	8	62
A			
A	0.8750	8	52
A			
A	0.8750	8	44
A			
A	0.8750	8	43
A			
A	0.8750	8	47
A			
A	0.8750	8	63
A			

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

The ANOVA Procedure

Student-Newman-Keuls Test for **Percentage Survival**

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	Accession
A	0.8125	8	64
A			
A	0.8125	8	56
A			
A	0.8125	8	65
A			
A	0.8125	8	59
A			
A	0.7500	8	58
A			
A	0.7500	8	46
A			
A	0.7500	8	61
A			
A	0.7143	7	48
A			
A	0.6875	8	49
A			
A	0.6667	6	42
A			
A	0.5714	7	54

The ANOVA Procedure

Dependent Variable: Height **Rating**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	280386.702	12190.726	2.39	0.0009
Error	158	804645.100	5092.691		
Corrected Total	181	1085031.802			

R-Square	Coeff Var	Root MSE	Height Mean
0.258413	28.55779	71.36309	249.8901

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	280386.7019	12190.7262	2.39	0.0009

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

The ANOVA Procedure

Dependent Variable: Vigor **Vigor Rating**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	40.8539148	1.7762572	2.29	0.0015
Error	158	122.3383929	0.7742936		
Corrected Total	181	163.1923077			

R-Square	Coeff Var	Root MSE	Vigor Mean
0.250342	22.87843	0.879940	3.846154

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	40.85391484	1.77625717	2.29	0.0015

The ANOVA Procedure

Dependent Variable: Seed_Num **Seed Number**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	96780.2139	4207.8354	0.95	0.5359
Error	158	701609.2807	4440.5651		
Corrected Total	181	798389.4945			

R-Square	Coeff Var	Root MSE	Seed_Num Mean
0.121219	209.2123	66.63756	31.85165

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	96780.21385	4207.83538	0.95	0.5359

15:15 Wednesday, February 27, 2008 8

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Dependent Variable: Seed_Percent **Seed Percentage**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	2.70728022	0.11770784	0.69	0.8472
Error	158	26.81607143	0.16972197		
Corrected Total	181	29.52335165			

R-Square	Coeff Var	Root MSE	Seed_Percent Mean
0.091700	73.15037	0.411973	0.563187

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	2.70728022	0.11770784	0.69	0.8472

The ANOVA Procedure

Dependent Variable: Caliper **Basal Caliper**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	16790.75413	730.03279	2.19	0.0025
Error	158	52615.30034	333.00823		
Corrected Total	181	69406.05447			

R-Square	Coeff Var	Root MSE	Caliper Mean
0.241921	29.18827	18.24851	62.52003

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	16790.75413	730.03279	2.19	0.0025

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

The ANOVA Procedure

Dependent Variable: DBH **Diameter Breast High**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	9200.46764	400.02033	2.34	0.0011
Error	158	27000.48790	170.88916		
Corrected Total	181	36200.95554			

R-Square	Coeff Var	Root MSE	DBH Mean
0.254150	45.01914	13.07246	29.03755

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Accession	23	9200.467638	400.020332	2.34	0.0011

The ANOVA Procedure

Student-Newman-Keuls Test for **Height**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha 0.05
Error Degrees of Freedom 158
Error Mean Square 5092.691
Harmonic Mean of Cell Sizes 7.486075

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6	7	8	9
Critical Range	72.853258	87.27417	95.77797	101.78828	106.41653	110.1675	113.31329	116.01715

Number of Means	10	11	12	13	14	15	16	17
Critical Range	118.38461	120.48776	122.37796	124.09308	125.66182	127.10643	128.44449	129.69015

Number of Means	18	19	20	21	22	23	24
Critical Range	130.85495	131.9484	132.97846	133.95184	134.87426	135.75061	136.58513

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
	A	309.63	8	55
	A			
	A	306.75	8	57
	A			
	A	295.25	8	53
	A			
	A	289.50	8	56
	A			
	A	286.00	7	45
	A			
	A	282.58	6	48
	A			
	A	281.19	8	62
	A			
B	A	273.71	7	61
B	A			
B	A	263.00	7	50
B	A			
B	A	261.31	8	63
B	A			
B	A	260.69	8	44
B	A			
B	A	257.63	8	47
B	A			
B	A	254.94	8	65
B	A			

The ANOVA Procedure

Student-Newman-Keuls Test for **Height**

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
B	A	247.38	8	59
B	A			
B	A	246.21	7	46
B	A			
B	A	238.38	8	60
B	A			
B	A	238.19	8	58
B	A			
B	A	225.19	8	52
B	A			
B	A	217.40	5	42
B	A			
B	A	215.13	8	64
B	A			
B	A	214.25	8	43

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

B	A			
B	A	194.21	7	54
B	A			
B	A	186.31	8	49
B				
B		150.25	8	51

Student-Newman-Keuls Test for **Vigor Rating**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	158
Error Mean Square	0.774294
Harmonic Mean of Cell Sizes	7.486075

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6	7	8	9
Critical Range	0.898314	1.0761305	1.1809862	1.2550961	1.3121645	1.3584158	1.3972048	1.4305446

Number of Means	10	11	12	13	14	15	16	17
Critical Range	1.4597364	1.4856692	1.5089762	1.5301245	1.5494677	1.5672804	1.5837794	1.5991389

Number of Means	18	19	20	21	22	23	24
Critical Range	1.6135014	1.6269841	1.6396852	1.6516875	1.6630614	1.6738672	1.6841572

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
	A	4.9375	8	51
	A			
B	A	4.5625	8	43
B	A			
B	A	4.5000	8	64
B	A			
B	A	4.4000	5	42
B	A			
B	A	4.2857	7	54
B	A			
B	A	4.2500	8	52
B	A			
B	A	4.1429	7	50
B	A			
B	A	4.1250	8	49

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

B	A			
B	A	4.0625	8	58
B	A			
B	A	4.0000	6	48
B	A			
B	A	3.9375	8	60
B	A			
B	A	3.9286	7	46
B	A			
B	A	3.7857	7	45
B	A			

Student-Newman-Keuls Test for **Vigor Rating**

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
B	A	3.7500	8	44
B	A			
B	A	3.6250	8	59
B	A			
B	A	3.5625	8	65
B	A			
B	A	3.4375	8	47
B	A			
B	A	3.4375	8	53
B	A			
B	A	3.4375	8	55
B	A			
B	A	3.3750	8	63
B	A			
B	A	3.3125	8	62
B	A			
B	A	3.3125	8	56
B				
B		3.2143	7	61
B				
B		3.1875	8	57

Student-Newman-Keuls Test for **Seed Number**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	158
Error Mean Square	4440.565
Harmonic Mean of Cell Sizes	7.486075

NOTE: Cell sizes are not equal.

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Number of Means	2	3	4	5	6	7	8	9
Critical Range	68.029058	81.495045	89.43574	95.048061	99.369831	102.87243	105.80991	108.33472

Number of Means	10	11	12	13	14	15	16	17
Critical Range	110.54541	112.50929	114.27433	115.87588	117.34074	118.68969	119.93915	121.10232

Number of Means	18	19	20	21	22	23	24
Critical Range	122.18999	123.21103	124.17288	125.08181	125.94315	126.76147	127.54073

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	Accession
A	88.75	8	63
A			
A	80.71	7	61
A			
A	64.50	8	62
A			
A	62.86	7	50
A			
A	49.00	8	65
A			
A	44.13	8	58
A			
A	39.81	8	52
A			
A	39.06	8	53
A			
A	34.38	8	44
A			
A	33.36	7	54
A			
A	27.71	7	46
A			
A	27.56	8	43
A			
A	26.14	7	45
A			

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Student-Newman-Keuls Test for **Seed Number**

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	Accession
A	23.50	8	57
A			
A	23.00	8	59
A			
A	21.42	6	48
A			
A	19.30	5	42
A			
A	18.13	8	56
A			
A	12.06	8	47
A			
A	8.25	8	49
A			
A	7.88	8	51
A			
A	6.75	8	64
A			
A	4.75	8	60
A			
A	3.06	8	55

Student-Newman-Keuls Test for **Seed Percentage**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha 0.05
Error Degrees of Freedom 158
Error Mean Square 0.169722
Harmonic Mean of Cell Sizes 7.486075

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6	7	8	9
Critical Range	0.4205759	0.5038266	0.5529184	0.5876154	0.6143339	0.635988	0.6541484	0.6697575

Number of Means	10	11	12	13	14	15	16	17
Critical Range	0.6834246	0.6955659	0.7064779	0.7163792	0.7254354	0.733775	0.7414995	0.7486906

Number of Means	18	19	20	21	22	23	24
Critical Range	0.7554149	0.7617273	0.7676737	0.773293	0.778618	0.7836772	0.7884948

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	Accession
A	0.7500	6	48
A			
A	0.7500	8	53
A			
A	0.6875	8	44
A			
A	0.6875	8	65
A			
A	0.6875	8	56
A			
A	0.6875	8	57
A			
A	0.6429	7	61
A			
A	0.6250	8	58
A			
A	0.6250	8	62
A			
A	0.6250	8	47
A			
A	0.6250	8	49
A			
A	0.6000	5	42
A			
A	0.5714	7	45
A			

Student-Newman-Keuls Test for **Seed Percentage**

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	Accession
A	0.5625	8	43
A			
A	0.5625	8	55
A			
A	0.5000	7	46
A			
A	0.5000	7	50
A			
A	0.5000	8	63
A			
A	0.4375	8	52
A			
A	0.4375	8	64
A			
A	0.4375	8	59

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

A			
A	0.3750	8	60
A			
A	0.3571	7	54
A			
A	0.3125	8	51

Student-Newman-Keuls Test for **Basal Caliper**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	158
Error Mean Square	333.0082
Harmonic Mean of Cell Sizes	7.486075

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6	7	8	9
Critical Range	18.62957	22.317193	24.49173	26.028649	27.212154	28.17133	28.975751	29.667164

Number of Means	10	11	12	13	14	15	16	17
Critical Range	30.272556	30.810359	31.293709	31.732289	32.133437	32.502843	32.845004	33.163537

Number of Means	18	19	20	21	22	23	24
Critical Range	33.46139	33.741	34.004401	34.253309	34.489184	34.713279	34.926677

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
	A	76.898	8	57
	A			
B	A	76.371	8	53
B	A			
B	A	74.289	8	55
B	A			
B	A	72.081	8	65
B	A			
B	A	69.662	7	61
B	A			
B	A	68.565	8	63
B	A			
B	A	68.531	8	56
B	A			
B	A	68.468	8	47
B	A			
B	A	68.393	6	48
B	A			
B	A	66.944	8	59

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

B	A			
B	A	66.228	8	62
B	A			
B	A	66.110	7	45
B	A			
B	A	65.079	7	50
B	A			

Student-Newman-Keuls Test for **Basal Caliper**

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
B	A	64.891	8	44
B	A			
B	A	63.357	8	58
B	A			
B	A	57.361	8	60
B	A			
B	A	54.771	8	49
B	A			
B	A	53.622	8	52
B	A			
B	A	53.510	7	46
B	A			
B	A	50.909	7	54
B	A			
B	A	50.435	8	43
B	A			
B	A	49.418	8	64
B	A			
B	A	47.630	5	42
B				
B		41.928	8	51

Student-Newman-Keuls Test for **Diameter Breast High**

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	158
Error Mean Square	170.8892
Harmonic Mean of Cell Sizes	7.486075

NOTE: Cell sizes are not equal.

Number of Means	2	3	4	5	6	7	8	9
Critical Range	13.345431	15.987087	17.544833	18.645816	19.493629	20.180742	20.756995	21.252294

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

Number of Means	10	11	12	13	14	15	16	17
Critical Range	21.685971	22.07123	22.417481	22.731661	23.019027	23.283653	23.528763	23.756947

Number of Means	18	19	20	21	22	23	24
Critical Range	23.970316	24.170617	24.359306	24.537613	24.706583	24.867116	25.019985

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
	A	41.006	8	57
	A			
B	A	36.994	8	55
B	A			
B	A	36.875	8	53
B	A			
B	A	36.373	6	48
B	A			
B	A	35.758	7	45
B	A			
B	A	35.196	8	65
B	A			
B	A	35.177	7	50
B	A			
B	A	33.906	8	59
B	A			
B	A	33.250	8	63
B	A			
B	A	33.155	7	61
B	A			
B	A	31.325	8	56
B	A			
B	A	30.868	8	62
B	A			
B	A	30.428	8	47
B	A			

Student-Newman-Keuls Test for **Diameter Breast High**

Means with the same letter are not significantly different.

SNK Grouping		Mean	N	Accession
B	A	28.836	8	44
B	A			
B	A	27.069	8	58
B	A			
B	A	26.720	7	46
B	A			
B	A	24.855	8	60

Appendix 3 – Bur oak provenance study, Analysis of Variance (ANOVA).

B	A			
B	A	23.836	8	52
B	A			
B	A	23.189	8	43
B	A			
B	A	20.629	8	64
B	A			
B	A	20.174	5	42
B	A			
B	A	19.259	8	49
B	A			
B	A	17.709	7	54
B				
B		13.244	8	51

II. INITIAL SEED INCREASE

Study Title: Seed and Plant 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 2009, breeder blocks of two grass species and a shrub produced approximately 5.3 kg (12 lb) of seed. The initial seed increase of one accession produced approximately 1.5 kg (3 lb) clean seed at the Center (Table 1).

Seed harvested from reimbursable projects totaled 45 kg (94 lb), including approximately 5.5 kg (12 lb) from three grass/grass-like species, two forbs, and two shrubs for the DATR project; approximately 1.6 kg (3.6 lb) from three grass/grass-like accessions and two forbs for Glacier National Park; and 35 kg (78 lb) from five grasses for Yellowstone National Park.

Table 1. Initial Seed Increase. Seed harvested in 2009 from Initial Evaluation Plantings, Initial Seed Increase, and Breeder Blocks at the Bridger Plant Materials Center.

Genus and Species	Accession	Field	Harvest Date	Clean Seed	
				lb	*kg*
Breeder Blocks (B.B.)					
Alopecurus arundinaceus	Garrison	2	6/30	1.500	0.680
Krascheninnikovia lanata	Open Range	7W	10/22	1.200	0.544
Pascopyrum smithii	Rosana	2	8/20	5.000	2.268
P. smithii	Rosana	21	8/13	4.000	1.814
			B.B. Subtotal	11.700	5.306
Initial Seed Increase (ISI), PMC					
Elymus elymoides	9019219	21	7/08	3.090	1.402
			PMC Subtotal	3.090	1.402
Initial Seed Increase, Warren Air Force Base (WAFB)					
Helianthus pumilus	9087382	2	9/10	4.550	2.064
			WAFB Subtotal	4.550	2.064
ISI Development of Acid-Tolerant Releases (DATR)					
Juncus balticus	9087653	4S	7/10	0.137	0.062
Pascopyrum smithii	9081968	22W	10/15	0.075	0.034
Phacelia hastata	9081832	15	9 and10	0.299	0.135
Potentilla hippiana	9076274	4S	8/25	4.586	2.080
Prunus virginiana	9081326	19	8/19	0.326	0.148
Pseudoroegneria spicata	9081636	20SE	7/16	2.770	1.256
Shepherdia argentea	9081334	30	9 and10	3.870	1.755
			DATR Subtotal	12.063	5.470
Initial Seed Increase, Glacier Park (GNP)					
Carex pachystachya	9078645	4S	7/10	0.657	0.298
Eurybia conspicua	9087433	4S	8/26	0.672	0.305
Festuca idahoensis	9075848	5W6W	7/8	0.500	0.227
Geum macrophyllum	9076144	4S	7/10-8/7	1.530	0.694
Pseudoroegneria spicata	9076127	4N	7/27	0.198	0.090
			GNP Subtotal	3.557	1.614
Initial Seed Increase, Yellowstone Park (YNP)					
Bromus marginatus	9054376	21	7/8	67.900	30.800
Elymus elymoides	9054405	1	7/14-20	0.738	0.335
Elymus trachycaulus	9076211	1	7/29	1.764	0.800
Hesperostipa comata	9081502	1	7/14-19	7.180	3.257
Pseudoroegneria spicata	9063432	1	7/16	0.392	0.178
			YNP Subtotal	77.974	35.370
18 species	22 accessions	-	2009 Grand Total	112.934	51.226

III. SEED AND PLANT INCREASE

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

Study Number: NA

Objective: To maintain adequate seed stocks of all Bridger PMC releases.

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*, numerous *Carex* species, *Geum macrocarpa*, 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 2009. 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.

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.

Table 1. Foundation and Breeders Seed Production, Bridger, MT, 2009.

Scientific Name	Release Name	2009 Production	Field Size	Lot or Field Number
Alopecurus arundinaceus	Garrison breeders	1.5	0.15	Field 2
Atriplex X aptera	Wytana	3.12	1.00	SFD-09-FLD1
Calamovilfa longifolia	Goshen	9	2.90	SFD-09-FLD12
Elymus lanceolatus ssp. lanceolatus	Critana	365	6.64	SFD-09-FLD5/6E
Elymus lanceolatus ssp. lanceolatus	Critana breeders	0	0.10	Field 22
Elymus trachycaulus ssp. trachycaulus	Pryor	147	2.50	SFD-09-FLD18
Elymus trachycaulus ssp. trachycaulus	Copperhead Germplasm	38.8	0.35	SFD-09-FLD20
Elymus trachycaulus ssp. trachycaulus	Copperhead Germplasm	new	0.78	Field 15
Hierochloe odorata	Spirit Germplasm	vegetative	0.10	SFD-09-FLD4
Juniperus scopulorum	Bridger-Select	6.6	2.77	SFD-09-FLD14
Krascheninnikovia lanata	Open Range breeders	1.2	0.05	Field 7W
Krascheninnikovia lanata	Open Range Germplasm	1.8	0.20	SFD-09-FLD12
Leymus cinereus	Trailhead	120	7.50	Field 17
Leymus triticoides	Shoshone	0	1.28	SFD-09-FLD20S
Leymus triticoides	Shoshone	22	0.96	SFD-09-FLD20N
Onobrychis vicifolia	Delaney	54	1.85	Field 16
Onobrychis vicifolia	Delaney	75	1.40	Field 18
Onobrychis vicifolia	Delaney	0	1.40	SFD-09-FLD20
Pascopyrum smithii	Rosana breeders	5	0.15	Field 2
Pascopyrum smithii	Rosana breeders	3	0.08	Field 21
Pascopyrum smithii	Rosana	70	2.00	SFD-09-FLD29
Penstemon eriantherus	Old Works	new	0.22	Field 15
Penstemon eriantherus	Old Works	new	0.10	Field 4
Pinus ponderosa	Hunter Germplasm	2.3	1.71	SFD-09-FLD19
Poa secunda	Opportunity Germplasm	15.25	0.50	SFD-09-FLD21
Poa secunda	Opportunity Germplasm	new	0.78	Field 15
Poa secunda	Opportunity Germplasm	6	0.24	SFD-09-FLD20
Quercus macrocarpa	Ekalaka Germplasm	87	3.20	SFD-09-FLD23
Symphoricarpos albus	Prospectors Germplasm	0	0.20	SFD-09-FLD19
Symphoricarpos occidentalis	Trapper Germplasm	0	0.47	SFD-09-FLD3
	pearl barley	1155		
	Willow Creek WW	3500		

Accession	Release Name	Scientific Name (Symbol) /	Lot Number	DandandD Number/DandandD	Shipped To	Amt. Shipped
66515	Lutana	Astragalus cicer (ASCI4) / cicer milkvetch	SFD-01-Fld16	MTPMC-09-052 / 9/28/2009	Pamela Scheinost / Pullman,WA	100 g 103.134 g
346419	Wytana	Atriplex aptera (ATAP) / moundscale	SFD-87-FLD101	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	2.436588 g 7 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus	SFD-05-FLD251	MTPMC-09-015 / 4/8/2009	Jim Haverkamp / Riverton,WY	1.1 lbs 1.149051 lbs
432403	Pryor	Elymus trachycaulus ssp. trachycaulus	SFD-05-FLD251	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	2.871936 g 3 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus	SFD-06-	MTPMC-09-041 / 6/10/2009	Greg Fenchel / Los Lunas,NM	0.5 lbs .5270008 lbs
432403	Pryor	Elymus trachycaulus ssp. trachycaulus	SFD-06-	MTPMC-09-030 / 4/30/2009	Pamela / Pullman,WA	200 g 210.8004 g
432403	Pryor	Elymus trachycaulus ssp. trachycaulus	SFD-07-FLD18	MTPMC-09-036 / 5/12/2009	USDA-NRCS, Bridger Plant Materials Center /	0 lbs 2.8 lbs
432403	Pryor	Elymus trachycaulus ssp. trachycaulus	SFD-08-FLD18	MTPMC-09-043 / 8/12/2009	L and H / Pullman,WA	200 lbs 211.0773 lbs
433949	Goshen	Calamovilfa longifolia (CALO) / prairie sandreed	SFD-00-Fld131	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	1.387237 g 1.5 g
434040	Shoshone	Leymus multicaulis (LEMU11) / manystem wildrye	SFD-08-FLD20S	MTPMC-09-017 / 4/6/2009	Arden Bruce / Townsend,MT	33.35136 lbs 35 lbs
436704	Garrison	Alopecurus arundinaceus (ALAR) / creeping meadow foxtail	SFD-06-FLD16	MTPMC-09-042 / 7/6/2009	Dave Stout / Pullman,WA	0.5 lbs 0.5302036 lbs
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-06-FLD5-6E	MTPMC-09-015 / 4/8/2009	Jim Haverkamp / Riverton,WY	1.1 lbs 1.168175 lbs
469235	Critana	Elymus lanceolatus ssp. lanceolatus (ELLAL) / streambank wheatgrass	SFD-07-FLD5/6E	MTPMC-08-050 / 1/29/2009	Katheryn Phesenti / Cheyenne,WY	47.6112 lbs 50 lbs
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-09-041 / 6/10/2009	Greg Fenchel / Los Lunas,NM	0.5 lbs0.5542513 lbs
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-08--FLD27	MTPMC-09-043 / 8/12/2009	L and H / Pullman,WA	250 lbs 278.8399 lbs
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-09-023 / 4/15/2009	Rudy Esquivel / Knox City,TX	1 lbs1.108503 lbs
469236	Rosana	Pascopyrum smithii (PASM) / western wheatgrass	SFD-07-FLD291	MTPMC-09-015 / 4/8/2009	Jim Haverkamp / Riverton,WY	1.3 lbs 1.441053 lbs
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-04-FLD171	MTPMC-09-033 / 5/12/2009	Beth Woodson / Billings,MT	3.5 lbs 4.076907 lbs
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-04-FLD171	MTPMC-09-038 / 5/27/2009	Beth Woodson / Billings,MT	7 lbs8.153813 lbs
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-04-FLD171	MTPMC-09-015 / 4/8/2009	Jim Haverkamp / Riverton,WY	8.2 lbs 9.55161 lbs
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-09-041 / 6/10/2009	Greg Fenchel / Los Lunas,NM	0.5 lbs 0.5300271 lbs
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-05-FLD171	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	1.886696 g 2 g

Accession	Release Name	Scientific Name (Symbol) /	Lot Number	DandandD Number/DandandD	Shipped To		Amt. Shipped
478831	Trailhead	Leymus cinereus (LECI4) / basin wildrye	SFD-06-	MTPMC-09-057 / 10/28/2009	Jim Jacobs / Bozeman,MT	10 lbs	11.27665 lbs
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian	SFD-03-FLD181	MTPMC-09-061 / 11/17/2009	Roger Hybner / Bridger,MT	4 lbs	4.221502 lbs
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian	SFD-03-FLD201	MTPMC-09-015 / 4/8/2009	Jim Haverkamp / Riverton,WY	15 lbs	15.33065 lbs
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian	SFD-03-FLD201	MTPMC-09-043 / 8/12/2009	L and H / Pullman,WA	400 lbs	404.6879 lbs
478833	Rimrock	Achnatherum hymenoides (ACHY) / Indian	SFD-04-FLD201	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	1.977426 g	2 g
478834	Antelope	Dalea candida (DACA7) /w.prairie clover	SFD-07-FLD131	MTPMC-09-001 / 1/2/2009	Brett Allen / Sidney,MT	3 lbs	3.104269 lbs
478834	Antelope	Dalea candida (DACA7) /w.prairie clover	SFD-04-FLD021	MTPMC-09-033 / 5/12/2009	Beth Woodson / Billings,MT	17 lbs	17.17687 lbs
478834	Antelope	Dalea candida (DACA7) / w.prairie clover	SFD-06-FLD131	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	0.95952 g	1 g
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian	SFD-06-FLD07	MTPMC-09-015 / 4/8/2009	Jim Haverkamp / Riverton,WY	0.8 lbs	0.8606454 lbs
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian	SFD-07-FLD7E	MTPMC-09-004 / 3/10/2009	Christina Smith / Lockeford,CA	25 lbs	28.32499 lbs
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian	SFD-07-FLD7E	MTPMC-09-005 / 3/17/2009	Steve McDonnell / Three Forks,MT	145.6311 lbs	165 lbs
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian	SFD-08-FLD7E	MTPMC-09-041 / 6/10/2009	Greg Fenchel / Los Lunas,NM	0.5 lbs	0.5407165 lbs
9027398	Bozoisky-	Psathyrostachys juncea (PSJU3) / Russian	SFD-08-FLD7E	MTPMC-09-005 / 3/17/2009	Steve McDonnell / Three Forks,MT	95.61388 lbs	103.4 lbs
9057902	Great	Achillea millefolium var. occidentalis	SFD-06-FLD241	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	0.214578 g	0.25 g
9057902	Great	Achillea millefolium var. occidentalis	SFD-06-FLD241	MTPMC-09-002 / 2/17/2009	Mike Knudson / Bismarck,ND	2 g	2.330155 g
9078388	Prospectors	Symphoricarpos albus (SYAL) / snowberry	VFD-08-DATRF19	MTPMC-09-011 / 3/20/2009	Beth Graham / Bridger,MT		39 ea
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-08-058 / 3/3/2009	Delbert Winterfeld / Swan Valley,ID	60 lbs	65.48531 lbs
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-	MTPMC-09-031 / 4/30/2009	Ray Bremer / Wheatland,WY	1 lbs	1.299464 lbs
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-09-003 / 3/3/2009	Darlene Hilkin / Pullman,WA	50 lbs	54.57109 lbs
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-05-FLD161	MTPMC-09-049 / 9/3/2009	Vicki Bradley / Pullman,WA	572.4083 g	695 g
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-05-FLD161	MTPMC-09-042 / 7/6/2009	Dave Stout / Pullman,WA	0.5 lbs	0.6070842 lbs
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-05-FLD161	MTPMC-09-041 / 6/10/2009	Greg Fenchel / Los Lunas,NM	0.5 lbs	0.6070842 lbs
9078408	High Plains	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-FLD13	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	0.916236 g	1 g
9078666	Foot Hills	Poa compressa (POCO) / Can. bluegrass	SFD-00-Fld121	MTPMC-09-030 / 4/30/2009	Pamela / Pullman,WA	100 g	112.9178 g
9081620	Copperhead	Elymus trachycaulus (ELTR7) / slender	SFD-07-	MTPMC-09-008 / 3/16/2009	Kevin Jensen / Logan,UT	11.80753 g	12 g
9081620	Copperhead	Elymus trachycaulus (ELTR7) / slender	SFD-07-	MTPMC-09-037 / 5/22/2009	Mike Moore / Powell,WY	48 lbs	49.2802 lbs
9081627	Washoe	Leymus cinereus (LECI4) / basin wildrye	SFD-06-DATC-	MTPMC-09-008 / 3/16/2009	Kevin Jensen / Logan,UT	11.19427 g	12 g
9081627	Washoe	Leymus cinereus (LECI4) / basin wildrye	SFD-03-DATC-	MTPMC-09-033 / 5/12/2009	Beth Woodson / Billings,MT	2.5 lbs	2.764508 lbs
9081633	Opportunity	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-DATC-	MTPMC-09-055 / 10/13/2009	Rayma Cates / American Falls,ID	0.2 lbs	0.2202993 lbs
9081633	Opportunity	Poa secunda (POSE) / Sandberg bluegrass	SFD-06-DATC-	MTPMC-09-008 / 3/16/2009	Kevin Jensen / Logan,UT	8.881199 g	10 g
9081843	Hunter	Pinus ponderosa (PIPO) / ponderosa pine	SFD-06-FLD19	MTPMC-09-029 / 4/28/2009	Randy Moench / Fort Collins,CO	119.7 g	200 g
9081843	Hunter	Pinus ponderosa (PIPO) / ponderosa pine	SFD-06-FLD19	MTPMC-09-060 / 11/16/2009	Mark Lovell / Mora,NM	119.7 g	200 g
9081988	Stillwater	Ratibida columnifera (RACO3) /coneflower	SFD-06-FLD131	MTPMC-09-020 / 4/23/2009	Richard Sparks / Center,CO	0.457976 lbs	0.5 lbs
9081988	Stillwater	Ratibida columnifera (RACO3) / coneflower	SFD-06-FLD131	MTPMC-09-063 / 12/30/2009	Jennifer Lyman / Billings,MT	0.492822 g	0.5 g
9081988	Stillwater	Ratibida columnifera (RACO3) / coneflower	SFD-06-FLD131	MTPMC-09-039 / 6/10/2009	Richard Avila / Denver,CO	20 lbs	21.83521 lbs
9081988	Stillwater	Ratibida columnifera (RACO3) / coneflower	SFD-06-FLD131	MTPMC-09-043 / 8/12/2009	L and H / Pullman,WA	200 lbs	202.913 lbs
9087640	Delaney	Onobrychis viciifolia (ONVI) / sainfoin	SFD-08-FLD16	MTPMC-09-016 / 4/6/2009	Pamela Scheinost / Pullman,WA	2 lbs	2.542324 lbs

IV. COMPARATIVE EVALUATION PLANTINGS (CEPs)

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

Study Number: MT-00-0006

Study Objective: To compare the performance of local seed sources of woody plants to non-local seed sources.

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 ~18 mi^2 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, *Pinus ponderosa* ponderosa pine, *Shepherdia argentea* silver buffaloberry, *Rosa woodsii* Woods' rose, *Symphoricarpos albus* common snowberry, *Symphoricarpos occidentalis* western snowberry, and *Ribes cereum* wax currant 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	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) and 2009 (September 7). 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 plant mortality.

Results: Overall percentage survival of the entrees in the Woody CEP after 1 year (2001) was local 91.4% and non-local 79.2%) (Table 3). The edaphic conditions have taken their toll, as survival has decreased each subsequent year; 2002—local 84.3% and non-local 52.5%, 2003—local 73.6% and non-local 43.8%, 2004—local 70.7% and non-local 40%, 2005 local 61.4% and non-local 37.5%, 2006-local 58.6% and non-local 32.9% 2007-local 55.7% and non-local 29.2%, 2008-local 53.6% and non-local 26.7%, and 2009—local 51.4% and non-local 24.6%. 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:

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

Table 2. Seed origin 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. and C. Lawson	Deer Lodge Co., MT	5850
P. ponderosa P. and C. Lawson	Lawrence Co., SD	5500
P. ponderosa P. and 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

Precipitation in Anaconda, therefore, was probably not a major factor in plant mortality.

In all species except *Symphoricarpos occidentalis,* the “local” source had equal or better survival than the “non-local” sources. As shown in Table 3, the superior accessions included *Pinus ponderosa* (Deer Lodge County, MT), *P. ponderosa* (Lawrence County, SD), *R. cereum* (Deer Lodge County, MT), *Symphoricarpos albus* (Deer Lodge County, MT), and *Shepherdia argentea* (Deer Lodge County, MT). Based on survival and growth, the best overall performing species have been *Pinus ponderosa,* followed by *Symphoricarpos albus, Shepherdia argentea, Ribes cereum, and Rosa woodsii.* All accessions of *Pinus contorta* have performed poorly.

Mean height growth data appears in Table 4. Mean height growth over the first 4-year period for the local source material was 14.99 cm (5.9 inches), while the non-local material averaged 10.33 cm (4.07 inches) of growth. In 2005, the local material averaged 13.44 cm of growth, while the non-local averaged 8.7 cm. In 2006, the local material averaged 3.59 cm of growth, while the non-local averaged 1.71 cm. In 2007, the local material averaged 0.489 cm and the non-local averaged 5.12 cm. Mean height data for 2008 and 2009 will be analyzed at the conclusion of study.

Generally, the local source material outgrew the non-local material except for the two snowberry species, *Symphoricarpos albus* and *Symphoricarpos occidentalis,* and the lodgepole pine (*Pinus contorta)*. Some

of the shrubs exhibited leader mortality or cropping by wildlife, which resulted in negative overall growth. The accessions with the greatest sustained growth were *Shepherdia argentea* (Deer Lodge County), *Symphoricapos occidentalis* (Wyoming source), *Rosa woodsii* (Deer Lodge County), and *Symphoricarpos albus* (Ravalli County).

Vigor rating was evaluated on a scale from 1 to 9 (1=best vigor) based on a visual assessment of plant vigor or robustness (Table 5). Dead plants were entered as missing values. The vigor rating for local source material was somewhat better than the non-local source material, but not significantly so: 2001—local 3.8 versus non-local 5.4, 2002—local 3.9 versus non-local 4.8, 2003--local 5.1 versus non-local 5.9, 2004--local 5.1 versus non-local 5.9, 2005--local 5.4 versus non-local 5.5, 2006—local 5.4 versus non-local 5.5, and 2007---local 5.2 versus non-local 5.7. There were no obvious variations in vigor based on species or origin, although local material had slightly better vigor rating than non-local.

The top-ranking accession for vigor was *Shepherdia argentea* (Deer Lodge County) followed by *Ribes cereum* (Deer Lodge County). *R. cereum* and *S. argentea* have consistently out-performed non-local sources since establishment. As in other categories, the lodgepole pine *Pinus contorta* accessions had the poorest overall performance. Vigor rating for 2008 and 2009 data will be analyzed at the conclusion of the study.

Table 3. DATR Woody CEP: percentage survival, 2002 through 2009.

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

Table 4. DATR Woody Comparative Evaluation Planting, mean height growth, 2002 through 2009.

Replication	2002 Mean Height Growth	2003 Mean Height Growth	2004 Mean Height Growth	2005 Mean Height Growth	2006 Mean Height Growth	2007 Mean Height Growth	2008 Mean Height Growth	2009 Mean. Height Growth
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
PICO 9078320	10.06	10.19	11.83	14.00	17.40	20.93	25.00	26.33
PICO m039ID0002	12.83	16.33	16.00	16.50	16.00	0	0	0
PICO m038WY0002	14.50	15.67	18.00	20.50	20.00	19.05	21.50	23.00
PIPO 9081318	24.68	27.38	25.79	31.26	32.32	30.65	31.69	34.50
PIPO m04CO0002	14.29	14.74	13.65	14.13	11.90	16.92	13.60	11.00
PIPO m020SD9903	26.80	32.10	31.47	38.32	41.63	46.99	61.00	65.07
RICE 9081329	25.50	47.15	52.00	78.67	93.92	89.33	114.25	111.46
RICE m024CO0003	12.31	24.00	25.60	46.88	56.75	57.02	78.14	71.63
ROWO 9081638	26.07	35.85	39.39	57.27	57.50	58.68	65.00	64.60
ROWO m076CO0003	9.00	5.00	4.00	0	0	0	0	0
ROWO m07MT0003	12.00	28.50	21.67	50.50	46.00	53.35	50.50	49.00
SHAR 9081334	29.88	37.94	41.69	73.93	79.93	84.18	98.30	85.36
SHAR m022WY0005	5.58	7.79	12.67	20.14	33.25	44.00	46.00	40.00
SHAR m015UT9901	9.20	13.25	15.00	31.50	24.00	38.10	57.50	67.00
SYAL 9078388	18.67	25.06	28.53	30.50	29.00	27.09	30.56	28.73
SYAL m045MT003	18.33	30.33	33.67	40.50	45.67	49.78	54.60	57.20
SYOC 9081639	18.06	16.09	18.62	26.50	27.25	29.88	31.75	28.00
SYOC m021WY0004	24.79	40.57	37.53	55.69	59.55	59.69	67.90	76.73
SYOC m018CO9904	16.61	22.79	23.71	35.93	36.39	41.42	39.55	44.60

Table 5. DATR Woody Comparative Evaluation Planting, vigor rating, 2002 through 2009

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

- *Vigor rating: 1+best vigor; 4=average vigor; 9=mortality

References

Bradshaw. A.D., M.O. Humphreys, and M.S. Johnson. 1978. The value of heavy metal tolerance in the revegetation of metalliferous mine wastes, pp. 311-333. *In*: Environmental Management of Mineral Wastes. G.T. Goodman and M.J. Chadwick (eds.). Sijthoff and Noordhoff, Alphen aan den Rejn, The Netherlands.

Dutton, B. 1992, August 27. Old Works Revegetation Project, Planting Trials Survival Analysis. ARCO Report, 11 p. Atlantic Richfield Company, Anaconda, MT.

Eliason, L. 1959, August. Anaconda Mineral Company Memorandum, Tailing Area Tree Planting Status Report. Montana Historical Archives, Boxes 90 and 91, Helena, MT

Gordon, R. 1984, December. Container Seedling Plots at Anaconda. Anaconda Minerals Company Internal Correspondence, MSE Records Library, Butte, MT.

Keammerer, Warren R. 1995, July. U.S. District Court, District of Montana, Helena Division. State of Montana vs. ARCO No. cv-83-317-HLN-PGH. Expert Report of Warren Keammerer. July 13, 1995.

Reclamation Research Unit and Schafer and Associates. 1993. Streambank Tailing and Revegetation Studies, STARS Phase III, Final Report. Montana Department of Health and Environmental Sciences, Helena, MT.

Reclamation Research Unit. 1997, July. Anaconda Revegetation Treatability Studies, Phase IV: Monitoring and Evaluation, Volume 1. Montana State University, Bozeman, MT 59717-0290. Document No.: ASSS-ARTS-IV-FR-073197.

Smith, R.A. and A.D. Bradshaw. 1972. Stabilization of toxic mine wastes by the use of tolerant plant populations. Trans. Inst. of Mining and Metallurgy 81:A230-238.

Study Title: Stucky Ridge Comparative Evaluation Planting (Development of Acid Tolerant Releases Project)

Study Number: MT-03-0008

Objective: To select native plant populations demonstrating tolerance to the environmental conditions in the Anaconda, Montana, area for use in reclamation and restoration activities.

Site Conditions: Located on Stucky Ridge, the CEP site is approximately 2 miles northeast of Anaconda, Montana, in Deer 1/4 of Section 30, Range 11 West, Township 5 North and North 46°09'09"/ West 112°54'30". The study plot occupies 1.5 acres in subpolygon OWSR-013.09, which is part of the Stucky Ridge Remedial Design Unit (RDU) #1 within the Anaconda Regional Water, Waste, and Soils Operable Unit.

RDU #1 encompasses 242 acres of the ~13,000 acres of upland terrestrial vegetation contaminated by emission fallout from the Washoe, as well as the Upper and Lower Works smelters. Concerns identified in the Stucky Ridge RDU include elevated arsenic concentrations in surface soils, barren or sparsely vegetated areas due to low pH and elevated contaminant concentrations, and steep slopes with high erosion potentials (ARCO 2002, May) (Table 1). Current and historic use of the area primarily consists of agricultural grazing, recreation, and open space/wildlife habitat.

The plot is situated on a stream terrace above Lost Creek at an elevation of 5,308 feet and covers most of the relatively flat ground on the east end of Stucky Ridge. Vegetation, although sparse, includes scattered groves of quaking aspen, shrublands dominated by Wood's rose, currant species, rubber rabbitbrush, and horsebrush; and grasslands dominated by redtop and basin wildrye. Annual precipitation at the site ranges from 10 to 14 inches with most of the precipitation occurring in the spring. The parent material is alluvium and the soil has a gravelly loam texture, which is well drained. Slope at the plot site averages approximately 5 to 10 percent.

Table 1. Pre-tillage soils data in the proximity of the plot site (ARCO 2002, May).

Soil Sample Station	Depth	As	Cu	Zn	Sat. Paste pH
	inches	*mg/kg*	*mg/kg*	*mg/kg*	*s.u.*
94S-SR-71	0-2	-----	-----	-----	4.70
94S-SR-71	2-8	-----	-----	-----	4.90
94S-SR-73	0-2	-----	-----	-----	4.30
94S-SR-73	2-8	-----	-----	-----	4.60
99-098A	0-2	495.0	1660.0	419.0	-----
99-098B	2-6	163.0	1320.0	276.0	-----
99-098C	0-6	-----	-----	-----	4.20
99-098D	6-12	-----	-----	-----	7.60
99-098E	12-18	-----	-----	-----	7.80
99-099A	0-2	489.0	1370.0	303.0	-----
99-099B	2-6	95.8	1020.0	245.0	-----
99-099C	0-6	-----	-----	-----	4.00
99-099D	6-12	-----	-----	-----	7.30
99-099E	12-18	-----	-----	-----	7.70
99-123A	0-2	656.0	1530.0	425.0	-----
99-123B	2-6	167.0	1530.0	332.0	-----
99-123C	0-6	-----	-----	-----	4.40
99-123D	6-12	-----	-----	-----	4.80
99-123E	12-18	-----	-----	-----	6.30
99-163A	0-2	537.0	2180.0	493.0	-----
99-163B	2-6	256.0	1430.0	365.0	-----
99-163C	0-6	-----	-----	-----	4.00
99-163D	6-12	-----	-----	-----	6.20
99-163E	12-18	-----	-----	-----	-----

Soil Treatment: The study plot site was ameliorated along with the rest of treatment area (OWSR-013.09) following the remedial actions specified in the Remedial Action Work Plan/Final Design Report (ARCO 2002, May). A remedy identified for the treatment area was soil tilling to 12 inches with the addition of a neutralizing amendment to ameliorate the low pH soil conditions. Remediation of the area was performed by Jordan Contracting, Inc. and their subcontractors starting in the fall of 2002. According to the work report from Jordan Contracting, Inc. (Bahr 2003, February 18) prior to tillage, many of the erosion rills and gullies were graded using a D8 Dozer and a CAT 330 excavator. The entire treatment area was pre-tilled by Western Reclamation, Inc. with a Rhome™ disc to approximately 12 inches in mid-September. Lime kiln dust, procured from Continental Lime, Inc., was then applied at a rate of ~22.0 tons/acre to neutralize the soil. Four additional passes were made with the Rhome™ disc to a depth of 12 inches to incorporate the lime. Lime incorporation was completed on November 14, 2002.

In the spring of 2003, fertilizer (12% N, 16%P_2O_5, 30% K_2O) was applied at a rate of 500 bulk pounds per acre and incorporated to 6 inches using a chisel plow. The tillage area was drill seeded in early May 2003 at a rate of 25 lbs/acre with "Revegetation Mix #1." Table 2 below lists the soil characteristics of pre-tillage soil data closest to the study site (northwest portion of treatment area [OWSR-013.09] as stated in the Remedial Action Work Plan/Final Design Report [ARCO 2002, May]).

Table 2. Post-planting grass, forb/sub-shrub, and seed mixture trial (0- to 6-inch) composite soil sample analysis from the Stucky Ridge Comparative Evaluation Planting.

Sample Id.	Sample Description.	pH	As	Cd	Cu	Pb	Zn
		s.u.	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
GR1	Grass Trial, Rep. 1	8.2	120	1	797	35	174
GR2	Grass Trial, Rep. 2	8.1	117	1	906	34	177
GR3	Grass Trial, Rep. 3	7.9	132	1	833	43	195
GR4	Grass Trial, Rep. 4	8.0	212	2	985	61	228
GDR1	Grass Trial, Rep. 1, Duplicate	7.7	121	1	703	39	153
GDR3	Grass Trial, Rep. 3, Alternate	7.7	178	1	845	57	201
FR1	Forb Trial, Rep. 1	8.0	115	1	774	38	185
FR2	Forb Trial, Rep. 2	7.2	127	2	888	45	182
FR3	Forb Trial, Rep. 3	7.7	153	2	1010	45	220
FR4	Forb Trial, Rep. 4	7.6	127	2	1080	40	210
FD1	Forb Trial, Rep. 1, Duplicate	8.0	91	ND†	681	31	170
FD3	Forb Trial, Rep. 3, Duplicate	7.9	106	1	828	33	171
MR1	Seed Mix. Trial, Rep. 1	8.0	39	1	721	6	143
MR2	Seed Mix. Trial, Rep. 2	7.5	367	2	909	97	226
MR3	Seed Mix. Trial, Rep. 3	7.7	39	ND	706	12	161
MR4	Seed Mix. Trial, Rep. 4	7.8	257	2	857	91	209
MDR1	Seed Mix. Trial, Rep. 1, Duplicate	7.4	130	1	925	35	165
MDR3	Seed Mix. Trial, Rep 3, Alternate	8.1	29	ND	525	9	153

† ND: Not detected at the reporting limit.

Post-Treatment Soil Sampling Methods and Results: Soil sampling of the grass, forb/sub-shrub, and seed mixture trials was completed on June 24, 2003, after planting. The soil samples were analyzed for pH (1:1 saturated paste), and total As, Cd, Cu, Pb, and Zn by Energy Laboratories, Inc. in Billings,

Montana. At the grass trial eight randomly selected treatment blocks in each replication were subsampled. The eight (0- to 6-inch, 0- to 15-cm) composite sub-samples collected from a replication were combined and mixed to form one representative sample. Duplicate soil samples were taken in replication 1 and alternate soil samples were taken in replication 3. In the forb/sub-shrub trial, four (0- to 6-inch) sub-samples were taken per replication to form one representative sample. Duplicate sub-samples were taken in replications 1 and 3. In the mixture trial, two (0- to 6-inch) sub-samples were taken per replication to form one representative sample. Duplicate sub-samples were taken in replication 1 and alternate sub-samples were taken in replication 3.

The arsenic and metal concentrations of the post-planting soil samples were generally moderate with the exception of copper. Copper concentrations within the three trials averaged 832 mg/kg and ranged from 525 mg/kg to 1080 mg/kg. The average copper concentrations in the grass, forb/sub-shrub, and seed mixture trials were 845 mg/kg, 877 mg/kg, and 774 mg/kg, respectively. Post-planting soil sample pHs were all above neutral, averaging 7.8 and ranging from 7.2 to 8.2.

Planting Design

The study is arranged as three separate trials (grass, forb/sub-shrub, and seed mixture) each in a Randomized Complete Block Design replicated four times. They are situated adjacent to each other as shown in Figure 1. The grass, forb/sub-shrub, and seed mixture trials are 0.96 acre, 0.44 acre, and 0.14 acre, respectively, with a total plot size of 1.52 acres. Between each replication, as well as between trials, an 8-foot strip of *Elymus trachycaulus* 'Pryor' was planted to minimize edge effect. The seed bed was prepared by DATC Project personnel on April 22, 2003, using a 5-foot box scraper to level the soil. Rocks greater than 6 inches in diameter within the plot boundary were hand-picked. After rock removal, another pass was made with the box scraper and spike-tooth harrow to till out tractor tire compressions.

On May 13, 2003, the seed treatments were planted using a 4-row Kincaid™ cone drill with 1-ft row spacing and a 0.5-inch planting depth. The seeding rate for the grass and forb/sub-shrub trials was 50 Pure Live Seeds (PLS) per linear foot of row. The seeding rate for the seed mixture trial was based on a total seeding rate of 50 PLS per square foot. Each component of the mix was calculated as a percentage of the per-square-foot rate.

The seed mixtures were formulated for two distinct applications. An "Upland" blend was designed for sloping areas with generally low water infiltration and to provide wildlife habitat. The "Waste Management Area" (WMA) blend was designed to provide a vegetative cover for areas in which remedial options appear to be limited and their use for containment of large volumes of waste appears logical (EPA, 1995a). "Developed" seed mixtures are the seed formulations, utilizing commercially available cultivars, currently specified for use in the Remedial Action Work Plan/Final Design Report 2002. The seed mixture previously referred to as Revegetation Mix #1, planted in the surrounding treatment area, is synonymous with the "Upland Developed" seed mixture. "Experimental" seed mixtures are local ecotypes of the same species from mine-impacted lands.

Each treatment block is 8 feet (8 rows) by 25 feet. In the grass and forb/sub-shrub trials, each treatment block was planted with a single accession. Two exceptions exist due to seed quantity restraints. In all replications of the grass trial, *Pascopyrum smithii* 9081968 was drilled in only 6 rows with *Elymus trachycaulus* 'Pryor' drilled into the remaining 2 rows. In all replications of the forb/sub-shrub trial, *Eriogonum ovalifolium* 9082098 was drilled into only 4 rows with *Elymus trachycaulus* 'Pryor' drilled into the remaining 4 rows.

As mentioned above, Elymus trachycaulus 'Pryor' was drilled in the border strips and also broadcast in the unplanted area south of the forb/sub-shrub trial. Wooden stakes spray painted orange and marked with an identification number, were installed in the northeast corner of each treatment block. Lastly, a single-strand, smooth wire fence was installed around the perimeter of the plot to designate plot boundaries and restrict vehicular trespassing. In mid-July and again in mid-September, volunteer Canadian thistle was spot sprayed initially with a 3% solution of 2-4-D Amine and subsequently with a 3% solution of Stinger™ (Copyralid) applied with a backpack sprayer.

	Grass Trial			Rep 1	Rep 2
4 ACHY Nezpar	16 ELTR San Luis	30 POSE Sherman	20 LECI Magnar	10 PHHA 9081632	8 PEST Bandera
24 PASM Rosana	32 POSE 9081635	23 PASM Rodan	36 ELWA Secar	12 POGI 9081679	5 KRLA Op.Range
19 LECI Washoe	22 PASM 9081968	29 POSE Opportunity	11 DECE Nortran	1 EROV 9082098	4 KRLA NCD
28 POAL 1858	2 ACHY 9081629	35 PSSP Goldar	18 LECI 9081625	14 SYCH 9078675	15 SYCH 9081678
26 POAL 01-13-1	15 ELTR Revenue	32 POSE 9081635	10 DECE 13970176	16 SYCH 5255-RS	9 PEVE Clearwater
21 LECI Trailhead	36 ELWA Secar	7 AGGI 9076266	8 AGGI Streaker	6 PEER Old Works	1 EROV 9082098
16 ELTR San Luis	13 ELTR 9081621	21 LECI Trailhead	4 ACHY Nezpar	4 KRLA NCD	6 PEER Old Works
25 POAL 9016273	1 ACHY 9081628	5 AGGI 9076276	30 POSE Sherman	9 PEVE Clearwater	7 PEEA Richfield
11 DECE Nortran	6 AGGI 9081619	1 ACHY 9081628	35 PSSP Goldar	7 PEEA Richfield	3 ERUM 01-206-1
27 POAL Gruening	26 POAL 01-13-1	26 POAL 01-13-1	23 PASM Rodan	11 PHHA 9003	12 POGR 9081679
14 ELTR Pryor	3 ACHY Rimrock	3 ACHY Rimrock	16 ELTR San Luis	3 ERUM 01-206-1	11 PHHA 9003
10 DECE 13970176	19 LECI Washoe	27 POAL Gruening	25 POAL 9016273	15 SYCH 9081678	10 PHHA 9081632
3 ACHY Rimrock	12 ELTR Copperhead	13 ELTR 9081621	29 POSE Opportunity	8 PEST Bandera	2 ERUM 450
12 ELTR Copperhead	27 POAL Gruening	34 PSSP 9081636	12 ELTR Copperhead	13 POHI 9076274	13 POHI 9076274
30 POSE Sherman	17 LECI 9081624	10 DECE 13970176	9 DECE 9076290	5 KRLA Op.Range	16 SYCH 5255-RS
17 LECI 9081624	5 AGGI 9076276	15 ELTR Revenue	27 POAL Gruening	2 ERUM 450	14 SYCH 9078675
36 ELWA Secar	30 POSE Sherman	18 LECI 9081625	6 AGGI 9081619	12 POGI 9081679	11 PHHA 9003
7 AGGI 9076266	10 DECE 13970176	12 ELTR Copperhead	5 AGGI 9076276	9 PEVE Clearwater	10 PHHA 9081632
22 PASM 9081968	11 DECE Nortran	25 POAL 9016273	13 ELTR 9081621	5 KRLA Op.Range	5 KRLA Op.Range
6 AGGI 9081619	34 PSSP 9081636	2 ACHY 9081629	32 POSE 9081635	4 KRLA NCD	13 POHI 9076274
8 AGGI Streaker	18 LECI 9081625	8 AGGI Streaker	2 ACHY 9081629	16 SYCH 5255-RS	6 PEER Old Works
13 ELTR 9081621	8 AGGI Streaker	16 ELTR San Luis	33 POSE 9081322	13 POHI 9076274	8 PEST Bandera
29 POSE Opportunity	33 POSE 9081322	22 PASM 9081968	26 POAL 01-13-1	10 PHHA 9081632	15 SYCH 9081678
18 LECI 9081625	21 LECI Trailhead	11 DECE Nortran	7 AGGI 9076266	15 SYCH 9081678	7 PEEA Richfield
33 POSE 9081322	29 POSE Opportunity	4 ACHY Nezpar	15 ELTR Revenue	11 PHHA 9003	4 KRLA NCD
15 ELTR Revenue	9 DECE 9076290	33 POSE 9081322	22 PASM 9081968	8 PEST Bandera	12 POGR 9081679
35 PSSP Goldar	14 ELTR Pryor	28 POAL 1858	28 POAL 1858	2 ERUM 450	2 ERUM 450
1 ACHY 9081628	23 PASM Rodan	24 PASM Rosana	31 POSE Canbar	1 EROV 9082098	9 PEVE Clearwater
9 DECE 9076290	28 POAL 1858	20 LECI Magnar	14 ELTR Pryor	6 PEER Old Works	1 EROV 9082098
31 POSE Canbar	24 PASM Rosana	36 ELWA Secar	24 PASM Rosana	3 ERUM 01-206-1	14 SYCH 9078675
34 PSSP 9081636	31 POSE Canbar	6 AGGI 9081619	19 LECI Washoe	7 PEEA Richfield	16 SYCH 5255-RS
32 POSE 9081635	4 ACHY Nezpar	31 POSE Canbar	34 PSSP 9081636	14 SYCH 9078675	3 ERUM 01-206-1
2 ACHY 9081629	35 PSSP Goldar	14 ELTR Pryor	17 LECI 9081624	Rep 3	Rep 4
5 AGGI 9076276	20 LECI Magnar	17 LECI 9081624	3 ACHY Rimrock		
23 PASM Rodan	7 AGGI 9076266	9 DECE 9076290	1 ACHY 9081628		
20 LECI Magnar	25 POAL 9016273	19 LECI Washoe	21 LECI Trailhead		
4 WMA Dev	3 WMA Exp	4 WMA Dev	1 UP Exp		
1 UP Exp	2 UP Dev	1 UP Exp	4 WMA Dev		
2 UP Dev	1 UP Exp	3 WMA Exp	3 WMA Exp		
3 WMA Exp	4 WMA Dev	2 UP Dev	2 UP Dev		
Rep 1	Rep 2	Rep 3	Rep 4		

Seed Mixture Trial

Figure 1. Layout of the grass, forb/sub-shrub, and seed mixture trials at the Stucky Ridge Comparative Evaluation Planting.

Seeded Species

The species entries consist of 36 grass accessions representing 9 grass genera, 14 forb accessions representing 5 forb genera, 2 sub-shrub accessions representing 1 sub-shrub species, and 4 seed mixtures representing 2 seed mixture formulations (Tables 3-8). The 15 total genera tested were selected for inclusion in the study based on results from previous Development of Acid/Heavy Metal-Tolerant Cultivars (DATC) Project (currently DATR) studies such as the Initial Evaluation Planting study (Marty 2000, July) and the Greenhouse Comparative Evaluation Planting study (Marty 2001, October).

Each genus tested includes at least one accession originating from metalliferous soil sites in the proximity of the Anaconda Smelter NPL Site, except in one case. Neither of the two *Krascheninnikovia lanata* accessions originated from metalliferous soils. In this report, accessions that originated from metalliferous soils are referred to as “local,” whereas accessions originating from undisturbed soils are referred to as “non-local.”

Sampling Methods

Seedling density was the growth response variable used to assess performance during the first growing season (2003). Measurements were taken using an 11.8- x 19.7-inch (30- x 50-cm) quadrat frame that was randomly placed at five sample locations within each (8- x 25-ft) treatment block. The quadrat was situated with its long axis perpendicular to the seeded rows so that each sampling measurement included two rows. Seedlings rooted within the quadrat frame were counted. Seeded seedlings, as well as non-seeded seedlings, were counted and recorded separately. Photographs of each treatment block were taken during sampling events. Density data was collected on June 24, 2003, to assess emergence and initial establishment and on August 26, 2003, to assess subsequent establishment and/or die off.

Table 3. Forb and sub-shrub treatments included in the forb/sub-shrub trial at the Stucky Ridge Uplands Comparative Evaluation Planting.

Species Id. #	Genus and Species	Accession/Variety	Origin
1	*Eriogonum ovalifolium*	9082098	Deer Lodge County, MT
2	*Eriogonum umbellatum*	9082271	Utah
3	*Eriogonum umbellatum*	9082273	Idaho
4	*Krascheninnikovia lantana*	Northern Cold Desert Germplasm	Composite from UT and ID
5	*Krascheninnikovia lantana*	Open Range Germplasm	Composite from MT and WY
6	*Penstemon eriantherus*	Old Works Germplasm	Deer Lodge County, MT
7	*Penstemon eatonii*	Richfield Selected	Sevier County, UT
8	*Penstemon strictus*	'Bandera' 477980	Torrance County, NM
9	*Penstemon venustus*	Clearwater Selected	Clearwater River area, ID
10	*Phacelia hastata*	9081632	Deer Lodge County, MT
11	*Phacelia hastata*	9082275	California
12	*Potentilla gracilis*	9081679	California
13	*Potentilla hippiana*	9076274	Deer Lodge County, MT
14	*Symphyotrichum chilense*	9078675	Deer Lodge County, MT
15	*Symphyotrichum chilense*	9081678	Colorado
16	*Symphyotrichum chilense*	9082274	Unknown

Table 4. Grass treatments included in the grass trial at the Stucky Ridge Uplands Comparative Evaluation Planting.

Species Id. #	Genus and Species	Accession/Variety	Origin
1	*Achnatherum hymenoides*	9081628	Deer Lodge County, MT
2	*Achnatherum hymenoides*	9081629	Deer Lodge County, MT
3	*Achnatherum hymenoides*	'Rimrock'	Yellowstone County, MT
4	*Achnatherum hymenoides*	'Nezpar'	White Bird, ID
5	*Agrostis gigantea*	9076276	Deer Lodge County, MT
6	*Agrostis gigantea*	9081619	Deer Lodge County, MT
7	*Agrostis gigantea*	9076266	Deer Lodge County, MT
8	*Agrostis gigantea*	'Streaker'	Illinois
9	*Deschampsia caespitosa*	9076290	Silver Bow County, MT
10	*Deschampsia caespitosa*	9082620	California
11	*Deschampsia caespitosa*	'Nortran'	Alaska
12	*Elymus trachycaulus*	Copperhead	Deer Lodge County, MT
13	*Elymus trachycaulus*	9081621	Deer Lodge County, MT
14	*Elymus trachycaulus*	'Pryor'	Carbon County, MT
15	*Elymus trachycaulus*	'Revenue'	Saskatchewan, Canada
16	*Elymus trachycaulus*	'San Luis'	Rio Grande County, CO
17	*Leymus cinereus*	9081624	Deer Lodge County, MT
18	*Leymus cinereus*	9081625	Deer Lodge County, MT
19	*Leymus cinereus*	Washoe Germplasm	Deer Lodge County, MT
20	*Leymus cinereus*	'Magnar'	Saskatchewan, Canada
21	*Leymus cinereus*	'Trailhead'	Musselshell County, MT
22	*Pascopyrum smithii*	9081968[†]	Deer Lodge County, MT
23	*Pascopyrum smithii*	'Rodan'	Morton County, ND
24	*Pascopyrum smithii*	'Rosana'	Rosebud County, MT
25	*Poa alpina*	9016273	Gallatin County, MT
26	*Poa alpina*	01-13-1	British Columbia, Canada
27	*Poa alpina*	'Gruening'	France/Switzerland
28	*Poa alpina*	1858	Unknown
29	*Poa secunda* (*nevadensis*)	Opportunity	Deer Lodge County, MT
30	*Poa secunda* (*ampla*)	'Sherman'	Sherman County, OR
31	*Poa secunda* (*canbyi*)	'Canbar'	Columbia County, WA
32	*Poa secunda*	9081635	Deer Lodge County, MT
33	*Poa secunda*	9081322	Lewis and Clark County, MT
34	*Pseudoroegneria spicata*	9081636	Deer Lodge County, MT
35	*Pseudoroegneria spicata*	'Goldar'	Asotin County, WA
36	*Elymus wawawaiensis*	'Secar'	Washington

Table 5. Upland Areas - Experimental Seed Mix Formulation.

Species Id. #	Genus and Species	Accession/Variety	Origin	Seed Mixture Percentage
1	GRASSES:			
	Achnatherum hymenoides	9081629	Deer Lodge County, MT	15.0
	Elymus trachycaulus	Copperhead	Deer Lodge County, MT	15.0
	Leymus cinereus	Washoe Germ.	Deer Lodge County, MT	15.0
	Pascopyrum smithii	9081968	Deer Lodge County, MT	5.0
	Poa alpina	90816273	Gallatin County, MT	10.0
	Poa secunda (*nevadensis*)	Opportunity	Deer Lodge County, MT	15.0
	Pseudoroegneria spicata	9081636	Deer Lodge County, MT	15.0
	FORBS:			
	Aster chilensis	9078675	Deer Lodge County, MT	2.5
	Penstemon eriantherus	Old Works Germ.	Deer Lodge County, MT	5.0
	Potentilla hippiana	9076274	Silverbow County, MT	2.5

Table 6. Upland Areas - Developed Seed Mix Formulation.

Species Id. #	Genus and Species	Accession/Variety	Origin	Seed Mixture Percentage
2	GRASSES:			
	Achnatherum hymenoides	'Nezpar'	White Bird, ID	5.0
	Elymus lanceolatus	'Critana'	Hill County, MT	15.0
	Elymus trachycaulus	'Revenue'	Saskatchewan, Canada	15.0
	Festuca ovina	'Covar'	Central Turkey	10.0
	Leymus cinereus	'Magnar'	Saskatchewan, Canada	15.0
	Pascopyrum smithii	'Rosana'	Rosebud County, MT	10.0
	Poa secunda (*ampla*)	'Sherman'	Sherman County, OR	14.5
	Pseudoroegneria spicata	'Goldar'	Asotin County, WA	10.0
	FORBS:			
	Achillea lanulosa	Great Northern	Flathead County, MT	2.5
	Artemisia frigida	9082258	Unknown	0.5
	Linum lewisii	'Appar'	Custer County, SD	2.5

Table 7. Waste Management Areas - Experimental Seed Mix Formulation

Species Id. #	Genus and Species	Accession/Variety	Origin	Seed Mixture Percentage
3	GRASSES:			
	Agrostis gigantea	9076276	Deer Lodge County, MT	15
	Deschampsia caespitosa	9076290	Silverbow County, MT	10
	Elymus trachycaulus	Copperhead	Deer Lodge County, MT	15
	Leymus cinereus	Washoe Germ.	Deer Lodge County, MT	15
	Pascopyrum smithii	9081968	Deer Lodge County, MT	5
	Poa secunda (*nevadensis*)	Opportunity	Deer Lodge County, MT	10
	Stipa comata	9078314	Deer Lodge County, MT	10
	FORBS:			
	Aster chilensis	9078675	Deer Lodge County, MT	10

Table 8. Waste Management Areas - Developed Seed Mix Formulation.

Species Id. #	Genus and Species	Accession/Variety	Origin	Seed Mixture Percentage
4	GRASSES:			
	Agropyrum intermedium	'Greenar'	Former USSR	10
	Bromus inermis	'Manchar'	Manchuria, China	15
	Elymus lanceolatus	'Critana'	Hill County, MT	10
	Elymus trachycaulus	'Revenue'	Saskatchewan, Canada	15
	Leymus cinereus	'Magnar'	Saskatchewan, Canada	15
	Poa secunda (*ampla*)	'Sherman'	Sherman County, OR	10
	Stipa viridula	9082255	Washington	10
	FORBS:			
	Medicago sativa	'Ladak'	Kashmir, India	15

Data was collected on June 30/July 1 and again on September 22-23, 2004, on August 29-30, 2005, and on August 28-29, 2006. During the early summer sampling, four randomly located frames (30 x 50 cm) were utilized, from which average plant height was measured, percentage stand was estimated, and ocular estimates of plant vigor were made. Random samples were located along rows 2-3 and 6-7 to avoid edge-effect error. In the fall the same random frame locations were used to estimate percentage stand, plant vigor, plant height (2005) and sample biomass production. If combined biomass samples from all four replications did not yield at least 10 grams of material, additional clipping was done so there would be enough biomass for tissue analysis. All biomass samples were oven dried at 60^0C (140^0F) for 24 hours, weighed, and later cut into small pieces and packaged in plastic zip-lock bags for delivery to Energy Laboratories, Inc. for tissue analysis.

Study Title: Comparative Evaluation Planting of Scarlet Globemallow

Study Number: MT-08-004

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

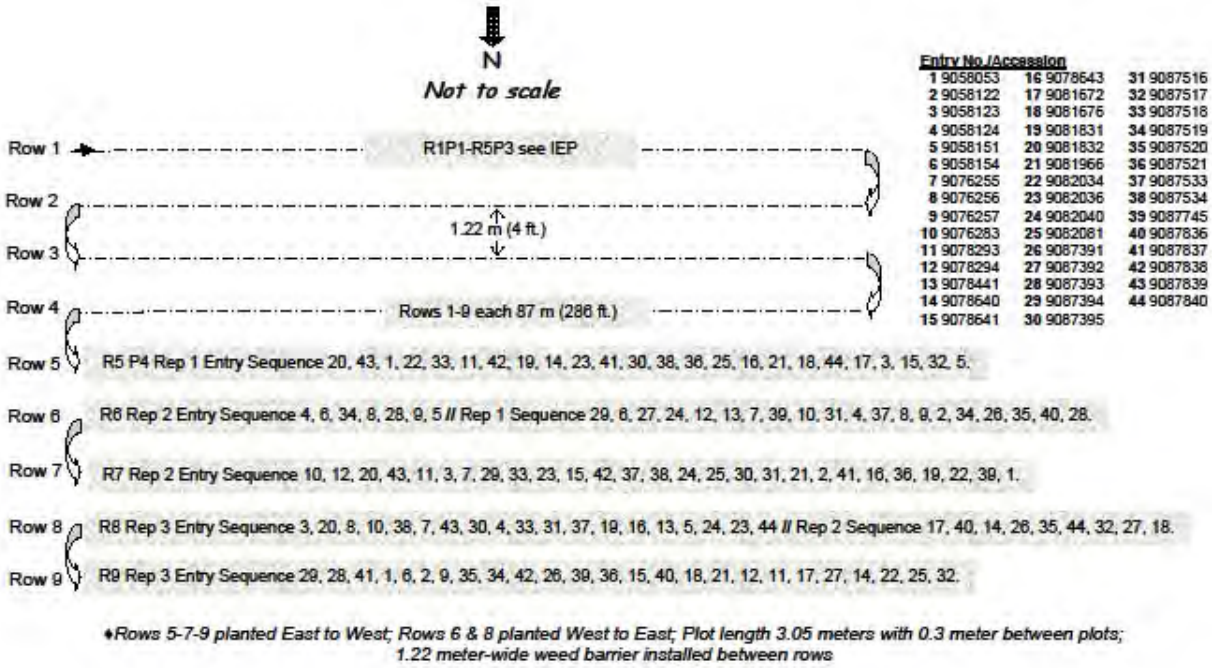
Project Description: Scarlet globemallow *Sphaeralcea coccinea* (Nutt.) Rydb. is a spreading perennial wildflower that is found throughout Great Plains grasslands and occurs naturally from southern British Columbia to western Iowa, south to Texas, and across the western U.S. to eastern Oregon. The generic 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 three to five, 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, so a study plan was developed and approved to continue evaluation and potential selection of this important native species.

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 9Figure 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 (1/2 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).

Results: All plots were evaluated with no emergence. The study was reseeded on November 9, 2009.



Entry No./Accession		
1 9058053	16 9078643	31 9087516
2 9058122	17 9081672	32 9087517
3 9058123	18 9081676	33 9087518
4 9058124	19 9081831	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 9082040	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	

Figure 1. Comparative Evaluation Planting—Scarlet Globemallow *Sphaeralcea coccinea*. The 2009 seeding of 44 accession entries, re-seeded in Field 2 at the Bridger PMC on November 9.

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

Study Numbers: MT-09-0037 and MT-09-0039

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 Ag Research Center (CARC) near Moccasin, and Dr. Darrin Boss, MSU Northern Agriculture 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. 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 percent 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. Data were analyzed using the Statistix 8.2 program.

Results: Stand percentage results for each study appear in Table 1. Analyzed results will be forwarded to cooperating scientists and Montana NRCS Field Offices.

Table 1. Cool season grass stand percentages at CARC and NARC in 2009.

Species	Latin Name	Selection	CARC	NARC
			%	%
Altai wildrye	*Leymus angustus*	Mustang	65.00	69.75
Altai wildrye	*Leymus angustus*	Prairieland	48.75	63.00
many-stemmed wildrye	*Leymus triticoides*	Shoshone	25.00	27.00
basin wildrye	*Leymus cinereus*	Trailhead	63.75	65.00
basin wildrye	*Leymus cinereus*	Washoe	43.75	59.50
Russian wildrye	*Psathyrostachys juncea*	Bozoisky-Select	68.75	81.25
Russian wildrye	*Psathyrostachys juncea*	Mankota	61.25	74.25
tall wheatgrass	*Thinopyrum ponticum*	Jose	75.00	75.50
tall wheatgrass	*Thinopyrum ponticum*	Largo	83.75	78.90
slender wheatgrass	*Elymus trachycaulus*	Pryor	86.25	76.25
slender wheatgrass	*Elymus trachycaulus*	Copperhead	76.25	59.50
thickspike wheatgrass	*Elymus lanceolatus*	Critana	72.50	72.75
thickspike wheatgrass	*Elymus lanceolatus*	Bannock	75.00	72.50
pubescent wheatgrass	*Thinopyrum intermedium*	Manska	90.00	75.75
pubescent wheatgrass	*Thinopyrum intermedium*	Luna	90.00	88.75
western wheatgrass	*Pascopyrum smithii*	Rosana	76.25	78.75
western wheatgrass	*Pascopyrum smithii*	Rodan	70.00	71.25
hybrid wheatgrass	*Elymus hoffmanii*	Newhy	61.25	73.75
hybrid wheatgrass	*Elymus hoffmanii*	AC Saltlander	80.00	77.50
Siberian wheatgrass	*Agropyron fragile*	Vavilov	77.50	72.50
Siberian wheatgrass	*Agropyron fragile*	Vavilov II	67.25	75.75
Indian ricegrass	*Achnatherum hymenoides*	Rimrock	13.75	48.75
Indian ricegrass	*Achnatherum hymenoides*	Nezpar	22.50	65.00
bottlebrush squirreltail	*Elymus elymoides*	Fish Creek	58.75	67.50
bottlebrush squirreltail	*Elymus elymoides*	Wapiti	75.00	57.50
green needlegrass	*Nassella viridula*	Lodorm	32.50	53.75
Nevada bluegrass	*Poa secunda*	Opportunity	7.50	3.750
Sandberg bluegrass	*Poa secunda*	Sherman	11.25	17.50
Sandberg bluegrass	*Poa secunda*	High Plains	6.25	20.50
bluebunch wheatgrass	*Pseudoroegneria spicata*	Goldar	63.75	64.25
bluebunch wheatgrass	*Pseudoroegneria spicata*	Anatone	76.25	68.25
tall fescue	*Lolium arundinaceus*	Bridgestone	56.25	62.50

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.

Conclusions: Individual stand percentages significantly varied between 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 when compared between the two test sites. Both sites had similar sandy loam soils.

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

Study Number: MT-09-0039

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, MT.

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. Assisting with the study is Dr. Darrin Boss, MSU Northern Ag Research Center (NARC). The goal of the study is to compare “newer” versus “older” grass selections 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 percent were replanted under dormant conditions at NARC on November 27, according to the same MT-46 seeding rates used previously. Data were analyzed using the Statistix 8.2 program.

Results: Stand percentage results appear in Table 1. Analyzed results will be forwarded to cooperating scientists and Montana NRCS Field Offices.

Table 1. Irrigated Cool Season Grass Stand Percentages at NARC, 2009.

Species	Latin Name	Selection	Stand
			%
birdsfoot trefoil, alfalfa, sainfoin, meadow brome, orchardgrass		Cooper Mix	76.00
orchardgrass, meadow brome, intermediate wheatgrass, creeping foxtail, alfalfa		Mix 2	59.50
basin wildrye	*Leymus cinereus*	Trailhead	27.50
basin wildrye	*Leymus cinereus*	Continental	29.50
tall wheatgrass	*Thinopyrum ponticum*	Jose	63.75
tall wheatgrass	*Thinopyrum ponticum*	Largo	68.00
orchardgrass	*Dactylis glomerata*	Potomac	53.25
pubescent wheatgrass	*Thinopyrum intermedium*	Manska	70.00
western wheatgrass	*Pascopyrum smithii*	Rosana	62.50
hybrid wheatgrass	*Elymus hoffmanii*	AC Saltlander	65.00
hybrid wheatgrass	*Elymus hoffmanii*	Newhy	41.25
Nevada bluegrass	*Poa secunda*	Opportunity	6.00
big bluegrass	*Poa secunda*	Sherman	4.25
meadow brome	*Bromus biebersteinii*	McBeth	67.25
intermediate wheatgrass	*Thinopyrum intermedium*	Manifest	70.75
intermediate wheatgrass	*Thinopyrum intermedium*	Oahe	48.75
timothy	*Phleum pratense*	Climax	70.00
creeping foxtail	*Alopecurus arundinaceus*	Garrison	25.25
tall fescue	*Lolium arundinaceus*	Bridgestone	68.75

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 percent. There were significant differences between accessions of the same species. AC Saltlander hybrid wheatgrass was significantly higher in stand percentage than Newhy. Manifest intermediate wheatgrass was significantly higher in stand percentage than Oahe.

Study Title: Inter Center Evaluation Planting of Tall Wheatgrass Bio-Mass Study

Study Number: MT-08-0001

Objective: To compare the bio-mass potential of four varieties of tall wheatgrass for bio-fuel production.

Project Description: To provide information on the acceptance of new species and selections for biofuel consideration and refine agronomic management technologies for further advancement of switchgrass and other grasses as a biofuel crop. The goal of the project is to determine whether tall wheatgrass could be a substitute for biofuel production in areas where switchgrass does not grow or persist well.

Methods and Materials: The Inter Center Evaluation Planting (ICEP) tall wheatgrass bio-mass study was planted at the Bridger Plant Materials Center, Bridger, Montana, on March 13, 2008. A Kincaid cone planter, set up for four rows spaced 12 inches apart, was used for establishment. The seed was placed ¼-inch deep into a firm, clod-free seedbed. Each plot is four feet by 20 feet in area and the four species of tall wheatgrass are each replicated four times. Test species include 'Alkar', 'Jose', 'Largo' and 'Szarvasi-1' (from Hungary). 'Trailhead' basin wildrye was planted around the study borders as a border and as an additional species for observational bio-mass consideration. The plot area was irrigated twice during the initial growing season at Bridger and good emergence and stands were noted for all the plots in the study. Weeds were controlled by hand-hoeing in May and July during the first growing season. Fall fertilization included the application of 50 lbs/acre actual N in the middle of October. An additional 50 lbs actual N and 50 lbs actual P were applied in early April of 2009. Plots were harvested with a REM flail forage harvester on August 4, 2009. Wet forage samples were taken from the 2nd rep and dried for determining moisture content of each variety. Forage yields are reported on a dry matter basis.

Results: Harvested forage yields were very similar for all four accessions of tall wheatgrass. There were no significant differences between these forage yields.

Table 1. ICEP tall wheatgrass bio-mass study forage yields, August 4, 2009, Bridger, Montana.

Variety	Percentage Stand	Forage Yield
	%	*tons/acre*
Alkar	81.25	3.69
Jose	82.50	3.51
Largo	82.50	3.54
Szarvasi-1	86.25	3.46

Conclusions: There is a very limited potential for tall wheatgrass to be grown for biofuel consideration in Montana and Wyoming. Other perennial crops producing larger biomass, such as alfalfa, or woody species like hybrid poplar or biomass resulting from forest thinning practices for fire abatement may be better options for consideration in these areas.

V. Management – Cultural – Establishment Trials

Study Title: Comparative Evaluation of Alternate Row Plantings of Cool Season Grasses and Alfalfa for Forage Production

Study Numbers: MT-09-0038

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

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 a Montana Agricultural Experiment Station. Assisting with the study is David Wichman, MSU Central Ag 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 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 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 percent were replanted under dormant conditions on November 25, according to the same MT-46 seeding rates used previously. Data were analyzed using the Statistix 8.2 program.

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

Table 1. Cool season grass stand percentages at CARC, 2009.

Species	Latin Name	Selection	Stand
			%
Altai wildrye	*Leymus angustus*	Mustang	31.75
basin wildrye	*Leymus cinereus*	Trailhead	50.00
Russian wildrye	*Psathyrostachys juncea*	Mankota	50.50
tall wheatgrass	*Thinopyrum ponticum*	Jose	53.00
thickspike wheatgrass	*Elymus lanceolatus*	Critana	62.50
pubescent wheatgrass	*Thinopyrum intermedium*	Manska	51.25
western wheatgrass	*Pascopyrum smithii*	Rosana	53.25
hybrid wheatgrass	*Elymus hoffmanii*	AC Saltlander	74.25
Indian ricegrass	*Achnatherum hymenoides*	Rimrock	30.00
Nevada bluegrass	*Poa secunda*	Opportunity	27.75
bluebunch wheatgrass	*Pseudoroegneria spicata*	Goldar	40.25
Siberian wheatgrass	*Agropyron fragile*	Vavilov	54.00
tall fescue	*Lolium arundinaceus*	Bridgestone	43.00

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 percent. There were significant differences between 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.

Study Title: Field Bindweed Control in Winterfat Seed Production Fields

Study Number: MT-08-0002

Objective: To compare the effects of aminopyralid, quinclorac and imazapic and a no herbicide control on field bindweed control and subsequent winterfat seed production.

Project Description: This project consists of three herbicides applied at various rates and times during the growing season. The project was coordinated with Dr. Jim Jacobs, NRCS Plant Materials Specialist, Bozeman, MT. The goal of the study is to determine the efficacy of various herbicides on field bindweed control and their effect on winterfat seed production.

Methods and Materials: The study was a randomized complete block design with four replications. Plots were 10 feet wide by 20 feet long and were composed of four rows of winterfat on 30 inch spacing. The study was initiated on July 1, 2008, when the bindweed was actively flowering. Aminopyralid was applied at 0.188, 0.313, and 0.375 lb ai/A rates, quinclorac was applied at 0.25 and 0.375 lb ai/A rates, and imazapic was applied at 0.25, 0.375, and 0.5 lb ai/A rates. Methylated seed oil was included in the spray solution at 1 qt/A. Nitrogen fertilizer was also added with UAN at 1 gal/A. The herbicides were applied using a pressurized, backpack plot sprayer delivering 15 gal/A spray solution. Visual ratings for field bindweed control occurred on July 16, 2008 and again on June 22, 2009. A fall 2008 application of herbicides was planned, but not implemented due to inadequate regrowth of the field bindweed in the study plots. Data were analyzed for herbicide, rate, and their interaction using Statistix 8.2.

Results: Visual observations showed all herbicides at all rates suppressed winterfat seed production to zero the autumn after herbicide application (2008). Herbicidal control of field bindweed depended on the rate. Imazapic at 0.5 lb ai/A resulted in 70 percent control of field bindweed, significantly greater than 30% field bindweed control where quinclorac was applied at 0.375 lb ai/A. The difference may be attributed to application timing as quinclorac is normally sprayed before the first killing frost in the fall for optimum field bindweed control. In addition, winterfat seed production was also adversely affected the following growing season (2009).

Table 1. Field Bindweed Control in Winterfat Seed Production Fields, Bridger PMC, June 2009.

Herbicide – Rate fl. oz per acre	**Field Bindweed Control Rating***	**Winterfat Injury Rating***
Imazapic - 4	4.75 bc	3.0 b
Imazapic – 6	6.0 bc	5.0 b
Imazapic – 8	3.0 c	3.75 b
Quinclorac - 6	5.25 bc	3.0 b
Quinclorac - 8	7.0 ab	3.0 b
Control	10	1

***Ratings are 1-10, with 1 being the best. Yields followed by the same letter are not significantly different (P = 0.05).

Conclusions: Although no winterfat plants died due to any of the herbicide treatments, it should be noted application of these herbicides does have a deleterious effect on subsequent seed production the year of application and also into the following year after application.

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

Study Number: MT-98-0002

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

Project Description: The use of native or introduced 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 nonirrigated 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 9 years, the west half of each of the original 10 plots have been periodically mowed to an approximate height of 2 inches, while the east half of each plot was 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. Annual precipitation in 2002 and 2003 was well below average, receiving 9.24 inches and 6.65 inches, respectively. Annual precipitation in 2004 was well below average at 8.46 inches; in 2005 it was above average at 14.22 inches; in 2006 it was 12.12 inches; in 2007 it was 6.65 inches; in 2008 it was 9.13 inches; and in 2009, it was well below average at 7.73 inches. Supplemental irrigation was applied in July of 2004-2009 to prevent further deterioration of the plots.

Results: All plots were periodically evaluated to monitor persistence and species trends across the study (see Bridger PMC Annual Technical Report 2006-2007). To date, the majority of the entries are performing as anticipated and the study will be maintained indefinitely.

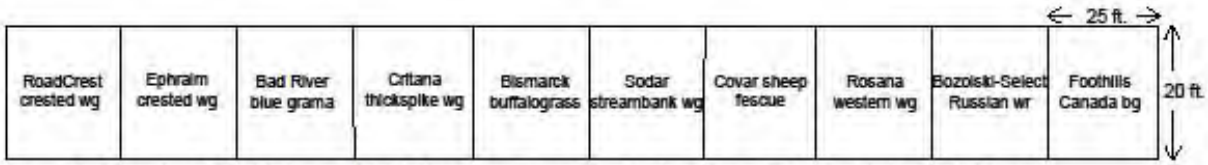


Figure 1. Cultural and Establishment Trial of Xeriscape Demonstration Area Grass Plots. Seeded in Field 19 at the Bridger PMC on April 10, 1998.

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.

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.

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 will be used primarily for demonstration purposes. All plots were evaluated on August 27, 2009. The percentage basal cover was estimated, and plant and/or seedhead height was randomly measured in centimeters three times in each plot.

Results: In 2009, the most noTable performers included, but were not limited to ‘Lodorm’ green needlegrass, ‘Magnar’ basin wildrye, the 2 Altai wildrye entries, 9019219 bottlebrush squirreltail, Copperhead Germplasm slender wheatgrass, ‘P-7’ bluebunch wheatgrass, ‘Regar’ meadow brome, ‘Sunnyview’ big bluestem, Bad River Germplasm bluegrama, and ‘Sunburst’ switchgrass. The bluegrass and squirreltail entries rated lower than in previous years. 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. The 2009 performance of conservation grasses for Montana and Wyoming; planted in F10W at the Bridger PMC on May 3, 2006.

Common Name	Cultivar	Origin	Vigor†	Establishment	Plant Height	Seedhead Abundance†	Seedhead Height
				%	*cm*		*cm*
Indian ricegrass	1-Nezpar	ID	2	80	30	2	63
Indian ricegrass	2-Rimrock	MT	3	80	21	3	55
Indian ricegrass	3-White River	NW CO	1	80	23	1	62
green needlegrass	4-Lodorm	ND	1	90	55	1	132
green needlegrass	5-Cucharas	SC CO	1	85	45	1	122
green needlegrass	6-Fowler	UT	6	65	30	5	95
basin wildrye	7-Magnar	Saskatchewan	2	95	100	2	162
basin wildrye	8-Trailhead	MT	2	90	100	1	172
basin wildrye	9-Washoe	MT	5	75	88	4	151
basin wildrye	10-Continental	UT	1	90	108	2	182
Altai wildrye	11-Prairieland	AG CA	2	100	80	1	132
Altai wildrye	12-Mustang‡	Prairieland-Eejay-Pearl	1	100	70	2	122
Sandberg bluegrass	13-High Plains	MT/WY	3	25	10	6	25
Sandberg bluegrass	14-Reliable	SC WA	4	5	6	9	0
Sandberg bluegrass	15-Hanford Source	SC WA	5	2	6	9	0
Canada bluegrass	16-Ruebens	ID	3	50	13	3	38
Canada bluegrass	17-Foothills	MT	3	45	18	4	45
big bluegrass	18-Sherman	NC OR	2	80	42	1	82
big bluegrass	19-9081633	MT	4	75	20	4	82
big squirreltail	20-Sand Hollow	SE ID	3	85	18	2	62
squirreltail	21-Fish Creek	SC ID	2	90	17	2	48
squirreltail	22-Toe Jam Creek	NW NV	2	88	20	2	50
squirreltail	23-9019219	WY	3	90	17	2	48
slender wg	24-Revenue	W. Sask.	2	95	40	2	100
slender wg	25-San Luis	SW CO	3	95	37	3	110
slender wg	26-Pryor	MT	1	95	37	1	120
slender wg	27-Copperhead	MT	4	90	27	3	100

† Rated 1-9 with 1 best
‡ Genetic cross Prairieland, Eejay, and Pearl.

Table 1. The 2009 performance of conservation grasses for Montana and Wyoming; planted in F10W at the Bridger PMC on May 3, 2006-cont'd.

Common Name	Cultivar	Origin	Vigor†	Establish	Plant Height	Seedhead Abundance†	Seedhead Height
				%	*cm*		*cm*
Snake River wg	28-Secar	NC ID	2	90	35	2	92
bluebunch wg	29-Goldar	SE WA	2	95	25	2	85
bluebunch wg	30-P-7[§]	BC-ID-MT-NV-OR-UT-WA	1	95	35	1	90
bluebunch wg	31-Anatone	SE WA	2	90	30	2	80
bluebunch wg	32-9081757	MT	3	85	30	2	90
bluebunch wg	33-9081636	MT	3	85	23	2	90
meadow brome	34-Regar	Turkey	2	99	62	2	135
meadow brome	35-McBeth[¶]	Paddock-Fleet-Regar	1	99	53	1	146
meadow brome	36-Cache[#]	Regar-Fleet-Paddock	1	99	63	2	132
big bluestem	37-Sunnyview	SD	2	90	60	2	170
big bluestem	38-Bison	ND	1	90	59	1	142
blue grama	39-Alma	CO/NM	3	95	33	3	47
blue grama	40-Bad River	SD	1	95	30	1	42
blue grama	41-Birds Eye	NC WY	2	95	27	2	45
switchgrass	42-Forestburg	SD	2	99	50	3	122
switchgrass	43-Dakotah	ND	2	95	48	1	112
switchgrass	44-Sunburst	SD	1	99	75	3	146
switchgrass	45-9005439	WY	2	96	50	2	142

† Rated 1-9 with 1 best

[§] Poly-cross origins from BC, ID, MT, NV, OR, UT, and WA.
[¶] Genetic cross Paddock, Fleet, and Regar.
[#] Genetic cross Regar, Fleet, and Paddock

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.

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 is 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.

All plots were evaluated on August 27, 2009. The percentage basal cover was estimated, and plant and/or seedhead height was randomly measured in centimeters three times in each plot.

Results: In 2009, the highest ratings went ‘Chemung’ crownvetch, Canada milkvetch (not yet released by the North Dakota PMC), ‘Lutana’ cicer milkvetch, ‘Ladak’ alfalfa, ‘Prairie Gold’ Maximillian 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.

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

Methods and Materials – continued.

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 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.

Results – continued.

All other 2009 mean evaluation results for Field 3 and Field 14 appear in Tables 2 and 3, respectively. All 2009 evaluation data for Field 3 and Field 14 appears 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.

Table 1. Mean percentage survival, sub-irrigation tube study, 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.

Results – continued.

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

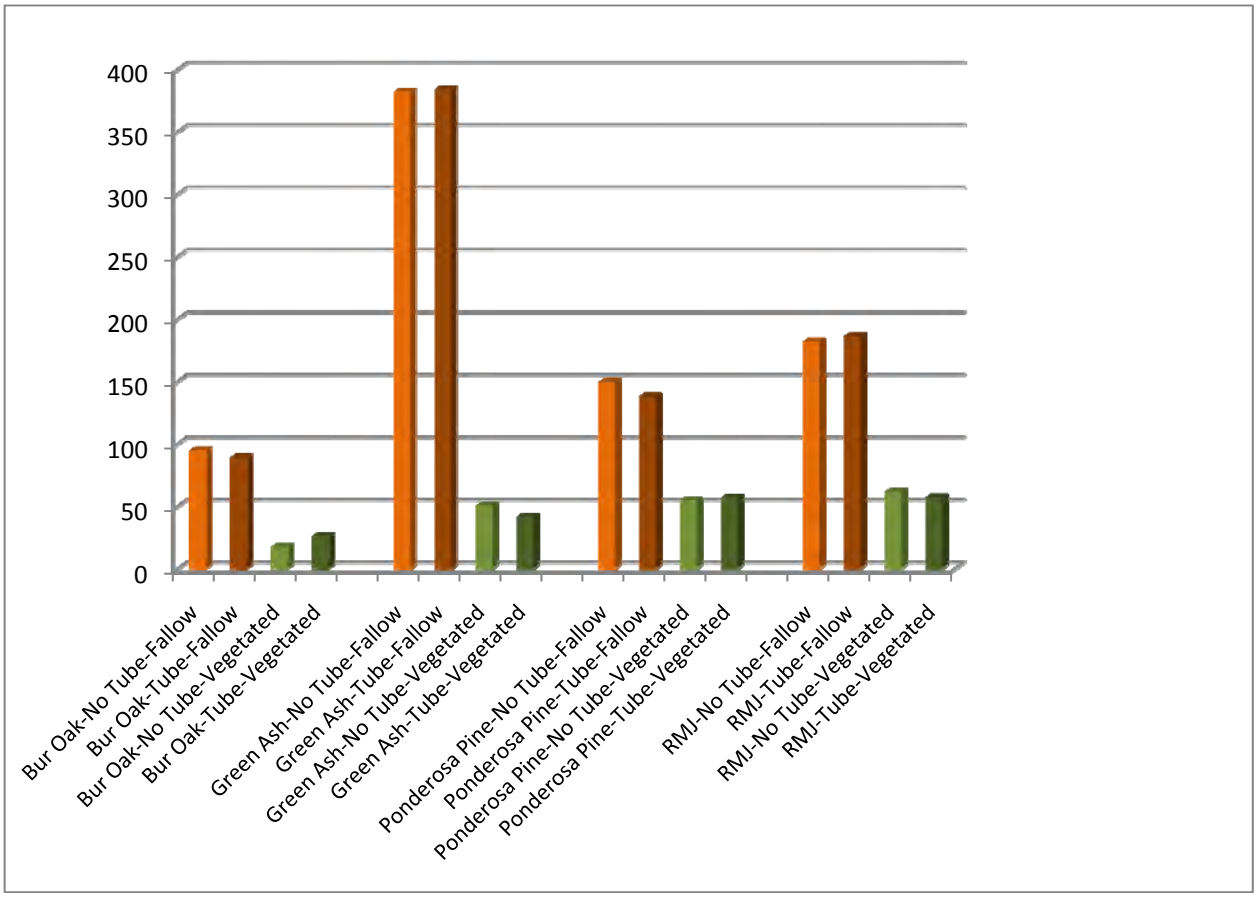


Chart 1 – Mean Plant Height by Treatment, 2009, Bridger, MT.

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. Differences in survival among the bur oak and green ash with and without tubes in Field 14 will be analyzed in 2010 for significance. 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.

Appendix 1. Irrigation Tube Study, Evaluation Form, Field 3 - Fallow November 3, 2009.

Species	I.D.		Block	Row	Pos.	Fall 2008 Survival	Fall 2009 Survival	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
						(0,1)	(0,1)	*cm*	*cm*	*mm*	(1-9)
ponderosa pine	Pine-I-NT-9	NT	I	1	1	1	1	125.0	41.0	61.65	4
bur oak	Oak-I-T-3	T	I	1	2	1	1	104.0	-1.0	19.89	3
green ash	Ash-I-NT-2	NT	I	1	3	1	1	94.0	11.0	38.02	6
ponderosa pine	Pine-I-T-1	T	I	1	4	1	1	195.0	57.0	66.90	1
ponderosa pine	Pine-I-T-6	NT	I	1	5	1	1	166.0	51.0	76.52	1
ponderosa pine	Pine-I-T-10	T	I	1	6	1	1	166.0	46.0	57.02	3
green ash	Ash-I-NT-10	NT	I	1	7	1	1	420.0	70.0	115.85	1
ponderosa pine	Pine-I-NT-10	NT	I	1	8	1	1	152.0	45.0	58.92	4
green ash	Ash-I-NT-4	NT	I	1	9	1	1	345.0	44.0	89.71	3
bur oak	Oak-I-NT-1	NT	I	1	10	1	1	122.0	-3.0	16.73	4
R.M. juniper	RMJ-I-T-5	T	I	1	11	1	1	110.0	29.0		6
green ash	Ash-I-T-9	T	I	1	12	1	1	435.0	45.0	108.04	1
green ash	Ash-I-T-1	T	I	1	13	1	1	375.0	55.0	57.23	4
green ash	Ash-I-T-8	T	I	1	14	1	1	435.0	75.0	82.36	3
ponderosa pine	Pine-I-T-7	T	I	1	15	1	1	171.0	51.0	65.37	3
ponderosa pine	Pine-I-T-6	T	I	1	16	1	1	96.0	43.0	39.37	5
R.M. juniper	RMJ-I-NT-5	NT	I	1	17	1	1	195.0	22.0		2
ponderosa pine	Pine-I-NT-2	NT	I	1	18	1	1	164.0	44.0	64.45	3
ponderosa pine	Pine-I-T-5	T	I	1	19	1	1	153.0	43.0	61.97	3
green ash	Ash-I-T-5	T	I	1	20	1	1	340.0	45.0	67.67	4
ponderosa pine	Pine-I-NT-8	NT	I	1	21	1	1	129.0	-6.0	58.44	4
R.M. juniper	RMJ-I-NT-10	NT	I	1	22	1	1	194.0	18.0		3
R.M. juniper	RMJ-I-NT-3	NT	I	1	23	1	1	180.0	27.0		3
bur oak	Oak-I-NT-6	NT	I	1	24	1	1	73.0	-13.0	13.66	5
green ash	Ash-I-T-2	T	I	1	25	1	1	121.0	35.0	39.64	6
R.M. juniper	RMJ-I-T-1	T	I	1	26	1	1	163.0	33.0		4
bur oak	Oak-I-T-6	T	I	1	27	1	1	82.0	7.0	13.68	4
green ash	Ash-I-NT-5	NT	I	2	1	1	1	305.0	45.0	98.41	3
R.M. juniper	RMJ-I-T-9	T	I	2	2	1	1	175.0	40.0		3
ponderosa pine	Pine-I-T-8	T	I	2	3	1	1	106.0	34.0	40.53	4
green ash	Ash-I-NT-9	NT	I	2	4	1	1	420.0	40.0	96.33	1
ponderosa pine	Pine-I-NT-4	NT	I	2	5	1	1	125.0	28.0	61.74	3
bur oak	Oak-I-T-2	T	I	2	6	1	1	106.0	1.0	14.57	3
bur oak	Oak-I-NT-7	NT	I	2	7	1	1	102.0	2.0	19.97	3
R.M. juniper	RMJ-I-NT-8	NT	I	2	8	1	1	198.0	28.0		2
green ash	Ash-I-T-7	T	I	2	9	1	1	445.0	55.0	94.14	1
green ash	Ash-I-NT-7	NT	I	2	10	1	1	435.0	55.0	85.45	2
R.M. juniper	RMJ-I-NT-2	NT	I	2	11	1	1	172.0	10.0		3
green ash	Ash-I-T-10	T	I	2	12	1	1	420.0	40.0	84.14	2
ponderosa pine	Pine-I-T-4	T	I	2	13	1	1	142.0	37.0	56.68	4
green ash	Ash-I-NT-3	NT	I	2	14	1	1	400.0	65.0	72.04	4
R.M. juniper	RMJ-I-T-8	T	I	2	15	1	1	186.0	32.0		4

Appendix 1. Irrigation Tube Study, Evaluation Form, Field 3 - Fallow November 3, 2009.

Species	I.D.		Block	Row	Pos.	Fall 2008 Survival	Fall 2009 Survival	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
						(0,1)	(0,1)	*cm*	*cm*	*mm*	(1-9)
bur oak	Oak-I-T-8	T	I	2	16	1	1	78.0	21.0	11.04	5
green ash	Ash-I-T-4	T	I	2	17	1	1	365.0	70.0	99.79	3
bur oak	Oak-I-T-1	T	I	2	18	1	1	96.0	10.0	15.26	3
ponderosa pine	Pine-I-T-2	T	I	2	19	1	1	155.0	47.0	59.63	3
ponderosa pine	Pine-I-NT-1	NT	I	2	20	1	1	174.0	51.0	69.48	1
bur oak	Oak-I-T-10	T	I	2	21	1	1	95.0	5.0	15.05	4
R.M. juniper	RMJ-I-NT-1	NT	I	2	22	1	1	195.0	27.0		2
bur oak	Oak-I-NT-3	NT	I	2	23	1	1	81.0	16.0	15.92	5
bur oak	Oak-I-T-7	T	I	2	24	1	1	75.0	0.0	13.22	4
ponderosa pine	Pine-I-NT-3	NT	I	2	25	1	1	110.0	33.0	61.40	4
green ash	Ash-I-NT-8	T	I	2	26	1	1	250.0	50.0	35.15	5
R.M. juniper	RMJ-I-T-3	NT	I	2	27	1	1	144.0	28.0		4
R.M. juniper	RMJ-I-T-7	T	I	3	1	1	1	168.0	35.0		3
green ash	Ash-I-NT-6	NT	I	3	2	1	1	325.0	50.0	75.87	5
green ash	Ash-I-T-3	T	I	3	3	1	1	330.0	65.0	83.15	5
bur oak	Oak-I-NT-8	NT	I	3	4	1	1	102.0	-1.0	17.89	3
R.M. juniper	RMJ-I-NT-7	NT	I	3	5	1	1	176.0	36.0		4
R.M. juniper	RMJ-I-T-2	T	I	3	6	1	1	186.0	32.0		2
Blank	Blank		I	3	7				0.0		
bur oak	Oak-I-T-9	T	I	3	8	1	1	91.0	1.0	14.71	3
ponderosa pine	Pine-I-NT-7	NT	I	3	9	1	1	195.0	61.0	72.71	2
green ash	Ash-I-NT-1	NT	I	3	10	1	1	375.0	65.0	61.64	4
R.M. juniper	RMJ-I-T-4	T	I	3	11	1	1	109.0	16.0		5
ponderosa pine	Pine-I-T-9	T	I	3	12	1	1	148.0	36.0	67.02	2
bur oak	Oak-I-T-5	T	I	3	13	1	1	71.0	2.0	11.98	4
ponderosa pine	Pine-I-NT-5	NT	I	3	14	1	1	145.0	31.0	66.69	3
R.M. juniper	RMJ-I-T-10	T	I	3	15	1	1	200.0	20.0		1
bur oak	Oak-I-NT-10	NT	I	3	16	1	1	104.0	-1.0	17.88	4
bur oak	Oak-I-NT-9	NT	I	3	17	1	1	99.0	-1.0	14.52	4
bur oak	Oak-I-T-4	T	I	3	18	1	1	88.0	4.0	13.10	4
R.M. juniper	RMJ-I-T-6	T	I	3	19	1	1	175.0	24.0		3
bur oak	Oak-I-NT-2	NT	I	3	20	1	1	95.0	0.0	13.20	4
R.M. juniper	RMJ-I-NT-9	NT	I	3	21	1	1	178.0	30.0		4
bur oak	Oak-I-NT-4	NT	I	3	22	1	0		-93.0		9
green ash	Ash-I-T-6	T	I	3	23	1	1	310.0	55.0	54.77	5
ponderosa pine	Pine-I-T-3	T	I	3	24	1	1	149.0	39.0	50.97	4
R.M. juniper	RMJ-I-NT-4	NT	I	3	25	1	1	97.0	6.0		5
bur oak	Oak-I-NT-5	NT	I	3	26	1	1	71.0	-11.0	11.28	5
R.M. juniper	RMJ-I-NT-6	NT	I	3	27	1	1	162.0	31.0		4
R.M. juniper	RMJ-II-T-7	T	II	4	1	1	1	190.0	30.0		2
R.M. juniper	RMJ-II-T-9	T	II	4	2	1	1	191.0	27.0		2
ponderosa pine	Pine-II-NT-1	NT	II	4	3	1	1	161.0	50.0	65.79	3
green ash	Ash-II-NT-2	NT	II	4	4	1	1	415.0	30.0	88.97	2

Appendix 1. Irrigation Tube Study, Evaluation Form, Field 3 - Fallow November 3, 2009.

Species	I.D.		Block	Row	Pos.	Fall 2008 Survival	Fall 2009 Survival	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
						(0,1)	(0,1)	*cm*	*cm*	*mm*	(1-9)
bur oak	Oak-II-NT-5	NT	II	4	5	1	1	95.0	0.0	18.42	3
bur oak	Oak-II-NT-1	NT	II	4	6	1	1	91.0	-1.0	10.29	4
ponderosa pine	Pine-II-T-8	T	II	4	7	1	1	164.0	55.0	63.42	3
green ash	Ash-II-T-3	T	II	4	8	1	1	400.0	55.0	84.58	3
green ash	Ash-II-NT-3	NT	II	4	9	1	1	395.0	35.0	71.08	4
green ash	Ash-II-NT-7	NT	II	4	10	1	1	330.0	65.0	58.57	5
R.M. juniper	RMJ-II-NT-6	NT	II	4	11	1	1	230.0	40.0		2
R.M. juniper	RMJ-II-NT-4	NT	II	4	12	1	1	177.0	22.0		3
bur oak	Oak-II-T-4	T	II	4	13	1	1	90.0	5.0	15.60	4
green ash	Ash-II-T-5	T	II	4	14	1	1	380.0	75.0	75.62	4
ponderosa pine	Pine-II-T-4	T	II	4	15	1	1	127.0	42.0	47.97	4
bur oak	Oak-II-NT-6	NT	II	4	16	1	1	80.0	10.0	14.45	4
bur oak	Oak-II-T-10	T	II	4	17	1	1	100.0	5.0	15.65	3
ponderosa pine	Pine-II-T-5	T	II	4	18	1	1	153.0	47.0	56.37	3
green ash	Ash-II-NT-8	NT	II	4	19	1	1	320.0	65.0	44.27	5
ponderosa pine	Pine-II-NT-6	NT	II	4	20	1	1	145.0	44.0	58.65	3
bur oak	Oak-II-NT-9	NT	II	4	21	1	1	87.0	-4.0	9.94	5
bur oak	Oak-II-NT-7	NT	II	4	22	1	1	90.0	0.0	16.19	3
green ash	Ash-II-T-4	T	II	4	23	1	1	360.0	65.0	61.07	4
bur oak	Oak-II-NT-4	NT	II	4	24	1	1	91.0	-3.0	14.14	4
bur oak	Oak-II-NT-10	NT	II	4	25	1	1	90.0	-4.0	15.38	4
ponderosa pine	Pine-II-T-2	T	II	4	26	1	1	133.0	34.0	57.88	3
ponderosa pine	Pine-II-NT-10	NT	II	4	27	1	1	174.0	49.0	60.06	2
ponderosa pine	Pine-II-NT-9	NT	II	5	1	1	1	140.0	29.0	70.78	3
R.M. juniper	RMJ-II-NT-1	NT	II	5	2	1	1	176.0	31.0		2
ponderosa pine	Pine-II-T-9	T	II	5	3	1	1	127.0	36.0	53.20	4
bur oak	Oak-II-T-1	T	II	5	4	1	1	84.0	-2.0	14.89	4
bur oak	Oak-II-T-7	T	II	5	5	1	1	61.0	-20.0	16.97	5
R.M. juniper	RMJ-II-NT-7	NT	II	5	6	1	1	192.0	30.0		2
bur oak	Oak-II-NT-3	NT	II	5	7	1	1	111.0	-8.0	18.60	3
R.M. juniper	RMJ-II-NT-8	NT	II	5	8	1	1	180.0	25.0		5
green ash	Ash-II-NT-9	NT	II	5	9	1	1	370.0	100.0	76.51	4
green ash	Ash-II-NT-1	NT	II	5	10	1	1	164.0	54.0	29.58	7
R.M. juniper	RMJ-II-T-10	T	II	5	11	1	1	174.0	30.0		2
bur oak	Oak-II-T-5	T	II	5	12	1	1	90.0	1.0	15.22	4
ponderosa pine	Pine-II-T-10	T	II	5	13	1	1	65.0	15.0	20.59	6
green ash	Ash-II-NT-10	NT	II	5	14	1	1	355.0	75.0	67.85	4
R.M. juniper	RMJ-II-T-8	T	II	5	15	1	1	185.0	35.0		2
bur oak	Oak-II-T-2	T	II	5	16	1	1	83.0	-2.0	14.44	4
bur oak	Oak-II-NT-8	NT	II	5	17	1	1	102.0	1.0	15.34	3
R.M. juniper	RMJ-II-T-6	T	II	5	18	1	1	215.0	38.0		3
green ash	Ash-II-NT-5	NT	II	5	19	1	1	205.0	95.0	39.67	7
R.M. juniper	RMJ-II-NT-3	NT	II	5	20	1	1	197.0	32.0		2

Appendix 1. Irrigation Tube Study, Evaluation Form, Field 3 - Fallow November 3, 2009.

Species	I.D.		Block	Row	Pos.	Fall 2008 Survival	Fall 2009 Survival	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
						(0,1)	(0,1)	*cm*	*cm*	*mm*	(1-9)
R.M. juniper	RMJ-II-NT-5	NT	II	5	21	1	1	169.0	26.0		3
bur oak	Oak-II-T-3	T	II	5	22	1	1	90.0	0.0	12.86	4
ponderosa pine	Pine-II-NT-7	NT	II	5	23	1	1	150.0	44.0	55.05	3
green ash	Ash-II-NT-6	NT	II	5	24	1	1	131.0	31.0	35.89	7
green ash	Ash-II-T-1	T	II	5	25	1	1	311.0	43.0	46.28	4
R.M. juniper	RMJ-II-T-1	T	II	5	26	1	1	170.0	25.0		4
green ash	Ash-II-T-7	T	II	5	27	1	1	217.0	38.0	38.56	5
green ash	Ash-II-T-10	T	II	6	1	1	1	370.0	75.0	75.19	2
bur oak	Oak-II-NT-2	NT	II	6	2	1	1	108.0	2.0	16.93	3
ponderosa pine	Pine-II-NT-8	NT	II	6	3	1	1	140.0	35.0	71.36	3
ponderosa pine	Pine-II-NT-5	NT	II	6	4	1	1	127.0	17.0	69.99	4
green ash	Ash-II-NT-4	NT	II	6	5	1	1	335.0	80.0	66.09	4
ponderosa pine	Pine-II-NT-2	NT	II	6	6	1	1	126.0	36.0	58.71	4
green ash	Ash-II-T-8	T	II	6	7	1	1	189.0	70.0	58.38	7
Blank	Blank		II	6	8				0.0		
R.M. juniper	RMJ-II-T-3	T	II	6	9	1	1	210.0	33.0		1
ponderosa pine	Pine-II-T-6	T	II	6	10	1	1	111.0	36.0	51.08	4
ponderosa pine	Pine-II-NT-3	NT	II	6	11	1	1	140.0	38.0	65.16	4
R.M. juniper	RMJ-II-T-2	T	II	6	12	1	1	201.0	41.0		4
green ash	Ash-II-T-2	T	II	6	13	1	1	410.0	65.0	78.74	2
R.M. juniper	RMJ-II-NT-9	NT	II	6	14	1	1	172.0	26.0		3
bur oak	Oak-II-T-8	T	II	6	15	1	1	100.0	5.0	14.33	3
bur oak	Oak-II-T-6	T	II	6	16	1	1	96.0	3.0	14.19	4
ponderosa pine	Pine-II-NT-4	NT	II	6	17	1	1	27.0	-2.0	12.16	8
R.M. juniper	RMJ-II-NT-2	NT	II	6	18	1	1	200.0	35.0		2
ponderosa pine	Pine-II-T-1	T	II	6	19	1	1	141.0	46.0	54.33	3
ponderosa pine	Pine-II-T-7	T	II	6	20	1	1	105.0	36.0	40.27	4
bur oak	Oak-II-T-9	T	II	6	21	1	1	93.0	0.0	16.32	3
R.M. juniper	RMJ-II-T-5	T	II	6	22	1	1	145.0	27.0		4
R.M. juniper	RMJ-II-NT-10	NT	II	6	23	1	1	165.0	25.0		3
green ash	Ash-II-T-6	T	II	6	24	1	1	295.0	45.0	53.81	5
green ash	Ash-II-T-9	T	II	6	25	1	1	335.0	55.0	49.15	5
R.M. juniper	RMJ-II-T-4	T	II	6	26	1	1	184.0	30.0		4
ponderosa pine	Pine-II-T-3	T	II	6	27	1	1	125.0	36.0	52.97	4
green ash	Ash-III-T-5	T	III	7	1	1	1	235.0	43.0	42.64	7
green ash	Ash-III-T-4	T	III	7	2	1	1	495.0	115.0	103.68	1
ponderosa pine	Pine-III-NT-3	NT	III	7	3	1	1	145.0	60.0	57.18	3
ponderosa pine	Pine-III-NT-6	NT	III	7	4	1	1	155.0	51.0	70.31	2
R.M. juniper	RMJ-III-T-10	T	III	7	5	1	1	200.0	35.0		2
bur oak	Oak-III-T-6	T	III	7	6	1	1	98.0	-1.0	14.49	4
green ash	Ash-III-NT-8	NT	III	7	7	1	1	270.0	75.0	54.46	6
green ash	Ash-III-NT-5	NT	III	7	8	1	1	225.0	20.0	48.62	7
bur oak	Oak-III-T-4	T	III	7	9	1	1	80.0	1.0	13.35	4

Appendix 1. Irrigation Tube Study, Evaluation Form, Field 3 - Fallow November 3, 2009.

Species	I.D.		Block	Row	Pos.	Fall 2008 Survival	Fall 2009 Survival	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
						(0,1)	(0,1)	*cm*	*cm*	*mm*	(1-9)
green ash	Ash-III-NT-7	NT	III	7	10	1	1	445.0	35.0	101.14	2
R.M. juniper	RMJ-III-T-1	T	III	7	11	1	1	185.0	26.0		2
green ash	Ash-III-NT-9	NT	III	7	12	1	1	250.0	69.0	57.24	7
R.M. juniper	RMJ-III-T-6	T	III	7	13	1	1	250.0	50.0		1
ponderosa pine	Pine-III-T-4	T	III	7	14	1	1	124.0	45.0	44.28	4
bur oak	Oak-III-NT-7	NT	III	7	15	1	1	96.0	3.0	15.47	4
green ash	Ash-III-NT-2	NT	III	7	16	1	1	390.0	90.0	79.61	3
R.M. juniper	RMJ-III-NT-3	NT	III	7	17	1	1	195.0	29.0		3
bur oak	Oak-III-NT-9	NT	III	7	18	1	1	96.0	-1.0	15.63	3
R.M. juniper	RMJ-III-NT-4	NT	III	7	19	1	1	193.0	28.0		2
green ash	Ash-III-T-2	T	III	7	20	1	1	390.0	35.0	70.34	4
R.M. juniper	RMJ-III-NT-5	NT	III	7	21	1	1	171.0	27.0		4
bur oak	Oak-III-T-7	T	III	7	22	1	1	90.0	-4.0	14.46	4
ponderosa pine	Pine-III-T-1	T	III	7	23	1	1	115.0	36.0	37.29	5
bur oak	Oak-III-T-2	T	III	7	24	1	1	94.0	0.0	13.18	4
R.M. juniper	RMJ-III-NT-7	NT	III	7	25	1	1	172.0	25.0		4
ponderosa pine	Pine-III-T-5	T	III	7	26	1	1	128.0	37.0	51.37	4
ponderosa pine	Pine-III-NT-7	NT	III	7	27	1	1	90.0	24.0	39.22	5
green ash	Ash-III-NT-1	NT	III	8	1	1	0		-75.0	29.27	9
R.M. juniper	RMJ-III-T-2	T	III	8	2	1	1	180.0	25.0		1
bur oak	Oak-III-NT-3	NT	III	8	3	1	1	95.0	1.0	17.29	4
R.M. juniper	RMJ-III-T-8	T	III	8	4	1	1	200.0	34.0		3
R.M. juniper	RMJ-III-NT-6	NT	III	8	5	1	1	190.0	36.0		2
green ash	Ash-III-T-9	T	III	8	6	1	1	490.0	70.0	88.87	1
R.M. juniper	RMJ-III-T-4	T	III	8	7	1	1	185.0	35.0		1
R.M. juniper	RMJ-III-T-3	T	III	8	8	1	1	200.0	35.0		2
bur oak	Oak-III-NT-5	NT	III	8	9	0			0.0		
R.M. juniper	RMJ-III-T-5	T	III	8	10	1	1	189.0	39.0		1
bur oak	Oak-III-NT-6	NT	III	8	11	1	1	96.0	2.0	15.65	4
bur oak	Oak-III-T-10	T	III	8	12	1	1	94.0	4.0	16.16	3
bur oak	Oak-III-NT-4	NT	III	8	13	1	1	95.0	0.0	15.44	3
bur oak	Oak-III-NT-8	NT	III	8	14	1	1	95.0	-1.0	15.08	3
green ash	Ash-III-T-10	T	III	8	15	1	1	390.0	55.0	91.49	2
ponderosa pine	Pine-III-NT-8	NT	III	8	16	1	1	170.0	48.0	69.60	2
R.M. juniper	RMJ-III-T-9	T	III	8	17	1	1	215.0	30.0		1
ponderosa pine	Pine-III-NT-2	NT	III	8	18	1	1	172.0	51.0	70.12	2
bur oak	Oak-III-NT-1	NT	III	8	19	1	1	98.0	-2.0	16.55	4
Blank	Blank		III	8	20				0.0		
green ash	Ash-III-T-3	T	III	8	21	1	1	370.0	60.0	62.91	4
R.M. juniper	RMJ-III-NT-1	NT	III	8	22	1	1	203.0	28.0		2
bur oak	Oak-III-T-8	T	III	8	23	0			0.0		
bur oak	Oak-III-NT-2	NT	III	8	24	1	1	104.0	4.0	15.83	3
R.M. juniper	RMJ-III-NT-10	NT	III	8	25	1	1	160.0	30.0		4

Appendix 1. Irrigation Tube Study, Evaluation Form, Field 3 - Fallow November 3, 2009.

Species	I.D.		Block	Row	Pos.	Fall 2008 Survival	Fall 2009 Survival	Fall 2009 Height	2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
						(0,1)	(0,1)	*cm*	*cm*	*mm*	(1-9)
ponderosa pine	Pine-III-T-10	T	III	8	26	1	1	106.0	36.0	42.97	5
green ash	Ash-III-T-1	T	III	8	27	1	1	325.0	70.0	44.34	4
ponderosa pine	Pine-III-T-3	T	III	9	1	1	1	140.0	55.0	46.65	4
bur oak	Oak-III-T-3	T	III	9	2	1	1	87.0	2.0	15.52	4
green ash	Ash-III-NT-10	NT	III	9	3	1	1	94.0	18.0	32.25	7
bur oak	Oak-III-NT-10	NT	III	9	4	1	1	85.0	1.0	15.21	4
R.M. juniper	RMJ-III-NT-8	NT	III	9	5	1	1	205.0	29.0		1
ponderosa pine	Pine-III-T-2	T	III	9	6	1	1	147.0	47.0	61.64	3
bur oak	Oak-III-T-9	T	III	9	7	1	1	103.0	1.0	17.49	3
green ash	Ash-III-NT-6	NT	III	9	8	1	1	120.0	9.0	42.92	7
ponderosa pine	Pine-III-T-9	T	III	9	9	1	1	134.0	52.0	62.20	4
green ash	Ash-III-T-7	T	III	9	10	1	1	365.0	65.0	84.90	2
ponderosa pine	Pine-III-T-6	T	III	9	11	1	1	133.0	38.0	54.05	4
ponderosa pine	Pine-III-NT-10	NT	III	9	12	1	1	166.0	51.0	65.01	3
R.M. juniper	RMJ-III-NT-2	NT	III	9	13	1	1	200.0	30.0		2
ponderosa pine	Pine-III-T-7	T	III	9	14	1	1	165.0	54.0	65.74	2
ponderosa pine	Pine-III-NT-1	NT	III	9	15	1	1	162.0	51.0	61.97	2
ponderosa pine	Pine-III-NT-5	NT	III	9	16	1	1	195.0	56.0	77.25	1
ponderosa pine	Pine-III-NT-9	NT	III	9	17	1	1	160.0	55.0	59.25	3
bur oak	Oak-III-T-5	T	III	9	18	1	1	77.0	2.0	15.40	5
green ash	Ash-III-T-6	T	III	9	19	1	1	370.0	65.0	70.92	4
green ash	Ash-III-T-8	T	III	9	20	1	1	400.0	55.0	63.76	4
R.M. juniper	RMJ-III-NT-9	NT	III	9	21	1	1	197.0	22.0		2
bur oak	Oak-III-T-1	T	III	9	22	1	1	87.0	12.0	13.47	4
green ash	Ash-III-NT-4	NT	III	9	23	1	1	256.0	36.0	39.63	6
ponderosa pine	Pine-III-T-8	T	III	9	24	1	1	144.0	49.0	54.99	4
ponderosa pine	Pine-III-NT-4	NT	III	9	25	1	1	130.0	45.0	51.52	4
green ash	Ash-III-NT-3	NT	III	9	26	1	1	238.0	43.0	26.07	6
R.M. juniper	RMJ-III-T-7	T	III	9	27	1	1	180.0	40.0		4

Appendix 2. Irrigation Tube Study, Evaluation Form, Field 14 – Vegetated, November 2009.

Species	I.D.		B	R	P	Grass Cover Species	Fall 2009 Surv.	Fall 2009 Height	Fall 2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
							(0,1)	*cm*	*cm*	*mm*	*(1-9)*
ponderosa pine	Pine-I-T-1	T	I	1	1	TWG	1	68.0	17.0	18.09	6
green ash	Ash-I-NT-7	NT	I	1	2	TWG	1	45.0	0.0	6.14	7
green ash	Ash-I-T-6	T	I	1	3	TWG	1	39.0	3.0	6.14	7
green ash	Ash-I-T-3	T	I	1	4	TWG	1	52.0	-1.0	6.66	7
ponderosa pine	Pine-I-NT-9	NT	I	1	5	TWG	1	50.0	7.0	16.09	6
green ash	Ash-I-T-2	T	I	1	6	TWG	1	32.5	-7.5	6.17	7
bur oak	Oak-I-T-2	T	I	1	7	TWG	1	53.0	8.0	6.92	8
R.M. juniper	RMJ-I-T-8	T	I	1	8	TWG	1	65.0	11.0	12.63	7
ponderosa pine	Pine -I-NT-3	NT	I	1	9	TWG	1	31.5	2.5	9.97	7
ponderosa pine	Pine-I-NT-1	NT	I	1	10	TWG	1	40.0	3.0	14.14	7
ponderosa pine	Pine-I-T-9	T	I	2	1	TWG	1	54.0	4.0	13.43	7
ponderosa pine	Pine-I-T-3	T	I	2	2	TWG	1	46.0	6.0	12.71	7
green ash	Ash-I-NT-2	NT	I	2	3	TWG	1	59.0	-8.0	7.13	7
R.M. juniper	RMJ-I-T-7	T	I	2	4	TWG	1	64.0	9.0	13.33	7
ponderosa pine	Pine-I-T-10	T	I	2	5	TWG	0				
green ash	Ash-I-NT-10	NT	I	2	6	TWG	1	26.0	-10.0	10.27	8
green ash	Ash-I-T-4	T	I	2	7	TWG	1	57.0	-7.0	7.16	6
R.M. juniper	RMJ-I-NT-3	NT	I	2	8	TWG	1	85.0	18.0	19.45	7
R.M. juniper	RMJ-I-T-5	T	I	2	9	TWG	1	61.0	6.0	17.05	7
R.M. juniper	RMJ-I-NT-8	NT	I	2	10	TWG	1	66.0	9.0	20.66	6
ponderosa pine	Pine-I-NT-2	NT	I	3	1	TWG	1	48.5	4.5	13.49	7
green ash	Ash-I-T-5	T	I	3	2	TWG	1	37.0	1.0	9.37	7
ponderosa pine	Pine-I-NT-10	NT	I	3	3	TWG	1	55.0	6.0	20.44	6
green ash	Ash-I-T-1	T	I	3	4	TWG	1	18.0	-7.0	9.29	8
bur oak	Oak-I-NT-10	NT	I	3	5	TWG	1	17.5	-3.5	2.81	7
ponderosa pine	Pine-I-T-4	T	I	3	6	TWG	1	71.0	10.0	22.01	6
R.M. juniper	RMJ-I-T-4	T	I	3	7	TWG	1	73.0	14.0	20.33	7
green ash	Ash-I-T-7	T	I	3	8	TWG	1	61.5	0.5	6.35	7
bur oak	Oak-I-T-7	T	I	3	9	TWG	1	18.0	3.0	2.34	8
bur oak	Oak-I-NT-6	NT	I	3	10	TWG	1	17.0	2.0	1.99	8
green ash	Ash-I-T-8	T	I	4	1	TWG	1	48.0	-12.0	6.29	7
bur oak	Oak-I-T-9	T	I	4	2	TWG	1	36.0	-1.0	6.77	7
bur oak	Oak-I-NT-2	NT	I	4	3	TWG	1	16.5	0.5	2.54	7
green ash	Ash-I-T-10	T	I	4	4	TWG	1	46.0	0.0	5.20	8
ponderosa pine	Pine-I-NT-4	NT	I	4	5	TWG	1	51.0	6.0	16.91	7
bur oak	Oak-I-NT-1	NT	I	4	6	TWG	0				
ponderosa pine	Pine-I-NT-7	NT	I	4	7	TWG	1	57.5	6.5	22.71	6
green ash	Ash-I-NT-1	NT	I	4	8	TWG	1	61.0	1.0	6.63	8
R.M. juniper	RMJ-I-NT-4	NT	I	4	9	TWG	1	62.0	12.0	15.42	7
green ash	Ash-I-NT-8	NT	I	4	10	TWG	1	16.0	-47.0	6.90	8
bur oak	Oak-I-NT-5	NT	I	5	1	TWG	1	11.0	-18.0	8.13	8
bur oak	Oak-I-NT-4	NT	I	5	2	TWG	0				
bur oak	Oak-I-T-6	T	I	5	3	TWG	1	19.0	-1.0	6.84	8

Appendix 2. Irrigation Tube Study, Evaluation Form, Field 14 – Vegetated, November 2009.

Species	I.D.		B	R	P	Grass Cover Species	Fall 2009 Surv.	Fall 2009 Height	Fall 2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
							(0,1)	*cm*	*cm*	*mm*	*(1-9)*
ponderosa pine	Pine-I-NT-5	NT	I	5	4	TWG	1	48.0	4.0	16.31	7
ponderosa pine	Pine-I-NT-6	NT	I	5	5	TWG	1	62.0	3.0	22.95	7
R.M. juniper	RMJ-I-T-1	T	I	5	6	TWG	1	67.5	14.5	14.90	7
R.M. juniper	RMJ-I-NT-5	NT	I	5	7	TWG	1	70.0	15.0	18.14	7
green ash	Ash-I-T-9	T	I	5	8	TWG	1	17.0	-38.0	6.37	7
R.M. juniper	RMJ-I-NT-7	NT	I	5	9	TWG	1	64.5	9.5	19.85	6
green ash	Ash-I-NT-3	NT	I	5	10	TWG	1	54.0	0.0	8.30	8
R.M. juniper	RMJ-I-NT-2	NT	I	6	1	TWG	1	64.0	9.0	15.58	7
ponderosa pine	Pine-I-T-6	T	I	6	2	TWG	1	82.0	12.0	24.43	5
R.M. juniper	RMJ-I-NT-10	NT	I	6	3	TWG	1	68.0	14.0	17.28	6
bur oak	Oak-I-T-3	T	I	6	4	TWG	1	22.0	2.0	7.42	7
R.M. juniper	RMJ-I-NT-6	NT	I	6	5	TWG	1	78.0	13.0	17.76	7
ponderosa pine	Pine-I-T-8	T	I	6	6	TWG	1	48.0	8.0	14.47	6
R.M. juniper	RMJ-I-T-10	T	I	6	7	TWG	1	58.0	8.0	17.52	7
bur oak	Oak-I-T-8	T	I	6	8	TWG	0				
R.M. juniper	RMJ-I-NT-1	NT	I	6	9	TWG	1	57.0	6.0	19.04	6
R.M. juniper	RMJ-I-T-9	T	I	6	10	TWG	1	55.0	6.0	12.38	7
bur oak	Oak-I-T-10	T	I	7	1	TWG	1	26.0	2.0	6.65	8
ponderosa pine	Pine-I-T-5	T	I	7	2	TWG	1	74.5	19.5	20.51	5
R.M. juniper	RMJ-I-T-2	T	I	7	3	TWG	1	80.0	20.0	16.91	7
R.M. juniper	RMJ-I-T-3	T	I	7	4	TWG	1	59.0	14.0	14.58	7
bur oak	Oak-I-NT-8	NT	I	7	5	TWG	0				
ponderosa pine	Pine-I-T-7	T	I	7	6	TWG	1	33.0	5.0	11.89	7
bur oak	Oak-I-T-4	T	I	7	7	TWG	1	34.0	-13.0	6.67	8
green ash	Ash-I-NT-9	NT	I	7	8	TWG	1	34.5	-0.5	7.27	7
R.M. juniper	RMJ-I-T-6	T	I	7	9	TWG	1	44.5	2.5	10.74	7
green ash	Ash-I-NT-5	NT	I	7	10	TWG	1	65.0	0.0	8.62	7
green ash	Ash-I-NT-4	NT	I	8	1	TWG	1	54.0	4.0	7.19	7
bur oak	Oak-I-NT-3	NT	I	8	2	TWG	1	20.0	5.0	7.77	7
ponderosa pine	Pine-I-T-2	T	I	8	3	TWG	1	56.0	6.0	16.98	6
bur oak	Oak-I-T-1	T	I	8	4	TWG	1	45.0	2.0	7.21	8
green ash	Ash-I-NT-6	NT	I	8	5	TWG	1	65.0	6.0	7.79	7
R.M. juniper	RMJ-I-NT-9	NT	I	8	6	TWG	1	63.0	13.0	15.53	7
bur oak	Oak-I-T-5	T	I	8	7	TWG	1	15.0	-8.0	6.52	8
bur oak	Oak-I-NT-7	NT	I	8	8	TWG	1	33.0	3.0	7.40	7
ponderosa pine	Pine-I-NT-8	NT	I	8	9	TWG	1	53.0	7.0	16.77	7
bur oak	Oak-I-NT-9	NT	I	8	10	TWG	1	5.0	-5.0	9.26	8
bur oak	Oak-II-NT-10	NT	II	9	1	TWG	1	8.5	-1.5	6.41	8
bur oak	Oak-II-NT-1	NT	II	9	2	TWG	1	31.0	5.0	7.36	7
bur oak	Oak-II-T-1	T	II	9	3	TWG	1	23.0	3.0	6.60	8
green ash	Ash-II-T-7	T	II	9	4	TWG	1	74.0	2.0	10.12	7
R.M. juniper	RMJ-II-NT-6	NT	II	9	5	TWG	1	42.0	7.0	15.99	7
R.M. juniper	RMJ-II-NT-9	NT	II	9	6	TWG	1	52.0	7.0	12.21	7

Appendix 2. Irrigation Tube Study, Evaluation Form, Field 14 – Vegetated, November 2009.

Species	I.D.		B	R	P	Grass Cover Species	Fall 2009 Surv.	Fall 2009 Height	Fall 2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
							(0,1)	*cm*	*cm*	*mm*	*(1-9)*
green ash	Ash-II-NT-6	NT	II	9	7	TWG	1	62.5	2.5	7.28	7
bur oak	Oak-II-NT-2	NT	II	9	8	TWG	0				
bur oak	Oak-II-T-2	T	II	9	9	TWG	1	58.0	2.0	8.08	6
ponderosa pine	Pine-II-NT-2	NT	II	9	10	TWG	1	84.0	14.0	25.72	5
ponderosa pine	Pine-II-T-6	T	II	10	1	TWG	1	66.0	3.0	23.58	5
green ash	Ash-II-T-9	T	II	10	2	TWG	1	35.0	-5.0	5.72	7
bur oak	Oak-II-T-3	T	II	10	3	TWG	1	10.0	-12.0	2.73	9
green ash	Ash-II-T-5	T	II	10	4	TWG	1	67.0	-13.0	7.30	7
ponderosa pine	Pine-II-NT-6	NT	II	10	5	TWG	1	27.0	2.0	10.44	8
green ash	Ash-II-T-10	T	II	10	6	TWG	1	36.5	-3.5	7.84	7
ponderosa pine	Pine-II-T-7	T	II	10	7	TWG	1	62.0	10.0	18.50	7
bur oak	Oak-II-NT-7	NT	II	10	8	TWG	1	14.0	5.0	1.99	8
ponderosa pine	Pine-II-NT-8	NT	II	10	9	TWG	1	61.0	7.0	19.88	6
green ash	Ash-II-NT-9	NT	II	10	10	TWG	1	57.0	4.0	6.40	7
R.M. juniper	RMJ-II-T-3	T	II	11	1	TWG	1	76.0	16.0	15.92	7
bur oak	Oak-II-NT-8	NT	II	11	2	TWG	1	30.5	3.5	6.67	9
bur oak	Oak-II-NT-6	NT	II	11	3	TWG	1	27.0	4.0	5.37	7
bur oak	Oak-II-T-5	T	II	11	4	TWG	1	23.0	11.0	3.42	7
R.M. juniper	RMJ-II-NT-8	NT	II	11	5	TWG	1	79.0	19.0	17.83	6
R.M. juniper	RMJ-II-NT-1	NT	II	11	6	TWG	1	79.0	19.0	17.44	6
R.M. juniper	RMJ-II-T-5	T	II	11	7	TWG	1	87.0	12.0	17.26	6
R.M. juniper	RMJ-II-T-8	T	II	11	8	TWG	1	70.0	16.0	17.94	6
ponderosa pine	Pine-II-T-5	T	II	11	9	TWG	1	40.5	5.5	16.50	7
green ash	Ash-II-T-4	T	II	11	10	TWG	1	55.0	1.0	7.85	7
ponderosa pine	Pine-II-NT-7	NT	II	12	1	TWG	1	94.0	16.0	23.63	5
ponderosa pine	Pine-II-NT-4	NT	II	12	2	TWG	1	70.0	13.0	20.17	6
green ash	Ash-II-NT-2	NT	II	12	3	TWG	1	29.0	3.0	8.42	7
bur oak	Oak-II-NT-9	NT	II	12	4	TWG	1	20.5	-16.5	8.26	7
bur oak	Oak-II-NT-5	NT	II	12	5	TWG	1	18.0	0.0	7.11	8
R.M. juniper	RMJ-II-NT-10	NT	II	12	6	TWG	1	62.0	13.0	15.14	7
green ash	Ash-II-NT-8	NT	II	12	7	TWG	1	51.5	8.5	5.84	7
green ash	Ash-II-NT-3	NT	II	12	8	TWG	1	72.0	5.0	7.60	6
R.M. juniper	RMJ-II-T-2	T	II	12	9	TWG	1	75.5	17.5	15.90	6
ponderosa pine	Pine-II-NT-1	NT	II	12	10	TWG	1	45.0	14.0	15.97	8
ponderosa pine	Pine-II-T-10	T	II	13	1	TWG	1	74.0	15.0	23.51	5
green ash	Ash-II-T-8	T	II	13	2	TWG	1	55.0	0.0	7.73	7
green ash	Ash-II-NT-1	NT	II	13	3	TWG	1	66.0	5.0	7.57	6
ponderosa pine	Pine-II-T-8	T	II	13	4	TWG	1	69.0	13.0	20.40	5
green ash	Ash-II-T-3	T	II	13	5	BB- Border	1	49.0	1.0	7.04	7
green ash	Ash-II-NT-4	NT	II	13	6	BB- Border	1	72.0	4.0	9.64	6
R.M. juniper	RMJ-II-T-10	T	II	13	7	BB- Border	1	63.5	18.5	14.24	7
bur oak	Oak-II-T-7	T	II	13	8	BB- Border	1	21.5	3.5	6.61	7
ponderosa pine	Pine-II-T-9	T	II	13	9	BB- Border	1	74.5	12.5	24.98	5

Appendix 2. Irrigation Tube Study, Evaluation Form, Field 14 – Vegetated, November 2009.

Species	I.D.		B	R	P	Grass Cover Species	Fall 2009 Surv.	Fall 2009 Height	Fall 2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
							(0,1)	*cm*	*cm*	*mm*	*(1-9)*
R.M. juniper	RMJ-II-NT-4	NT	II	13	10	BB- Border	1	93.0	8.0	23.26	6
bur oak	Oak-II-T-9	T	II	14	1	TWG	1	34.5	-5.5	7.60	7
green ash	Ash-II-T-6	T	II	14	2	TWG	1	47.5	2.5	7.99	7
bur oak	Oak-II-NT-4	NT	II	14	3	TWG	1	13.0	-1.0	2.51	8
ponderosa pine	Pine-II-T-2	T	II	14	4	TWG	1	77.0	12.0	20.08	5
green ash	Ash-II-T-1	T	II	14	5	BB	1	50.0	2.0	5.90	7
ponderosa pine	Pine-II-NT-9	NT	II	14	6	BB	1	63.0	14.0	22.42	5
R.M. juniper	RMJ-II-T-1	T	II	14	7	BB	1	33.0	-22.0	16.77	6
R.M. juniper	RMJ-II-NT-2	NT	II	14	8	BB	1	88.0	14.0	19.27	5
ponderosa pine	Pine-II-NT-10	NT	II	14	9	BB	1	51.0	13.0	13.96	6
R.M. juniper	RMJ-II-T-6	T	II	14	10	BB	1	79.5	19.5	20.78	6
bur oak	Oak-II-NT-3	NT	II	15	1	TWG	1	18.5	-9.5	5.14	7
R.M. juniper	RMJ-II-T-7	T	II	15	2	TWG	1	67.5	13.5	15.94	6
R.M. juniper	RMJ-II-NT-3	NT	II	15	3	TWG	1	60.0	15.0	13.74	7
ponderosa pine	Pine-II-NT-3	NT	II	15	4	TWG	1	71.0	7.0	20.74	6
R.M. juniper	RMJ-II-T-4	T	II	15	5	BB	1	59.0	14.0	13.10	7
bur oak	Oak-II-T-8	T	II	15	6	BB	1	35.0	5.0	5.99	7
bur oak	Oak-II-T-6	T	II	15	7	BB	1	5.0	-18.0	3.10	8
R.M. juniper	RMJ-II-NT-5	NT	II	15	8	BB	1	91.0	20.0	20.75	6
R.M. juniper	RMJ-II-T-9	T	II	15	9	BB	1	93.0	28.0	16.30	6
bur oak	Oak-II-T-10	T	II	15	10	BB	1	19.0	-15.0	6.62	7
green ash	Ash-II-NT-5	NT	II	16	1	TWG	1	55.0	4.0	8.11	7
ponderosa pine	Pine-II-T-1	T	II	16	2	TWG	1	61.0	11.0	20.23	6
green ash	Ash-II-NT-7	NT	II	16	3	TWG	1	10.0	1.0	2.81	9
green ash	Ash-II-NT-10	NT	II	16	4	TWG	1	65.5	0.5	9.18	7
ponderosa pine	Pine-II-T-3	T	II	16	5	BB	1	33.0	4.0	15.35	8
R.M. juniper	RMJ-II-NT-7	NT	II	16	6	BB	1	65.0	14.0	16.72	5
ponderosa pine	Pine-II-NT-5	NT	II	16	7	BB	1	76.0	15.0	23.81	5
ponderosa pine	Pine-II-T-4	T	II	16	8	BB	1	92.0	22.0	31.84	4
green ash	Ash-II-T-2	T	II	16	9	BB	1	59.5	0.5	7.58	7
bur oak	Oak-II-T-4	T	II	16	10	BB	1	30.5	6.5	4.81	7
green ash	Ash-III-NT-3	NT	III	17	1	TWG	1	69.0	5.0	7.49	7
green ash	Ash-III-NT-5	NT	III	17	2	TWG	1	53.5	2.5	5.83	7
R.M. juniper	RMJ-III-NT-4	NT	III	17	3	TWG	1	63.0	13.0	13.03	6
bur oak	Oak-III-NT-8	NT	III	17	4	TWG	1	8.0	-22.0	5.62	7
ponderosa pine	Pine-III-NT-2	NT	III	17	5	TWG	0				
bur oak	Oak-III-T-8	T	III	17	6	TWG	1	18.0	3.0	5.28	8
bur oak	Oak-III-T-1	T	III	17	7	TWG	1	8.5	-1.5	4.54	9
R.M. juniper	RMJ-III-T-5	T	III	17	8	TWG	1	80.0	12.0	17.92	7
green ash	Ash-III-NT-9	NT	III	17	9	TWG	1	96.0	27.0	8.80	7
R.M. juniper	RMJ-III-T-10	T	III	17	10	TWG	1	55.0	15.0	12.97	6
green ash	Ash-III-NT-2	NT	III	18	1	TWG	1	27.0	2.0	8.74	7
ponderosa pine	Pine-III-T-10	T	III	18	2	TWG	1	58.0	10.0	16.20	6

Appendix 2. Irrigation Tube Study, Evaluation Form, Field 14 – Vegetated, November 2009.

Species	I.D.		B	R	P	Grass Cover Species	Fall 2009 Surv.	Fall 2009 Height	Fall 2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
							(0,1)	*cm*	*cm*	*mm*	*(1-9)*
R.M. juniper	RMJ-III-NT-2	NT	III	18	3	TWG	1	66.0	11.0	18.68	6
green ash	Ash-III-NT-6	NT	III	18	4	TWG	1	40.0	0.0	5.71	7
green ash	Ash-III-T-5	T	III	18	5	TWG	1	49.5	13.5	5.50	8
bur oak	Oak-III-NT-3	NT	III	18	6	TWG	1	9.5	-17.5	6.41	9
ponderosa pine	Pine-III-NT-9	NT	III	18	7	TWG	1	33.5	3.5	13.75	7
bur oak	Oak-III-T-7	T	III	18	8	TWG	1	21.0	0.0	7.69	
bur oak	Oak-III-T-10	T	III	18	9	TWG	1	17.0	2.0	5.16	8
ponderosa pine	Pine-III-NT-3	NT	III	18	10	TWG	1	36.0	8.0	13.13	8
ponderosa pine	Pine-III-T-5	T	III	19	1	TWG	1	100.0	17.0	33.21	5
R.M. juniper	RMJ-III-T-4	T	III	19	2	TWG	1	45.0	5.0	10.60	7
green ash	Ash-III-T-10	T	III	19	3	SRWR	0				
bur oak	Oak-III-NT-1	NT	III	19	4	SRWR	0				
R.M. juniper	RMJ-III-NT-7	NT	III	19	5	SRWR	1	39.5	4.5	9.48	7
green ash	Ash-III-NT-1	NT	III	19	6	SRWR	1	12.0	-33.0	5.73	8
bur oak	Oak-III-NT-7	NT	III	19	7	SRWR	0				
ponderosa pine	Pine-III-NT-6	NT	III	19	8	SRWR	0				
green ash	Ash-III-T-1	T	III	19	9	SRWR	0				
ponderosa pine	Pine-III-T-3	T	III	19	10	TWG	1	56.5	6.5	16.34	6
green ash	Ash-III-NT-7	NT	III	20	1	TWG	1	52.5	5.5	7.99	7
bur oak	Oak-III-T-6	T	III	20	2	TWG	1	49.0	-1.0	6.14	8
green ash	Ash-III-T-4	T	III	20	3	SRWR	1	14.5	-20.5	5.80	8
ponderosa pine	Pine-III-NT-5	NT	III	20	4	SRWR	0				
R.M. juniper	RMJ-III-NT-10	NT	III	20	5	SRWR	1	46.5	7.5	9.20	8
ponderosa pine	Pine-III-T-7	T	III	20	6	SRWR	1	26.0	4.0	10.82	8
bur oak	Oak-III-NT-2	NT	III	20	7	SRWR	0				
ponderosa pine	Pine-III-T-6	T	III	20	8	SRWR	1	28.0	-5.0	11.46	8
ponderosa pine	Pine-III-T-9	T	III	20	9	SRWR	1	21.5	-0.5	7.95	8
green ash	Ash-III-NT-8	NT	III	20	10	TWG	1	33.0	12.0	8.11	8
ponderosa pine	Pine-III-NT-7	NT	III	21	1	TWG	1	89.0	14.0	24.44	5
bur oak	Oak-III-NT-4	NT	III	21	2	TWG	1	20.0	-10.0	8.83	7
R.M. juniper	RMJ-III-NT-8	NT	III	21	3	SRWR	1	53.0	7.0	10.71	7
ponderosa pine	Pine-III-NT-1	NT	III	21	4	SRWR	1	35.0	0.0	12.14	8
ponderosa pine	Pine-III-T-8	T	III	21	5	SRWR	1	30.0	2.0	7.05	8
R.M. juniper	RMJ-III-T-8	T	III	21	6	SRWR	1	63.0	12.0	15.19	7
ponderosa pine	Pine-III-T-1	T	III	21	7	SRWR	0				
R.M. juniper	RMJ-III-T-3	T	III	21	8	SRWR	1	15.0	7.0	8.13	9
bur oak	Oak-III-T-3	T	III	21	9	SRWR	0				
bur oak	Oak-III-NT-9	NT	III	21	10	TWG	0				
green ash	Ash-III-NT-4	NT	III	22	1	TWG	1	55.0	-5.0	8.62	8
ponderosa pine	Pine-III-T-4	T	III	22	2	TWG	1	33.5	1.5	15.90	8
bur oak	Oak-III-T-9	T	III	22	3	SRWR	0				
R.M. juniper	RMJ-III-T-2	T	III	22	4	SRWR	1	18.0	0.0	13.01	9
ponderosa pine	Pine-III-T-2	T	III	22	5	SRWR	0				

Appendix 2. Irrigation Tube Study, Evaluation Form, Field 14 – Vegetated, November 2009.

Species	I.D.		B	R	P	Grass Cover Species	Fall 2009 Surv.	Fall 2009 Height	Fall 2009 Height Growth	Fall 2009 Caliper	Fall 2009 Vigor Rating
							(0,1)	*cm*	*cm*	*mm*	*(1-9)*
bur oak	Oak-III-NT-10	NT	III	22	6	SRWR	0				
green ash	Ash-III-T-3	T	III	22	7	SRWR	1	12.0	-14.0	6.79	9
R.M. juniper	RMJ-III-T-9	T	III	22	8	SRWR	1	11.0	3.0	7.00	9
R.M. juniper	RMJ-III-T-1	T	III	22	9	SRWR	1	10.0	2.0	5.78	9
bur oak	Oak-III-NT-5	NT	III	22	10	TWG	1	10.5	0.5	1.75	9
ponderosa pine	Pine-III-NT-10	NT	III	23	1	TWG	1	32.5	1.5	11.22	8
bur oak	Oak-III-T-4	T	III	23	2	TWG	1	11.0	-21.0	1.37	9
green ash	Ash-III-NT-10	NT	III	23	3	SRWR	0				
R.M. juniper	RMJ-III-T-6	T	III	23	4	SRWR	0				
bur oak	Oak-III-T-2	T	III	23	5	SRWR	0				
ponderosa pine	Pine-III-NT-8	NT	III	23	6	SRWR	0				
green ash	Ash-III-T-9	T	III	23	7	SRWR	1	35.5	-3.5	5.44	7
R.M. juniper	RMJ-III-NT-1	NT	III	23	8	SRWR	1	21.0	-19.0	8.58	9
R.M. juniper	RMJ-III-T-7	T	III	23	9	SRWR	1	28.0	4.0	6.37	9
R.M. juniper	RMJ-III-NT-5	NT	III	23	10	TWG	1	43.5	4.5	11.33	8
ponderosa pine	Pine-III-NT-4	NT	III	24	1	TWG	1	57.0	8.0	19.18	7
R.M. juniper	RMJ-III-NT-3	NT	III	24	2	TWG	1	47.0	8.0	10.50	8
bur oak	Oak-III-T-5	T	III	24	3	SRWR	0				
green ash	Ash-III-T-2	T	III	24	4	SRWR	1	10.5	-6.5	7.23	9
green ash	Ash-III-T-6	T	III	24	5	SRWR	1	22.0	0.0	5.47	8
bur oak	Oak-III-NT-6	NT	III	24	6	SRWR	0				
green ash	Ash-III-T-8	T	III	24	7	SRWR	0				
R.M. juniper	RMJ-III-NT-9	NT	III	24	8	SRWR	1	20.5	-5.5	6.69	9
green ash	Ash-III-T-7	T	III	24	9	TWG	0				
R.M. juniper	RMJ-III-NT-6	NT	III	24	10	TWG	1	57.0	8.0	11.94	8

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

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

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

level of the 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 evaluation data for 2006, 2007, 2008, and 2009 appears in Appendices 1, 3, 5, and 7, respectively. Soil evaluation data for 2006, 2007, 2008, and 2009 appears in Appendices 2, 4, 6, and 8, respectively. Mean seedling root length and plant percentage survival over time appears in Table 2.

Data analysis for 2005 through 2009 will appear in the 2010 Annual Technical Report upon study completion.

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**

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival (0,1)	Fall 2006 Height *cm*	2006 Growth *cm*	Summer Vigor Rating (1-9)	Comments
south end of plot							
Shepherdia argentea	1	east border					
Shepherdia argentea	1	1	1	65.0	4.0	2	
Shepherdia argentea	1	2	1	64.0	8.0	3	
Shepherdia argentea	1	3	1	48.5	2.5	2	
Shepherdia argentea	1	4	1	63.0	4.5	2	
Shepherdia argentea	1	5	1	55.0	3.5	3	
Shepherdia argentea	1	6	1	60.5	6.5	3	
Shepherdia argentea	1	7	1	75.0	14.0	2	
Shepherdia argentea	1	8	1	69.5	16.5	**2**	
Shepherdia argentea	1	9	1	65.5	9.5	3	
Shepherdia argentea	1	10	1	65.0	24.0	**3**	
Shepherdia argentea	1	11	1	43.0	1.0	4	browsed
Shepherdia argentea	1	12	1	55.5	2.5	4	
Shepherdia argentea	1	13	1	57.0	9.5	4	
Shepherdia argentea	1	14	1	56.0	6.0	4	
Shepherdia argentea	1	15	0	**54.5**	0.0	9	dead
Shepherdia argentea	1	16	0	**53.5**	0.0	9	dead
Shepherdia argentea	1	17	1	53.0	0.0	5	
Shepherdia argentea	1	18	1	58.0	3.0	**5**	
Shepherdia argentea	1	19	1	60.0	4.0	6	
Shepherdia argentea	1	20	0	53.5	0.0	9	dead
Shepherdia argentea	1	21	0	32.0	0.0	9	dead
Shepherdia argentea	1	22	0	41.0	0.0	9	dead
Shepherdia argentea	1	23	1	63.0	6.0	3	
Shepherdia argentea	1	24	0	45.0	0.0	9	dead
Shepherdia argentea	1	25	1	40.0	0.5	5	
Shepherdia argentea	1	26	1	54.5	0.5	6	
Shepherdia argentea	1	27	1	50.0	1.0	5	
Shepherdia argentea	1	28	1	59.0	1.0	4	
Shepherdia argentea	1	29	1	65.0	0.5	6	
Shepherdia argentea	1	30	0	56.0	0.0	9	dead
Shepherdia argentea	1	west border					
Shepherdia argentea	2	east border					
Prunus virginiana	2	1	1	40.0	1.0	**6**	browsed
Prunus virginiana	2	2	1	44.0	3.5	4	very browsed
Prunus virginiana	2	3	1	53.5	5.0	4	browsed
Prunus virginiana	2	4	1	53.0	9.0	5	very browsed
Prunus virginiana	2	5	1	53.5	7.5	4	very browsed
Prunus virginiana	2	6	1	47.5	5.0	4	
Prunus virginiana	2	7	1	37.0	2.5	7	
Prunus virginiana	2	8	1	53.0	2.5	6	
Prunus virginiana	2	9	1	55.0	2.0	6	
Prunus virginiana	2	10	1	55.5	7.5	5	

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Prunus virginiana	2	11	1	48.0	2.0	5	
Prunus virginiana	2	12	1	47.0	1.0	5	
Prunus virginiana	2	13	1	64.5	11.0	4	browsed
Prunus virginiana	2	14	1	56.5	6.5	6	
Prunus virginiana	2	15	0	12.0	0.0	9	dead
Prunus virginiana	2	16	0	0.0	0.0	9	dead
Prunus virginiana	2	17	0	0.0	0.0	9	dead
Prunus virginiana	2	18	0	23.5	0.0	9	dead
Prunus virginiana	2	19	0	19.5	0.0	9	dead
Prunus virginiana	2	20	0	45.0	0.0	9	dead
Prunus virginiana	2	21	0	22.0	0.0	9	dead
Prunus virginiana	2	22	0	30.5	0.0	9	dead
Prunus virginiana	2	23	0	0.0	0.0	9	dead
Prunus virginiana	2	24	0	0.0	0.0	9	dead
Prunus virginiana	2	25	0	0.0	0.0	9	dead
Prunus virginiana	2	26	0	0.0	0.0	9	dead
Prunus virginiana	2	27	0	0.0	0.0	9	dead
Prunus virginiana	2	28	0	0.0	0.0	9	dead
Prunus virginiana	2	29	0	0.0	0.0	9	dead
Prunus virginiana	2	30	0	0.0	0.0	9	dead
Shepherdia argentea	2	west border					
Shepherdia argentea	3	east border					
Picea pungens	3	1	1	**8.5**	2.0	7	leader damaged
Picea pungens	3	2	1	13	3.5	6	leader damaged
Picea pungens	3	3	1	18.5	9.5	5	
Picea pungens	3	4	1	27.5	16.5	4	
Picea pungens	3	5	1	23	8.0	4	
Picea pungens	3	6	1	25	12.0	4	
Picea pungens	3	7	1	23	13.0	4	
Picea pungens	3	8	1	20.5	8.5	4	
Picea pungens	3	9	1	27	10.5	3	
Picea pungens	3	10	1	23.5	11.5	5	
Picea pungens	3	11	1	18.5	6.5	4	
Picea pungens	3	12	1	22.5	10.5	5	
Picea pungens	3	13	1	17	8.0	6	
Picea pungens	3	14	0	8.5	0.0	9	dead
Picea pungens	3	15	0	8.0	0.0	9	dead
Picea pungens	3	16	0	8.0	0.0	9	dead
Picea pungens	3	17	0	10.5	0.0	7	dead
Picea pungens	3	18	0	12.5	0.0	7	dead
Picea pungens	3	19	0	15.0	0.0	9	dead
Picea pungens	3	20	1	24.5	5.5	**6**	
Picea pungens	3	21	0	12.5	0.0	9	dead
Picea pungens	3	22	**0**	15.5	0.0	9	dead

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Picea pungens	3	23	**0**	19.0	0.0	9	dead
Picea pungens	3	24	**0**	7.0	0.0	9	dead
Picea pungens	3	25	**0**	13.0	0.0	9	dead
Picea pungens	3	26	**0**	13.0	0.0	9	dead
Picea pungens	3	27	**0**	10.5	0.0	9	dead
Picea pungens	3	28	**0**	10.0	0.0	9	dead
Picea pungens	3	29	**0**	10.0	0.0	9	dead
Picea pungens	3	30	**0**	15.5	0.0	9	dead
Shepherdia argentea	3	west border					
Shepherdia argentea	4	east border					
Lonicera korolkowii	4	1	1	59.0	16.0	2	
Lonicera korolkowii	4	2	1	61.0	14.0	3	
Lonicera korolkowii	4	3	1	79.0	41.0	2	browsed
Lonicera korolkowii	4	4	1	52.0	10.0	2	
Lonicera korolkowii	4	5	1	51.5	10.5	3	insects
Lonicera korolkowii	4	6	1	73.5	10.5	2	insects
Lonicera korolkowii	4	7	1	58.0	7.0	5	insect damage
Lonicera korolkowii	4	8	1	67.5	12.5	2	insect damage
Lonicera korolkowii	4	9	1	77.0	23.5	3	insect damage
Lonicera korolkowii	4	10	1	60.5	4.0	3	insect damage
Lonicera korolkowii	4	11	1	75.0	26.5	3	
Lonicera korolkowii	4	12	1	84.5	29.5	2	insects
Lonicera korolkowii	4	13	1	61.0	11.0	3	insects
Lonicera korolkowii	4	14	1	51.5	6.5	3	insects
Lonicera korolkowii	4	15	1	59.0	13.5	4	
Lonicera korolkowii	4	16	1	60.5	8.5	3	
Lonicera korolkowii	4	17	1	58.5	7.5	3	insects
Lonicera korolkowii	4	18	1	43.0	2.5	4	
Lonicera korolkowii	4	19	1	55.0	1.0	4	
Lonicera korolkowii	4	20	1	55.0	6.0	4	
Lonicera korolkowii	4	21	1	**64.0**	2.0	4	
Lonicera korolkowii	4	22	0	20.0	0.0	9	dead
Lonicera korolkowii	4	23	1	56.5	0.0	7	
Lonicera korolkowii	4	24	1	**31.0**	-14.0	6	
Lonicera korolkowii	4	25	1	**52.0**	-7.0	5	
Lonicera korolkowii	4	26	1	36.5	1.0	5	
Lonicera korolkowii	4	27	0	29.0	0.0	9	dead
Lonicera korolkowii	4	28	0	28.5	0.0	9	dead
Lonicera korolkowii	4	29	1	**42.0**	-1.0	4	
Lonicera korolkowii	4	30	1	43.5	0.0	5	
Shepherdia argentea	4	west border					
Shepherdia argentea	5	east border					
Elaeagnus commutata	5	1	1	46.0	15.0	2	
Elaeagnus commutata	5	2	1	54.5	2.0	3	browsed

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Elaeagnus commutata	5	3	1	49.5	4.0	2	
Elaeagnus commutata	5	4	1	44.0	14.0	4	browsed
Elaeagnus commutata	5	5	1	63.5	26.0	4	
Elaeagnus commutata	5	6	1	51.0	26.5	4	
Elaeagnus commutata	5	7	1	32.0	0.5	5	
Elaeagnus commutata	5	8	1	41.0	2.0	4	
Elaeagnus commutata	5	9	1	43.0	4.5	3	
Elaeagnus commutata	5	10	1	60.5	18.5	4	
Elaeagnus commutata	5	11	1	42.0	12.5	4	
Elaeagnus commutata	5	12	1	34.0	0.0	6	
Elaeagnus commutata	5	13	1	52.0	6.0	5	
Elaeagnus commutata	5	14	1	28.0	2.5	5	browsed
Elaeagnus commutata	5	15	1	43.0	2.0	5	browsed
Elaeagnus commutata	5	16	1	40.0	1.0	6	
Elaeagnus commutata	5	17	1	26.0	3.5	7	
Elaeagnus commutata	5	18	1	26.5	0.5	7	
Elaeagnus commutata	5	19	1	53.0	0.5	7	
Elaeagnus commutata	5	20	0	39.5	0.0	9	dead
Elaeagnus commutata	5	21	1	33.5	0.0	7	
Elaeagnus commutata	5	22	0	0.0	0.0	9	dead
Elaeagnus commutata	5	23	1	37.5	0.5	7	
Elaeagnus commutata	5	24	0	0.0	0.0	9	dead
Elaeagnus commutata	5	25	0	46.5	0.0	**9**	dead
Elaeagnus commutata	5	26	1	34.0	3.0	7	
Elaeagnus commutata	5	27	1	37.5	1.0	6	
Elaeagnus commutata	5	28	1	46.5	0.5	7	
Elaeagnus commutata	5	29	0	8.5	0.0	9	dead
Elaeagnus commutata	5	30	0	31.0	0.0	9	dead
Shepherdia argentea	5	west border					
Shepherdia argentea	6	east border					
Ribes aureum	6	1	1	48.0	7.0	3	
Ribes aureum	6	2	1	56.5	11.5	2	
Ribes aureum	6	3	1	66.5	28.5	4	
Ribes aureum	6	4	1	48.0	12.0	3	
Ribes aureum	6	5	1	60.0	27.0	4	browsed
Ribes aureum	6	6	1	53.5	9.5	3	
Ribes aureum	6	7	1	56.0	17.0	3	
Ribes aureum	6	8	1	36.0	12.0	4	
Ribes aureum	6	9	1	45.0	4.0	5	browsed
Ribes aureum	6	10	1	52.5	6.5	4	
Ribes aureum	6	11	1	42.0	7.0	5	
Ribes aureum	6	12	1	63.0	17.0	4	
Ribes aureum	6	13	1	64.5	29.5	5	
Ribes aureum	6	14	1	57.0	20.0	4	

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Ribes aureum	6	15	1	48.0	11.0	5	
Ribes aureum	6	16	0	0.0	0.0	9	dead
Ribes aureum	6	17	1	65.0	25.0	6	
Ribes aureum	6	18	1	47.5	8.5	4	
Ribes aureum	6	19	1	39.0	11.0	7	
Ribes aureum	6	20	1	47.5	11.5	3	
Ribes aureum	6	21	0	0.0	0.0		dead
Ribes aureum	6	22	0	0.0	0.0		dead
Ribes aureum	6	23	1	39.0	28.0	4	
Ribes aureum	6	24	0	0.0	0.0	9	dead
Ribes aureum	6	25	0	0.0	0.0	9	dead
Ribes aureum	6	26	0	0.0	0.0	9	dead
Ribes aureum	6	27	0	21.0	0.0	9	dead
Ribes aureum	6	28	0	0.0	0.0	9	dead
Ribes aureum	6	29	0	0.0	0.0	9	dead
Ribes aureum	6	30	0	0.0	0.0	9	dead
Shepherdia argentea	6	west border					
Shepherdia argentea	7	east border					
Hippophae rhamnoides	7	1	1	37.0	9.0	4	
Hippophae rhamnoides	7	2	1	47.0	8.0	5	
Hippophae rhamnoides	7	3	1	48.0	9.0	3	
Hippophae rhamnoides	7	4	1	41.0	10.0	5	
Hippophae rhamnoides	7	5	1	54.5	16.5	5	
Hippophae rhamnoides	7	6	1	43.5	9.5	5	
Hippophae rhamnoides	7	7	1	52.0	18.0	4	browsed
Hippophae rhamnoides	7	8	1	36.5	3.5	6	
Hippophae rhamnoides	7	9	1	34.0	11.0	5	
Hippophae rhamnoides	7	10	1	36.5	4.5	6	
Hippophae rhamnoides	7	11	1	37.0	5.0	7	
Hippophae rhamnoides	7	12	1	34.0	14.0	4	browsed
Hippophae rhamnoides	7	13	0	0.0	0.0	9	dead
Hippophae rhamnoides	7	14	1	41.0	6.0	5	
Hippophae rhamnoides	7	15	1	31.0	8.0	4	
Hippophae rhamnoides	7	16	1	47.5	13.0	5	
Hippophae rhamnoides	7	17	1	45.0	10.0	4	
Hippophae rhamnoides	7	18	1	41.5	5.5	4	browsed
Hippophae rhamnoides	7	19	1	56.0	10.0	5	
Hippophae rhamnoides	7	20	0	0.0	0.0	9	dead
Hippophae rhamnoides	7	21	1	44.0	12.0	**4**	
Hippophae rhamnoides	7	22	1	56.0	23.0	5	
Hippophae rhamnoides	7	23	0	0.0	0.0	9	dead
Hippophae rhamnoides	7	24	1	35.5	4.5	6	
Hippophae rhamnoides	7	25	1	31.5	3.5	6	
Hippophae rhamnoides	7	26	1	29.0	2.0	6	

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Hippophae rhamnoides	7	27	1	34.0	6.0	6	
Hippophae rhamnoides	7	28	0	0.0	0.0	9	dead
Hippophae rhamnoides	7	29	1	37.5	10.5	6	
Hippophae rhamnoides	7	30	0	0.0	0.0	9	dead
Shepherdia argentea	7	west border					
Shepherdia argentea	8	east border					
Elaeagnus angustifolia	8	1	1	106.0	55.5	2	
Elaeagnus angustifolia	8	2	1	88.0	41.0	2	
Elaeagnus angustifolia	8	3	1	122.5	64.0	1	
Elaeagnus angustifolia	8	4	1	130.0	73.0	2	
Elaeagnus angustifolia	8	5	1	119.0	70.0	2	broken leader
Elaeagnus angustifolia	8	6	1	109.0	68.0	2	
Elaeagnus angustifolia	8	7	1	89.0	44.0	2	
Elaeagnus angustifolia	8	8	1	89.0	34.0	2	
Elaeagnus angustifolia	8	9	1	65.0	14.0	2	
Elaeagnus angustifolia	8	10	1	51.0	14.0	3	
Elaeagnus angustifolia	8	11	1	81.0	33.0	2	
Elaeagnus angustifolia	8	12	1	72.0	25.0	2	
Elaeagnus angustifolia	8	13	1	79.0	41.5	2	
Elaeagnus angustifolia	8	14	1	84.0	37.0	2	
Elaeagnus angustifolia	8	15	1	90.0	44.5	2	
Elaeagnus angustifolia	8	16	1	120.5	75.5	2	
Elaeagnus angustifolia	8	17	1	99.0	55.0	2	
Elaeagnus angustifolia	8	18	1	68.0	26.0	3	
Elaeagnus angustifolia	8	19	1	74.5	21.0	2	
Elaeagnus angustifolia	8	20	1	108.5	61.5	2	
Elaeagnus angustifolia	8	21	1	74.0	23.5	2	
Elaeagnus angustifolia	8	22	1	98.0	50.5	2	
Elaeagnus angustifolia	8	23	1	100.0	45.0	2	
Elaeagnus angustifolia	8	24	1	98.5	44.5	1	
Elaeagnus angustifolia	8	25	1	117.0	67.5	2	
Elaeagnus angustifolia	8	26	1	111.0	63.0	2	
Elaeagnus angustifolia	8	27	1	86.0	57.0	3	
Elaeagnus angustifolia	8	28	1	84.5	36.5	3	
Elaeagnus angustifolia	8	29	1	46.0	4.0	7	
Elaeagnus angustifolia	8	30	0	19.0	0.0	9	dead
Shepherdia argentea	8	west border					
Shepherdia argentea	9	east border					
Caragana arborescens	9	1	1	42.0	1.5	4	
Caragana arborescens	9	2	0	39.0	0.0	9	dead
Caragana arborescens	9	3	1	50.0	1.0	6	
Caragana arborescens	9	4	1	64.5	7.5	4	browsed
Caragana arborescens	9	5	1	44.5	4.5	6	bowsed
Caragana arborescens	9	6	0	38.0	0.0	9	dead

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Caragana arborescens	9	7	1	35.0	2.0	7	browsed
Caragana arborescens	9	8	0	52.0	0.0	9	dead
Caragana arborescens	9	9	1	43.0	4.0	6	browsed
Caragana arborescens	9	10	1	65.0	16.5	5	browsed
Caragana arborescens	9	11	1	61.5	22.5	4	browsed
Caragana arborescens	9	12	1	46.5	5.5	5	browsed
Caragana arborescens	9	13	1	49.5	9.5	6	chlorotic/browsed
Caragana arborescens	9	14	1	55.0	8.0	4	chlorotic
Caragana arborescens	9	15	0	0.0	0.0	9	dead
Caragana arborescens	9	16	1	75.5	34.5	5	
Caragana arborescens	9	17	1	53.5	11.0	5	
Caragana arborescens	9	18	1	52.0	9.0	6	chlorotic
Caragana arborescens	9	19	1	38.0	3.0	**8**	chlorotic
Caragana arborescens	9	20	1	47.0	0.0	**5**	chlorotic
Caragana arborescens	9	21	1	39.5	1.5	6	chlorotic
Caragana arborescens	9	22	1	42.0	0.5	7	
Caragana arborescens	9	23	1	90.0	45.0	5	
Caragana arborescens	9	24	1	41.0	0.5	7	chlorotic
Caragana arborescens	9	25	1	44.0	4.0	8	chlorotic
Caragana arborescens	9	26	1	42.0	1.0	7	chlorotic
Caragana arborescens	9	27	1	78.0	29.0	5	new growth not chl
Caragana arborescens	9	28	0	42.0	0.0	9	dead
Caragana arborescens	9	29	**0**	0.0	0.0	9	dead
Caragana arborescens	9	30	0	0.0	0.0	9	dead
Shepherdia argentea	9	west border					
Shepherdia argentea	10	east border					
Ulmus pumila	10	1	1	81.0	62.0	2	browsed
Ulmus pumila	10	2	1	70.5	38.5	2	browsed
Ulmus pumila	10	3	1	52.0	29.0	2	
Ulmus pumila	10	4	1	49.0	15.0	2	
Ulmus pumila	10	5	1	58.0	28.0	3	
Ulmus pumila	10	6	1	63.5	43.5	2	
Ulmus pumila	10	7	1	76.0	51.0	2	
Ulmus pumila	10	8	1	61.0	38.0	2	
Ulmus pumila	10	9	1	65.0	40.0	2	
Ulmus pumila	10	10	1	86.5	48.5	2	
Ulmus pumila	10	11	1	67.0	41.0	2	
Ulmus pumila	10	12	1	80.0	40.0	2	
Ulmus pumila	10	13	1	64.0	37.0	2	
Ulmus pumila	10	14	1	79.5	54.5	2	
Ulmus pumila	10	15	1	70.0	39.0	3	
Ulmus pumila	10	16	1	68.0	40.0	2	
Ulmus pumila	10	17	1	38.0	19.0	4	
Ulmus pumila	10	18	1	40.0	4.0	4	

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Ulmus pumila	10	19	1	50.0	19.0	3	
Ulmus pumila	10	20	1	61.0	19.5	5	
Ulmus pumila	10	21	1	51.0	30.0	4	
Ulmus pumila	10	22	1	58.0	24.0	3	
Ulmus pumila	10	23	1	68.0	47.0	2	
Ulmus pumila	10	24	1	67.5	31.5	3	
Ulmus pumila	10	25	1	73.0	55.0	2	
Ulmus pumila	10	26	1	22.0	7.0	7	
Ulmus pumila	10	27	0	0.0	0.0	9	dead
Ulmus pumila	10	28	0	0.0	0.0	9	dead
Ulmus pumila	10	29	0	0.0	0.0	9	dead
Ulmus pumila	10	30	1	35.0	6.0	7	
Shepherdia argentea	10	west border					
Shepherdia argentea	11	east border					
Pinus ponderosa	11	1	1	32.0	7.0	3	
Pinus ponderosa	11	2	1	24.5	6.5	3	
Pinus ponderosa	11	3	1	21.0	5.0	4	
Pinus ponderosa	11	4	1	19.0	3.0	4	
Pinus ponderosa	11	5	1	18.0	5.0	4	
Pinus ponderosa	11	6	1	39.5	11.0	1	
Pinus ponderosa	11	7	1	31.5	8.0	4	
Pinus ponderosa	11	8	1	25.0	4.0	4	
Pinus ponderosa	11	9	1	39.5	12.5	2	
Pinus ponderosa	11	10	1	35.0	11.0	2	
Pinus ponderosa	11	11	1	27.0	1.0	3	
Pinus ponderosa	11	12	1	26.5	6.5	3	
Pinus ponderosa	11	13	1	24.0	6.0	4	
Pinus ponderosa	11	14	1	44.0	15.0	3	
Pinus ponderosa	11	15	1	34.0	10.0	3	
Pinus ponderosa	11	16	1	40.0	16.0	5	
Pinus ponderosa	11	17	1	28.0	6.5	5	
Pinus ponderosa	11	18	1	36.5	17.5	4	
Pinus ponderosa	11	19	1	**18.0**	3.0	4	top chopped off
Pinus ponderosa	11	20	1	34.0	14.0	3	
Pinus ponderosa	11	21	1	26.5	8.0	5	
Pinus ponderosa	11	22	1	28.0	5.5	4	
Pinus ponderosa	11	23	1	36.5	10.5	4	
Pinus ponderosa	11	24	1	28.0	8.0	5	
Pinus ponderosa	11	25	1	27.5	6.0	4	
Pinus ponderosa	11	26	1	36.5	10.5	5	
Pinus ponderosa	11	27	1	31.0	4.0	7	
Pinus ponderosa	11	28	1	36.0	7.5	5	
Pinus ponderosa	11	29	1	37.5	8.5	5	
Pinus ponderosa	11	30	1	33.0	8.5	5	

Appendix 1. Plant Evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival (0,1)	Fall 2006 Height *cm*	2006 Growth *cm*	Summer Vigor Rating (1-9)	Comments
Shepherdia argentea	11	west border					
Shepherdia argentea	12	east border					
Symphoricarpos sp.	12	1	1	45.5	0.0	4	browsed
Symphoricarpos sp.	12	2	1	59.0	-1.5	2	browsed
Symphoricarpos sp.	12	3	1	73.0	1.0	3	browsed
Symphoricarpos sp.	12	4	1	61.0	3.0	4	browsed
Symphoricarpos sp.	12	5	1	70.0	4.0	4	browsed
Symphoricarpos sp.	12	6	1	52.0	3.0	4	browsed
Symphoricarpos sp.	12	7	1	55.0	0.0	4	
Symphoricarpos sp.	12	8	1	61.5	-8.0	4	browsed
Symphoricarpos sp.	12	9	1	56.5	2.5	5	browsed
Symphoricarpos sp.	12	10	1	56.5	4.5	3	browsed
Symphoricarpos sp.	12	11	1	50.0	0.0	4	browsed
Symphoricarpos sp.	12	12	1	40.0	-5.0	4	browsed
Symphoricarpos sp.	12	13	1	50.0	2.0	4	browsed
Symphoricarpos sp.	12	14	1	56.0	3.0	4	browsed
Symphoricarpos sp.	12	15	1	54.0	1.5	3	
Symphoricarpos sp.	12	16	1	63.0	0.0	3	browsed
Symphoricarpos sp.	12	17	1	57.0	0.0	6	
Symphoricarpos sp.	12	18	1	54.0	5.5	5	browsed
Symphoricarpos sp.	12	19	1	64.5	0.0	**5**	browsed
Symphoricarpos sp.	12	20	1	67.0	7.0	4	
Symphoricarpos sp.	12	21	1	68.0	12.0	4	
Symphoricarpos sp.	12	22	1	56.0	1.0	5	browsed
Symphoricarpos sp.	12	23	1	54.5	1.5	4	browsed
Symphoricarpos sp.	12	24	1	55.0	5.5	4	
Symphoricarpos sp.	12	25	1	64.0	15.5	3	browsed
Symphoricarpos sp.	12	26	1	43.0	2.0	4	browsed
Symphoricarpos sp.	12	27	1	32.0	11.5	5	browsed
Symphoricarpos sp.	12	28	1	65.0	4.5	4	browsed
Symphoricarpos sp.	12	29	1	62.0	10.5	5	browsed
Symphoricarpos sp.	12	30	1	64.0	0.0	3	browsed
Shepherdia argentea	12	west border					
Shepherdia argentea	13	east border					
Fraxinus pennsylvanica	13	1	1	70.0	7.0	3	grasshoppers
Fraxinus pennsylvanica	13	2	1	97.0	13.0	2	grasshoppers
Fraxinus pennsylvanica	13	3	1	49.0	1.0	5	grasshoppers
Fraxinus pennsylvanica	13	4	1	59.0	4.0	4	grasshoppers
Fraxinus pennsylvanica	13	5	1	62.5	11.5	4	grasshoppers
Fraxinus pennsylvanica	13	6	1	67.0	4.5	5	grasshoppers
Fraxinus pennsylvanica	13	7	1	54.0	4.0	5	grasshoppers
Fraxinus pennsylvanica	13	8	1	51.5	24.5	**5**	grasshoppers
Fraxinus pennsylvanica	13	9	1	51.5	11.5	4	grasshoppers
Fraxinus pennsylvanica	13	10	1	47.5	7.5	4	grasshoppers

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Fraxinus pennsylvanica	13	11	1	63.0	5.0	**4**	
Fraxinus pennsylvanica	13	12	1	78.0	7.0	5	grasshoppers
Fraxinus pennsylvanica	13	13	1	57.0	10.5	5	grasshoppers
Fraxinus pennsylvanica	13	14	1	47.0	9.5	5	grasshoppers
Fraxinus pennsylvanica	13	15	1	50.0	4.0	5	grasshoppers
Fraxinus pennsylvanica	13	16	1	55.0	4.5	4	grasshoppers
Fraxinus pennsylvanica	13	17	1	43.0	0.5	6	grasshoppers
Fraxinus pennsylvanica	13	18	1	56.0	6.5	5	grasshoppers
Fraxinus pennsylvanica	13	19	1	40.0	1.5	5	
Fraxinus pennsylvanica	13	20	1	41.5	6.5	5	grasshoppers
Fraxinus pennsylvanica	13	21	1	39.0	3.0	5	
Fraxinus pennsylvanica	13	22	1	43.0	6.0	5	
Fraxinus pennsylvanica	13	23	1	61.5	12.0	4	grasshoppers
Fraxinus pennsylvanica	13	24	1	46.0	2.5	4	grasshoppers
Fraxinus pennsylvanica	13	25	1	49.0	6.5	5	grasshoppers
Fraxinus pennsylvanica	13	26	1	45.0	19.0	5	grasshoppers
Fraxinus pennsylvanica	13	27	1	36.5	1.5	6	grasshoppers
Fraxinus pennsylvanica	13	28	1	51.0	6.5	5	grasshoppers
Fraxinus pennsylvanica	13	29	1	45.0	4.0	5	grasshoppers
Fraxinus pennsylvanica	13	30	1	51.0	3.5	7	barely alive
Shepherdia argentea	13	west border					
Shepherdia argentea	14	east border					
Prunus americana	14	1	0	66.5	0.0	9	dead
Prunus americana	14	2	1	62.0	0.0	**6**	
Prunus americana	14	3	1	62.0	-2.0	6	
Prunus americana	14	4	1	59.0	0.0	5	
Prunus americana	14	5	1	63.0	7.5	4	
Prunus americana	14	6	1	61.0	-1.0	5	
Prunus americana	14	7	1	51.0	-7.0	7	healthy sprout
Prunus americana	14	8	1	56.0	0.5	4	
Prunus americana	14	9	1	56.5	5.5	5	
Prunus americana	14	10	1	47.0	6.0	5	
Prunus americana	14	11	1	65.0	2.5	4	browsed
Prunus americana	14	12	1	69.0	11.0	4	
Prunus americana	14	13	1	55.5	3.0	**5**	
Prunus americana	14	14	1	50.0	-6.0	**6**	
Prunus americana	14	15	1	47.0	2.0	6	
Prunus americana	14	16	1	60.0	4.0	6	browsed
Prunus americana	14	17	1	69.0	3.0	6	
Prunus americana	14	18	1	62.5	1.0	6	
Prunus americana	14	19	1	55.5	0.0	7	
Prunus americana	14	20	1	66.0	0.5	7	
Prunus americana	14	21	1	75.5	2.5	5	
Prunus americana	**14**	**22**	**1**	**61.0**	**0.0**	**9**	**dead; deer?**

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Prunus americana	14	23	1	65.0	8.5	6	
Prunus americana	14	24	1	53.0	0.0	**5**	
Prunus americana	14	25	1	55.5	3.0	8	marg. necr./chlor.
Prunus americana	14	26	1	9.0	9.0	8	marg. necr./chlor.
Prunus americana	14	27	1	46.0	2.5	7	
Prunus americana	14	28	0	32.5	0.0	9	dead
Prunus americana	14	29	0	13.0	0.0	9	dead
Prunus americana	14	30	0	6.0	0.0	9	dead
Shepherdia argentea	14	west border					
Shepherdia argentea	15	east border					
Prunus besseyi	15	1	1	48.5	20.5	3	
Prunus besseyi	15	2	1	51.5	13.5	3	
Prunus besseyi	15	3	1	55.0	22.0	4	
Prunus besseyi	15	4	1	39.0	9.0	3	
Prunus besseyi	15	5	1	68.0	30.0	3	
Prunus besseyi	15	6	1	65.5	29.5	2	browsed
Prunus besseyi	15	7	1	51.0	17.0	4	browsed
Prunus besseyi	15	8	1	58.5	10.5	4	browsed
Prunus besseyi	15	9	1	69.0	14.0	4	browsed
Prunus besseyi	15	10	1	66.5	13.5	3	
Prunus besseyi	15	11	1	63.5	16.5	3	
Prunus besseyi	15	12	1	50.0	7.0	3	browsed
Prunus besseyi	15	13	1	70.0	24.0	3	browsed
Prunus besseyi	15	14	1	55.0	10.0	2	browsed
Prunus besseyi	15	15	1	67.5	23.5	3	browsed
Prunus besseyi	15	16	1	59.5	14.5	3	browsed
Prunus besseyi	15	17	1	46.0	5.0	4	
Prunus besseyi	15	18	1	49.5	3.5	3	browsed
Prunus besseyi	15	19	1	52.0	12.0	3	browsed
Prunus besseyi	15	20	1	64.5	16.5	2	browsed
Prunus besseyi	15	21	1	45.0	8.0	4	
Prunus besseyi	15	22	0	36.0	0.0	9	dead
Prunus besseyi	15	23	0	33.0	0.0	9	dead
Prunus besseyi	15	24	1	59.0	14.0	4	
Prunus besseyi	15	25	1	62.0	8.0	4	
Prunus besseyi	15	26	1	48.0	6.0	7	
Prunus besseyi	15	27	0	21.0	0.0	9	dead
Prunus besseyi	15	28	0	17.0	0.0	9	dead
Prunus besseyi	15	29	0	0.0	0.0	9	dead
Prunus besseyi	15	30	1	43.5	1.5	7	
Shepherdia argentea	15	west border					
Shepherdia argentea	16	east border					
Rhus trilobata	16	1	1	33.0	19.0	4	
Rhus trilobata	16	2	**0**	0.0	0.0	9	dead

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Rhus trilobata	16	3	**0**	0.0	0.0	9	dead
Rhus trilobata	16	4	1	47.0	26.0	3	
Rhus trilobata	16	5	1	57.0	0.0	5	browsed
Rhus trilobata	16	6	1	32.5	32.0	5	basal sprout
Rhus trilobata	16	7	1	66.5	4.0	4	
Rhus trilobata	16	8	1	27.0	17.5	5	basal sprout
Rhus trilobata	16	9	1	67.0	23.0	2	browsed
Rhus trilobata	16	10	1	67.5	19.5	2	browsed
Rhus trilobata	16	11	1	55.0	10.0	3	browsed
Rhus trilobata	16	12	1	64.0	11.0	4	
Rhus trilobata	16	13	1	31.0	29.0	4	basal sprout
Rhus trilobata	16	14	1	68.0	13.0	2	
Rhus trilobata	16	15	1	30.5	18.0	4	basal sprout
Rhus trilobata	16	16	1	47.0	3.0	5	
Rhus trilobata	16	17	1	52.0	5.0	5	browsed
Rhus trilobata	16	18	1	20.0	17.0	6	basal sprout
Rhus trilobata	16	19	0	0.0	0.0	9	dead
Rhus trilobata	16	20	0	0.0	0.0	9	dead
Rhus trilobata	16	21	1	54.5	10.5	3	
Rhus trilobata	16	22	1	60.5	7.5	4	
Rhus trilobata	16	23	1	34.0	3.0	7	
Rhus trilobata	16	24	1	13.0	10.0	7	basal sprout
Rhus trilobata	16	25	0	0.0	0.0	9	dead
Rhus trilobata	16	26	1	6.0	5.0	7	basal sprout
Rhus trilobata	16	27	0	0.0	0.0	9	dead
Rhus trilobata	16	28	1	13.5	9.5	7	basal sprout
Rhus trilobata	16	29	0	0.0	0.0	9	dead
Rhus trilobata	16	30	1	36.0	23.0	5	
Shepherdia argentea	16	west border					
Shepherdia argentea	17	east border					
Prunus tomentosa	17	1	0	0.0	0.0	9	dead
Prunus tomentosa	17	2	0	45.0	0.0	9	dead
Prunus tomentosa	17	3	0	0.0	0.0	9	dead
Prunus tomentosa	17	4	0	0.0	0.0	9	dead
Prunus tomentosa	17	5	0	0.0	0.0	9	dead
Prunus tomentosa	17	6	1	43.0	0.0	8	
Prunus tomentosa	17	7	1	46.0	9.0	5	
Prunus tomentosa	17	8	0	37.0	0.0	9	dead
Prunus tomentosa	17	9	1	44.0	12.0	5	
Prunus tomentosa	17	10	1	48.0	9.0	5	
Prunus tomentosa	17	11	1	45.5	8.5	8	
Prunus tomentosa	17	12	1	50.5	12.5	8	
Prunus tomentosa	17	13	0	0.0	0.0	9	dead
Prunus tomentosa	17	14	0	0.0	0.0	9	dead

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Prunus tomentosa	17	15	0	39.5	0.0	9	dead
Prunus tomentosa	17	16	1	53.0	0.0	5	browsed
Prunus tomentosa	17	17	0	31.0	0.0	9	dead
Prunus tomentosa	17	18	0	0.0	0.0	9	dead
Prunus tomentosa	17	19	0	0.0	0.0	9	dead
Prunus tomentosa	17	20	0	0.0	0.0	9	dead
Prunus tomentosa	17	21	0	52.5	0.0	9	dead
Prunus tomentosa	17	22	0	0.0	0.0	9	dead
Prunus tomentosa	17	23	0	0.0	0.0	9	dead
Prunus tomentosa	17	24	0	42.0	0.0	9	dead
Prunus tomentosa	17	25	0	0.0	0.0	9	dead
Prunus tomentosa	17	26	0	0.0	0.0	9	dead
Prunus tomentosa	17	27	0	0.0	0.0	9	dead
Prunus tomentosa	17	28	0	0.0	0.0	9	dead
Prunus tomentosa	17	29	0	44.0	0.0	9	dead
Prunus tomentosa	17	30	0	0.0	0.0	9	dead
Shepherdia argentea	17	west border					
Shepherdia argentea	18	east border					
Populus deltoides	18	1	1	82.0	47.0	4	severe deer
Populus deltoides	18	2	1	89.0	44.0	3	severe deer
Populus deltoides	18	3	1	100.0	69.0	3	severe deer
Populus deltoides	18	4	1	135.0	102.0	1	severe deer
Populus deltoides	18	5	1	144.0	103.0	1	severe deer
Populus deltoides	18	6	1	**145.0**	108.0	2	severe deer
Populus deltoides	18	7	1	170.0	136.0	1	severe deer
Populus deltoides	18	8	1	105.0	70.0	2	severe deer
Populus deltoides	18	9	1	116.0	81.0	3	severe deer
Populus deltoides	18	10	1	100.0	67.0	3	severe deer
Populus deltoides	18	11	1	104.0	74.0	4	severe deer
Populus deltoides	18	12	1	60.5	20.5	5	severe deer
Populus deltoides	18	13	1	90.0	49.0	4	severe deer
Populus deltoides	18	14	1	95.0	50.0	4	severe deer
Populus deltoides	18	15	1	104.0	69.0	5	severe deer
Populus deltoides	18	16	1	98.0	60.0	4	severe deer
Populus deltoides	18	17	1	69.0	28.0	5	severe deer
Populus deltoides	18	18	1	78.0	42.0	5	severe deer
Populus deltoides	18	19	1	**102.0**	57.0	4	severe deer
Populus deltoides	18	20	1	113.0	66.0	3	severe deer
Populus deltoides	18	21	1	140.0	103.5	1	severe deer
Populus deltoides	18	22	1	133.5	91.0	2	severe deer
Populus deltoides	18	23	1	**133.0**	104.0	1	severe deer
Populus deltoides	18	24	1	133.0	104.0	1	severe deer
Populus deltoides	18	25	1	**133.0**	107.0	4	severe deer
Populus deltoides	18	26	1	73.5	39.5	5	severe deer

Appendix 1. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	Fall 2006 Survival	Fall 2006 Height	2006 Growth	Summer Vigor Rating	Comments
			(0,1)	*cm*	*cm*	(1-9)	
Populus deltoides	18	27	1	102.0	68.0	4	severe deer
Populus deltoides	18	28	1	82.0	50.0	4	severe deer
Populus deltoides	18	29	1	94.0	64.5	4	severe deer
Populus deltoides	18	30	1	88.0	52.0	4	severe deer
Shepherdia argentea	18	west border					

North end of plot

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10)*
					dS/m
south end of plot					
Shepherdia argentea	1	east border			
Shepherdia argentea	1	1	sample	0.10	0.30
Shepherdia argentea	1	2		0.10	0.30
Shepherdia argentea	1	3		0.10	0.30
Shepherdia argentea	1	4		0.30	0.90
Shepherdia argentea	1	5		0.30	0.90
Shepherdia argentea	1	6		0.25	0.75
Shepherdia argentea	1	7		0.20	0.60
Shepherdia argentea	1	8		0.50	1.50
Shepherdia argentea	1	9		0.50	1.50
Shepherdia argentea	1	10		0.70	2.10
Shepherdia argentea	1	11		0.80	2.40
Shepherdia argentea	1	12		0.75	2.25
Shepherdia argentea	1	13		0.75	2.25
Shepherdia argentea	1	14		0.90	2.70
Shepherdia argentea	1	15	sample	0.90	2.70
Shepherdia argentea	1	16		0.85	2.55
Shepherdia argentea	1	17		0.85	2.55
Shepherdia argentea	1	18		0.95	2.85
Shepherdia argentea	1	19		0.90	2.70
Shepherdia argentea	1	20		0.95	2.85
Shepherdia argentea	1	21		1.00	3.00
Shepherdia argentea	1	22		0.95	2.85
Shepherdia argentea	1	23		0.90	2.70
Shepherdia argentea	1	24		0.95	2.85
Shepherdia argentea	1	25		0.95	2.85
Shepherdia argentea	1	26		1.00	3.00
Shepherdia argentea	1	27		1.00	3.00
Shepherdia argentea	1	28		1.05	3.15
Shepherdia argentea	1	29		1.05	3.15
Shepherdia argentea	1	30	sample	1.05	3.15
Shepherdia argentea	1	west border			
Shepherdia argentea	2	east border			
Prunus virginiana	2	1		0.05	0.15
Prunus virginiana	2	2		0.05	0.15
Prunus virginiana	2	3		0.10	0.30
Prunus virginiana	2	4		0.05	0.15
Prunus virginiana	2	5		0.05	0.15
Prunus virginiana	2	6		0.10	0.30
Prunus virginiana	2	7		0.20	0.60
Prunus virginiana	2	8		0.40	1.20
Prunus virginiana	2	9		0.45	1.35

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Prunus virginiana	2	10		0.70	2.10
Prunus virginiana	2	11		0.50	1.50
Prunus virginiana	2	12		0.60	1.80
Prunus virginiana	2	13		0.65	1.95
Prunus virginiana	2	14		0.85	2.55
Prunus virginiana	2	15		0.80	2.40
Prunus virginiana	2	16		0.85	2.55
Prunus virginiana	2	17		0.85	2.55
Prunus virginiana	2	18		1.00	3.00
Prunus virginiana	2	19		0.85	2.55
Prunus virginiana	2	20		0.85	2.55
Prunus virginiana	2	21		0.90	2.70
Prunus virginiana	2	22		0.90	2.70
Prunus virginiana	2	23		0.90	2.70
Prunus virginiana	2	24		0.90	2.70
Prunus virginiana	2	25		0.90	2.70
Prunus virginiana	2	26		0.85	2.55
Prunus virginiana	2	27		0.90	2.70
Prunus virginiana	2	28		0.95	2.85
Prunus virginiana	2	29		0.90	2.70
Prunus virginiana	2	30		0.95	2.85
Shepherdia argentea	2	west border			
Shepherdia argentea	3	east border			
Picea pungens	3	1		0.00	0.00
Picea pungens	3	2		0.50	1.50
Picea pungens	3	3		0.50	1.50
Picea pungens	3	4		0.10	0.30
Picea pungens	3	5		0.10	0.30
Picea pungens	3	6		0.15	0.45
Picea pungens	3	7		0.10	0.30
Picea pungens	3	8		0.20	0.60
Picea pungens	3	9		0.35	1.05
Picea pungens	3	10		0.70	2.10
Picea pungens	3	11		0.35	1.05
Picea pungens	3	12		0.50	1.50
Picea pungens	3	13		0.55	1.65
Picea pungens	3	14		0.60	1.80
Picea pungens	3	15		0.70	2.10
Picea pungens	3	16		0.65	1.95
Picea pungens	3	17		0.70	2.10
Picea pungens	3	18		0.70	2.10
Picea pungens	3	19		0.60	1.80

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken 0-12"/12-24"	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK ([reading x 30]/10) dS/m
Picea pungens	3	20		0.80	2.40
Picea pungens	3	21		0.70	2.10
Picea pungens	3	22		0.80	2.40
Picea pungens	3	23		0.75	2.25
Picea pungens	3	24		0.80	2.40
Picea pungens	3	25		0.80	2.40
Picea pungens	3	26		0.85	2.55
Picea pungens	3	27		0.80	2.40
Picea pungens	3	28		0.85	2.55
Picea pungens	3	29		0.90	2.70
Picea pungens	3	30		0.90	2.70
Shepherdia argentea	3	west border			
Shepherdia argentea	4	east border			
Lonicera korolkowii	4	1		0.25	0.75
Lonicera korolkowii	4	2		0.20	0.60
Lonicera korolkowii	4	3		0.15	0.45
Lonicera korolkowii	4	4		0.20	0.60
Lonicera korolkowii	4	5		0.20	0.60
Lonicera korolkowii	4	6		0.40	1.20
Lonicera korolkowii	4	7		0.35	1.05
Lonicera korolkowii	4	8		0.35	1.05
Lonicera korolkowii	4	9		0.50	1.50
Lonicera korolkowii	4	10		0.90	2.70
Lonicera korolkowii	4	11		0.40	1.20
Lonicera korolkowii	4	12		0.65	1.95
Lonicera korolkowii	4	13		0.60	1.80
Lonicera korolkowii	4	14		0.70	2.10
Lonicera korolkowii	4	15		0.65	1.95
Lonicera korolkowii	4	16		0.65	1.95
Lonicera korolkowii	4	17		0.80	2.40
Lonicera korolkowii	4	18		0.70	2.10
Lonicera korolkowii	4	19		0.75	2.25
Lonicera korolkowii	4	20		0.65	1.95
Lonicera korolkowii	4	21		0.70	2.10
Lonicera korolkowii	4	22		0.75	2.25
Lonicera korolkowii	4	23		0.80	2.40
Lonicera korolkowii	4	24		0.75	2.25
Lonicera korolkowii	4	25		0.70	2.10
Lonicera korolkowii	4	26		0.75	2.25
Lonicera korolkowii	4	27		0.80	2.40
Lonicera korolkowii	4	28		0.80	2.40
Lonicera korolkowii	4	29		0.80	2.40

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken 0-12"/12-24"	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK ***([reading x 30]/10) dS/m***
Lonicera korolkowii	4	30		0.85	2.55
Shepherdia argentea	4	west border			
Shepherdia argentea	5	east border			
Elaeagnus commutata	5	1		0.10	0.30
Elaeagnus commutata	5	2		0.20	0.60
Elaeagnus commutata	5	3		0.30	0.90
Elaeagnus commutata	5	4		0.20	0.60
Elaeagnus commutata	5	5		0.20	0.60
Elaeagnus commutata	5	6		0.25	0.75
Elaeagnus commutata	5	7		0.20	0.60
Elaeagnus commutata	5	8		0.30	0.90
Elaeagnus commutata	5	9		0.45	1.35
Elaeagnus commutata	5	10		0.80	2.40
Elaeagnus commutata	5	11		0.40	1.20
Elaeagnus commutata	5	12		0.50	1.50
Elaeagnus commutata	5	13		0.70	2.10
Elaeagnus commutata	5	14		0.65	1.95
Elaeagnus commutata	5	15		0.75	2.25
Elaeagnus commutata	5	16		0.70	2.10
Elaeagnus commutata	5	17		0.80	2.40
Elaeagnus commutata	5	18		0.70	2.10
Elaeagnus commutata	5	19		0.75	2.25
Elaeagnus commutata	5	20		0.65	1.95
Elaeagnus commutata	5	21		0.70	2.10
Elaeagnus commutata	5	22		0.70	2.10
Elaeagnus commutata	5	23		0.70	2.10
Elaeagnus commutata	5	24		0.65	1.95
Elaeagnus commutata	5	25		0.70	2.10
Elaeagnus commutata	5	26		0.75	2.25
Elaeagnus commutata	5	27		0.70	2.10
Elaeagnus commutata	5	28		0.70	2.10
Elaeagnus commutata	5	29		0.80	2.40
Elaeagnus commutata	5	30		0.75	2.25
Shepherdia argentea	5	west border			
Shepherdia argentea	6	east border			
Ribes aureum	6	1		0.15	0.45
Ribes aureum	6	2		0.05	0.15
Ribes aureum	6	3		0.00	0.00
Ribes aureum	6	4		0.05	0.15
Ribes aureum	6	5		0.00	0.00
Ribes aureum	6	6		0.05	0.15
Ribes aureum	6	7		0.10	0.30

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Ribes aureum	6	8		0.10	0.30
Ribes aureum	6	9		0.15	0.45
Ribes aureum	6	10	sample	0.50	1.50
Ribes aureum	6	11		0.20	0.60
Ribes aureum	6	12		0.40	1.20
Ribes aureum	6	13		0.55	1.65
Ribes aureum	6	14		0.40	1.20
Ribes aureum	6	15		0.50	1.50
Ribes aureum	6	16		0.65	1.95
Ribes aureum	6	17		0.50	1.50
Ribes aureum	6	18		0.40	1.20
Ribes aureum	6	19		0.45	1.35
Ribes aureum	6	20	sample	0.55	1.65
Ribes aureum	6	21		0.50	1.50
Ribes aureum	6	22		0.55	1.65
Ribes aureum	6	23		0.55	1.65
Ribes aureum	6	24		0.60	1.80
Ribes aureum	6	25		0.60	1.80
Ribes aureum	6	26		0.60	1.80
Ribes aureum	6	27		0.65	1.95
Ribes aureum	6	28		0.65	1.95
Ribes aureum	6	29		0.70	2.10
Ribes aureum	6	30		0.80	2.40
Shepherdia argentea	6	west border			
Shepherdia argentea	7	east border			
Hippophae rhamnoides	7	1		0.00	0.00
Hippophae rhamnoides	7	2		0.05	0.15
Hippophae rhamnoides	7	3		0.00	0.00
Hippophae rhamnoides	7	4		0.00	0.00
Hippophae rhamnoides	7	5		0.00	0.00
Hippophae rhamnoides	7	6		0.10	0.30
Hippophae rhamnoides	7	7		0.00	0.00
Hippophae rhamnoides	7	8		0.10	0.30
Hippophae rhamnoides	7	9		0.15	0.45
Hippophae rhamnoides	7	10		0.50	1.50
Hippophae rhamnoides	7	11		0.25	0.75
Hippophae rhamnoides	7	12		0.30	0.90
Hippophae rhamnoides	7	13		0.50	1.50
Hippophae rhamnoides	7	14		0.45	1.35
Hippophae rhamnoides	7	15		0.40	1.20
Hippophae rhamnoides	7	16		0.55	1.65
Hippophae rhamnoides	7	17		0.60	1.80

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Hippophae rhamnoides	7	18		0.45	1.35
Hippophae rhamnoides	7	19		0.50	1.50
Hippophae rhamnoides	7	20		0.50	1.50
Hippophae rhamnoides	7	21		0.50	1.50
Hippophae rhamnoides	7	22		0.45	1.35
Hippophae rhamnoides	7	23		0.55	1.65
Hippophae rhamnoides	7	24		0.55	1.65
Hippophae rhamnoides	7	25		0.50	1.50
Hippophae rhamnoides	7	26		0.55	1.65
Hippophae rhamnoides	7	27		0.65	1.95
Hippophae rhamnoides	7	28		0.60	1.80
Hippophae rhamnoides	7	29		0.70	2.10
Hippophae rhamnoides	7	30		0.70	2.10
Shepherdia argentea	7	west border			
Shepherdia argentea	8	east border			
Elaeagnus angustifolia	8	1		0.00	0.00
Elaeagnus angustifolia	8	2		0.00	0.00
Elaeagnus angustifolia	8	3		0.00	0.00
Elaeagnus angustifolia	8	4		0.00	0.00
Elaeagnus angustifolia	8	5		0.00	0.00
Elaeagnus angustifolia	8	6		0.00	0.00
Elaeagnus angustifolia	8	7		0.00	0.00
Elaeagnus angustifolia	8	8		0.10	0.30
Elaeagnus angustifolia	8	9		0.15	0.45
Elaeagnus angustifolia	8	10		0.60	1.80
Elaeagnus angustifolia	8	11		0.25	0.75
Elaeagnus angustifolia	8	12		0.25	0.75
Elaeagnus angustifolia	8	13		0.35	1.05
Elaeagnus angustifolia	8	14		0.50	1.50
Elaeagnus angustifolia	8	15		0.40	1.20
Elaeagnus angustifolia	8	16		0.50	1.50
Elaeagnus angustifolia	8	17		0.55	1.65
Elaeagnus angustifolia	8	18		0.45	1.35
Elaeagnus angustifolia	8	19		0.40	1.20
Elaeagnus angustifolia	8	20		0.50	1.50
Elaeagnus angustifolia	8	21		0.40	1.20
Elaeagnus angustifolia	8	22		0.45	1.35
Elaeagnus angustifolia	8	23		0.45	1.35
Elaeagnus angustifolia	8	24		0.50	1.50
Elaeagnus angustifolia	8	25		0.50	1.50
Elaeagnus angustifolia	8	26		0.50	1.50
Elaeagnus angustifolia	8	27		0.55	1.65

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Elaeagnus angustifolia	8	28		0.60	1.80
Elaeagnus angustifolia	8	29		0.65	1.95
Elaeagnus angustifolia	8	30		0.70	2.10
Shepherdia argentea	8	west border			
Shepherdia argentea	9	east border			
Caragana arborescens	9	1	sample	0.00	0.00
Caragana arborescens	9	2		0.00	0.00
Caragana arborescens	9	3		0.00	0.00
Caragana arborescens	9	4		0.00	0.00
Caragana arborescens	9	5		0.00	0.00
Caragana arborescens	9	6		0.05	0.15
Caragana arborescens	9	7		0.00	0.00
Caragana arborescens	9	8		0.15	0.45
Caragana arborescens	9	9		0.20	0.60
Caragana arborescens	9	10		0.55	1.65
Caragana arborescens	9	11		0.40	1.20
Caragana arborescens	9	12		0.20	0.60
Caragana arborescens	9	13		0.25	0.75
Caragana arborescens	9	14		0.60	1.80
Caragana arborescens	9	15	sample	0.45	1.35
Caragana arborescens	9	16		0.40	1.20
Caragana arborescens	9	17		0.50	1.50
Caragana arborescens	9	18		0.50	1.50
Caragana arborescens	9	19		0.45	1.35
Caragana arborescens	9	20		0.50	1.50
Caragana arborescens	9	21		0.50	1.50
Caragana arborescens	9	22		0.45	1.35
Caragana arborescens	9	23		0.50	1.50
Caragana arborescens	9	24		0.50	1.50
Caragana arborescens	9	25		0.55	1.65
Caragana arborescens	9	26		0.55	1.65
Caragana arborescens	9	27		0.55	1.65
Caragana arborescens	9	28		0.60	1.80
Caragana arborescens	9	29		0.65	1.95
Caragana arborescens	9	30	sample	0.70	2.10
Shepherdia argentea	9	west border			
Shepherdia argentea	10	east border			
Ulmus pumila	10	1		0.00	0.00
Ulmus pumila	10	2		0.00	0.00
Ulmus pumila	10	3		0.00	0.00
Ulmus pumila	10	4		0.00	0.00
Ulmus pumila	10	5		0.00	0.00

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Ulmus pumila	10	6		0.00	0.00
Ulmus pumila	10	7		0.00	0.00
Ulmus pumila	10	8		0.00	0.00
Ulmus pumila	10	9		0.00	0.00
Ulmus pumila	10	10		0.50	1.50
Ulmus pumila	10	11		0.15	0.45
Ulmus pumila	10	12		0.25	0.75
Ulmus pumila	10	13		0.15	0.45
Ulmus pumila	10	14		0.30	0.90
Ulmus pumila	10	15		0.25	0.75
Ulmus pumila	10	16		0.40	1.20
Ulmus pumila	10	17		0.40	1.20
Ulmus pumila	10	18		0.40	1.20
Ulmus pumila	10	19		0.30	0.90
Ulmus pumila	10	20		0.35	1.05
Ulmus pumila	10	21		0.45	1.35
Ulmus pumila	10	22		0.30	0.90
Ulmus pumila	10	23		0.35	1.05
Ulmus pumila	10	24		0.35	1.05
Ulmus pumila	10	25		0.45	1.35
Ulmus pumila	10	26		0.50	1.50
Ulmus pumila	10	27		0.50	1.50
Ulmus pumila	10	28		0.50	1.50
Ulmus pumila	10	29		0.60	1.80
Ulmus pumila	10	30		0.60	1.80
Shepherdia argentea	10	west border			
Shepherdia argentea	11	east border			
Pinus ponderosa	11	1		0.00	0.00
Pinus ponderosa	11	2		0.00	0.00
Pinus ponderosa	11	3		0.00	0.00
Pinus ponderosa	11	4		0.00	0.00
Pinus ponderosa	11	5		0.00	0.00
Pinus ponderosa	11	6		0.00	0.00
Pinus ponderosa	11	7		0.25	0.75
Pinus ponderosa	11	8		0.30	0.90
Pinus ponderosa	11	9		0.45	1.35
Pinus ponderosa	11	10		0.70	2.10
Pinus ponderosa	11	11		0.50	1.50
Pinus ponderosa	11	12		0.50	1.50
Pinus ponderosa	11	13		0.50	1.50
Pinus ponderosa	11	14		0.60	1.80
Pinus ponderosa	11	15		0.65	1.95

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Pinus ponderosa	11	16		0.70	2.10
Pinus ponderosa	11	17		0.75	2.25
Pinus ponderosa	11	18		0.70	2.10
Pinus ponderosa	11	19		0.65	1.95
Pinus ponderosa	11	20		0.60	1.80
Pinus ponderosa	11	21		0.60	1.80
Pinus ponderosa	11	22		0.65	1.95
Pinus ponderosa	11	23		0.60	1.80
Pinus ponderosa	11	24		0.70	2.10
Pinus ponderosa	11	25		0.60	1.80
Pinus ponderosa	11	26		0.70	2.10
Pinus ponderosa	11	27		0.65	1.95
Pinus ponderosa	11	28		0.65	1.95
Pinus ponderosa	11	29		0.70	2.10
Pinus ponderosa	11	30		0.70	2.10
Shepherdia argentea	11	west border			
Shepherdia argentea	12	east border			
Symphoricarpos sp.	12	1		0.05	0.15
Symphoricarpos sp.	12	2		0.05	0.15
Symphoricarpos sp.	12	3		0.05	0.15
Symphoricarpos sp.	12	4		0.10	0.30
Symphoricarpos sp.	12	5		0.10	0.30
Symphoricarpos sp.	12	6		0.15	0.45
Symphoricarpos sp.	12	7		0.20	0.60
Symphoricarpos sp.	12	8		0.25	0.75
Symphoricarpos sp.	12	9		0.50	1.50
Symphoricarpos sp.	12	10	sample	0.45	1.35
Symphoricarpos sp.	12	11		0.25	0.75
Symphoricarpos sp.	12	12		0.30	0.90
Symphoricarpos sp.	12	13		0.30	0.90
Symphoricarpos sp.	12	14		0.35	1.05
Symphoricarpos sp.	12	15		0.50	1.50
Symphoricarpos sp.	12	16		0.50	1.50
Symphoricarpos sp.	12	17		0.55	1.65
Symphoricarpos sp.	12	18		0.55	1.65
Symphoricarpos sp.	12	19		0.60	1.80
Symphoricarpos sp.	12	20	sample	0.55	1.65
Symphoricarpos sp.	12	21		0.55	1.65
Symphoricarpos sp.	12	22		0.55	1.65
Symphoricarpos sp.	12	23		0.50	1.50
Symphoricarpos sp.	12	24		0.50	1.50
Symphoricarpos sp.	12	25		0.50	1.50

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Symphoricarpos sp.	12	26		0.50	1.50
Symphoricarpos sp.	12	27		0.50	1.50
Symphoricarpos sp.	12	28		0.50	1.50
Symphoricarpos sp.	12	29		0.55	1.65
Symphoricarpos sp.	12	30		0.55	1.65
Shepherdia argentea	12	west border			
Shepherdia argentea	13	east border			
Fraxinus pennsylvanica	13	1		0.00	0.00
Fraxinus pennsylvanica	13	2		0.05	0.15
Fraxinus pennsylvanica	13	3		0.15	0.45
Fraxinus pennsylvanica	13	4		0.15	0.45
Fraxinus pennsylvanica	13	5		0.15	0.45
Fraxinus pennsylvanica	13	6		0.20	0.60
Fraxinus pennsylvanica	13	7		0.30	0.90
Fraxinus pennsylvanica	13	8		0.25	0.75
Fraxinus pennsylvanica	13	9		0.40	1.20
Fraxinus pennsylvanica	13	10		0.45	1.35
Fraxinus pennsylvanica	13	11		0.40	1.20
Fraxinus pennsylvanica	13	12		0.40	1.20
Fraxinus pennsylvanica	13	13		0.45	1.35
Fraxinus pennsylvanica	13	14		0.50	1.50
Fraxinus pennsylvanica	13	15		0.60	1.80
Fraxinus pennsylvanica	13	16		0.50	1.50
Fraxinus pennsylvanica	13	17		0.55	1.65
Fraxinus pennsylvanica	13	18		0.60	1.80
Fraxinus pennsylvanica	13	19		0.55	1.65
Fraxinus pennsylvanica	13	20		0.60	1.80
Fraxinus pennsylvanica	13	21		0.60	1.80
Fraxinus pennsylvanica	13	22		0.60	1.80
Fraxinus pennsylvanica	13	23		0.55	1.65
Fraxinus pennsylvanica	13	24		0.55	1.65
Fraxinus pennsylvanica	13	25		0.60	1.80
Fraxinus pennsylvanica	13	26		0.60	1.80
Fraxinus pennsylvanica	13	27		0.60	1.80
Fraxinus pennsylvanica	13	28		0.60	1.80
Fraxinus pennsylvanica	13	29		0.60	1.80
Fraxinus pennsylvanica	13	30		0.65	1.95
Shepherdia argentea	13	west border			
Shepherdia argentea	14	east border			
Prunus americana	14	1		0.10	0.30
Prunus americana	14	2		0.20	0.60
Prunus americana	14	3		0.25	0.75

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Prunus americana	14	4		0.20	0.60
Prunus americana	14	5		0.30	0.90
Prunus americana	14	6		0.40	1.20
Prunus americana	14	7		0.35	1.05
Prunus americana	14	8		0.40	1.20
Prunus americana	14	9		0.60	1.80
Prunus americana	14	10		0.50	1.50
Prunus americana	14	11		0.50	1.50
Prunus americana	14	12		0.50	1.50
Prunus americana	14	13		0.50	1.50
Prunus americana	14	14		0.60	1.80
Prunus americana	14	15		0.50	1.50
Prunus americana	14	16		0.60	1.80
Prunus americana	14	17		0.65	1.95
Prunus americana	14	18		0.65	1.95
Prunus americana	14	19		0.60	1.80
Prunus americana	14	20		0.60	1.80
Prunus americana	14	21		0.65	1.95
Prunus americana	14	22		0.55	1.65
Prunus americana	14	23		0.55	1.65
Prunus americana	14	24		0.55	1.65
Prunus americana	14	25		0.60	1.80
Prunus americana	14	26		0.60	1.80
Prunus americana	14	27		0.60	1.80
Prunus americana	14	28		0.65	1.95
Prunus americana	14	29		0.65	1.95
Prunus americana	14	30		0.70	2.10
Shepherdia argentea	14	west border			
Shepherdia argentea	15	east border			
Prunus besseyi	15	1		0.20	0.60
Prunus besseyi	15	2		0.25	0.75
Prunus besseyi	15	3		0.30	0.90
Prunus besseyi	15	4		0.30	0.90
Prunus besseyi	15	5		0.35	1.05
Prunus besseyi	15	6		0.45	1.35
Prunus besseyi	15	7		0.40	1.20
Prunus besseyi	15	8		0.50	1.50
Prunus besseyi	15	9		0.85	2.55
Prunus besseyi	15	10		0.60	1.80
Prunus besseyi	15	11		0.80	2.40
Prunus besseyi	15	12		0.60	1.80
Prunus besseyi	15	13		0.60	1.80

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Prunus besseyi	15	14		0.70	2.10
Prunus besseyi	15	15		0.70	2.10
Prunus besseyi	15	16		0.70	2.10
Prunus besseyi	15	17		0.60	1.80
Prunus besseyi	15	18		0.60	1.80
Prunus besseyi	15	19		0.70	2.10
Prunus besseyi	15	20		0.60	1.80
Prunus besseyi	15	21		0.60	1.80
Prunus besseyi	15	22		0.60	1.80
Prunus besseyi	15	23		0.65	1.95
Prunus besseyi	15	24		0.65	1.95
Prunus besseyi	15	25		0.65	1.95
Prunus besseyi	15	26		0.60	1.80
Prunus besseyi	15	27		0.65	1.95
Prunus besseyi	15	28		0.65	1.95
Prunus besseyi	15	29		0.65	1.95
Prunus besseyi	15	30		0.60	1.80
Shepherdia argentea	15	west border			
Shepherdia argentea	16	east border			
Rhus trilobata	16	1		0.10	0.30
Rhus trilobata	16	2		0.10	0.30
Rhus trilobata	16	3		0.05	0.15
Rhus trilobata	16	4		0.10	0.30
Rhus trilobata	16	5		0.15	0.45
Rhus trilobata	16	6		0.15	0.45
Rhus trilobata	16	7		0.20	0.60
Rhus trilobata	16	8		0.40	1.20
Rhus trilobata	16	9		0.70	2.10
Rhus trilobata	16	10		0.45	1.35
Rhus trilobata	16	11		0.45	1.35
Rhus trilobata	16	12		0.40	1.20
Rhus trilobata	16	13		0.40	1.20
Rhus trilobata	16	14		0.50	1.50
Rhus trilobata	16	15		0.45	1.35
Rhus trilobata	16	16		0.50	1.50
Rhus trilobata	16	17		0.45	1.35
Rhus trilobata	16	18		0.50	1.50
Rhus trilobata	16	19		0.50	1.50
Rhus trilobata	16	20		0.50	1.50
Rhus trilobata	16	21		0.50	1.50
Rhus trilobata	16	22		0.55	1.65
Rhus trilobata	16	23		0.55	1.65

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Rhus trilobata	16	24		0.60	1.80
Rhus trilobata	16	25		0.60	1.80
Rhus trilobata	16	26		0.60	1.80
Rhus trilobata	16	27		0.60	1.80
Rhus trilobata	16	28		0.65	1.95
Rhus trilobata	16	29		0.60	1.80
Rhus trilobata	16	30		0.60	1.80
Shepherdia argentea	16	west border			
Shepherdia argentea	17	east border			
Prunus tomentosa	17	1		0.10	0.30
Prunus tomentosa	17	2		0.10	0.30
Prunus tomentosa	17	3		0.20	0.60
Prunus tomentosa	17	4		0.20	0.60
Prunus tomentosa	17	5		0.20	0.60
Prunus tomentosa	17	6		0.25	0.75
Prunus tomentosa	17	7		0.35	1.05
Prunus tomentosa	17	8		0.50	1.50
Prunus tomentosa	17	9		0.80	2.40
Prunus tomentosa	17	10		0.50	1.50
Prunus tomentosa	17	11		0.55	1.65
Prunus tomentosa	17	12		0.50	1.50
Prunus tomentosa	17	13		0.50	1.50
Prunus tomentosa	17	14		0.55	1.65
Prunus tomentosa	17	15		0.60	1.80
Prunus tomentosa	17	16		0.55	1.65
Prunus tomentosa	17	17		0.70	2.10
Prunus tomentosa	17	18		0.60	1.80
Prunus tomentosa	17	19		0.65	1.95
Prunus tomentosa	17	20		0.70	2.10
Prunus tomentosa	17	21		0.65	1.95
Prunus tomentosa	17	22		0.65	1.95
Prunus tomentosa	17	23		0.60	1.80
Prunus tomentosa	17	24		0.60	1.80
Prunus tomentosa	17	25		0.60	1.80
Prunus tomentosa	17	26		0.55	1.65
Prunus tomentosa	17	27		0.60	1.80
Prunus tomentosa	17	28		0.55	1.65
Prunus tomentosa	17	29		0.60	1.80
Prunus tomentosa	17	30		0.55	1.65
Shepherdia argentea	17	west border			
Shepherdia argentea	18	east border			
Populus deltoides	18	1	sample	0.15	0.45

Appendix 2. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2006, Bridger, MT.

Species	Row No.	Row Position	2006 Soil Samples Taken	2006 Actual EC Reading w/ SVF and RK	EC Values w/ SVF and RK
			0-12"/12-24"		*([reading x 30]/10) dS/m*
Populus deltoides	18	2		0.20	0.60
Populus deltoides	18	3		0.25	0.75
Populus deltoides	18	4		0.40	1.20
Populus deltoides	18	5		0.35	1.05
Populus deltoides	18	6		0.50	1.50
Populus deltoides	18	7		0.45	1.35
Populus deltoides	18	8		0.50	1.50
Populus deltoides	18	9		0.60	1.80
Populus deltoides	18	10		0.60	1.80
Populus deltoides	18	11		0.60	1.80
Populus deltoides	18	12		0.60	1.80
Populus deltoides	18	13		0.65	1.95
Populus deltoides	18	14		0.55	1.65
Populus deltoides	18	15	sample	0.60	1.80
Populus deltoides	18	16		0.65	1.95
Populus deltoides	18	17		0.70	2.10
Populus deltoides	18	18		0.70	2.10
Populus deltoides	18	19		0.70	2.10
Populus deltoides	18	20		0.65	1.95
Populus deltoides	18	21		0.60	1.80
Populus deltoides	18	22		0.60	1.80
Populus deltoides	18	23		0.55	1.65
Populus deltoides	18	24		0.50	1.50
Populus deltoides	18	25		0.60	1.80
Populus deltoides	18	26		0.60	1.80
Populus deltoides	18	27		0.60	1.80
Populus deltoides	18	28		0.55	1.65
Populus deltoides	18	29		0.60	1.80
Populus deltoides	18	30	sample	0.60	1.80
Shepherdia argentea	18	west border			

North end of plot

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
south end of plot						
Shepherdia argentea	1	east border				
Shepherdia argentea	1	1	1	94.0	3	browsed
Shepherdia argentea	1	2	1	93.0	3	browsed
Shepherdia argentea	1	3	1	88.0	4	browsed
Shepherdia argentea	1	4	1	99.0	4	browsed
Shepherdia argentea	1	5	1	92.0	4	browsed
Shepherdia argentea	1	6	1	88.0	3	browsed
Shepherdia argentea	1	7	1	89.0	4	browsed
Shepherdia argentea	1	8	1	91.0	4	browsed
Shepherdia argentea	1	9	1	91.0	4	browsed
Shepherdia argentea	1	10	1	90.0	5	browsed
Shepherdia argentea	1	11	1	57.0	5	
Shepherdia argentea	1	12	1	85.0	5	
Shepherdia argentea	1	13	1	63.0	5	
Shepherdia argentea	1	14	1	100.0	4	
Shepherdia argentea	1	15	0			
Shepherdia argentea	1	16	0			
Shepherdia argentea	1	17	0			
Shepherdia argentea	1	18	1	17.0	8	basal sprouts
Shepherdia argentea	1	19	1	16.0	8	basal sprouts
Shepherdia argentea	1	20	0			
Shepherdia argentea	1	21	0			
Shepherdia argentea	1	22	0			
Shepherdia argentea	1	23	1	70.0	5	
Shepherdia argentea	1	24	0			
Shepherdia argentea	1	25	1	65.0	5	
Shepherdia argentea	1	26	0			
Shepherdia argentea	1	27	1	81.0	5	
Shepherdia argentea	1	28	1	59.0	5	
Shepherdia argentea	1	29	0			
Shepherdia argentea	1	30	0			
Shepherdia argentea	1	west border				
Shepherdia argentea	2	east border				
Prunus virginiana	2	1	0			dead; deer loss?
Prunus virginiana	2	2	1	24.0	8	deer
Prunus virginiana	2	3	1	60.0	4	
Prunus virginiana	2	4	1	70.0	4	
Prunus virginiana	2	5	1	58.0	5	
Prunus virginiana	2	6	1	79.0	4	
Prunus virginiana	2	7	0			dead
Prunus virginiana	2	8	1	60.0	5	browsed
Prunus virginiana	2	9	1	64.0	4	
Prunus virginiana	2	10	1	63.0	4	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus virginiana	2	11	1	48.0	5	browsed
Prunus virginiana	2	12	1	67.0	5	
Prunus virginiana	2	13	1	92.0	3	
Prunus virginiana	2	14	1	64.0	8	
Prunus virginiana	2	15	0			dead
Prunus virginiana	2	16	0			dead
Prunus virginiana	2	17	0			dead
Prunus virginiana	2	18	0			dead
Prunus virginiana	2	19	0			dead
Prunus virginiana	2	20	0			dead
Prunus virginiana	2	21	0			dead
Prunus virginiana	2	22	0			dead
Prunus virginiana	2	23	0			dead
Prunus virginiana	2	24	0			dead
Prunus virginiana	2	25	0			dead
Prunus virginiana	2	26	0			dead
Prunus virginiana	2	27	0			dead
Prunus virginiana	2	28	0			dead
Prunus virginiana	2	29	0			dead
Prunus virginiana	2	30	0			dead
Shepherdia argentea	2	west border				
Shepherdia argentea	3	east border				
Picea pungens	3	1	0			
Picea pungens	3	2	0			
Picea pungens	3	3	0			
Picea pungens	3	4	1	27	8	
Picea pungens	3	5	0			
Picea pungens	3	6	1	21	8	
Picea pungens	3	7	1	20	8	
Picea pungens	3	8	0			appears dead
Picea pungens	3	9	1	29	8	
Picea pungens	3	10	0			
Picea pungens	3	11	0			
Picea pungens	3	12	0			
Picea pungens	3	13	0			
Picea pungens	3	14	0			
Picea pungens	3	15	0			
Picea pungens	3	16	0			
Picea pungens	3	17	0			
Picea pungens	3	18	0			
Picea pungens	3	19	0			
Picea pungens	3	20	0			
Picea pungens	3	21	0			
Picea pungens	3	22	0			

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Picea pungens	3	23	0			
Picea pungens	3	24	0			
Picea pungens	3	25	0			
Picea pungens	3	26	0			
Picea pungens	3	27	0			
Picea pungens	3	28	0			
Picea pungens	3	29	0			
Picea pungens	3	30	0			
Shepherdia argentea	3	west border				
Shepherdia argentea	4	east border				
Lonicera korolkowii	4	1	1	70.0	5	
Lonicera korolkowii	4	2	1	126.0	2	
Lonicera korolkowii	4	3	1	98.0	3	
Lonicera korolkowii	4	4	1	70.0	4	
Lonicera korolkowii	4	5	1	94.0	4	
Lonicera korolkowii	4	6	1	88.0	4	
Lonicera korolkowii	4	7	1	86.0	4	
Lonicera korolkowii	4	8	1	114.0	2	
Lonicera korolkowii	4	9	1	84.0	4	
Lonicera korolkowii	4	10	1	85.0	5	
Lonicera korolkowii	4	11	1	69.0	4	
Lonicera korolkowii	4	12	1	93.0	3	
Lonicera korolkowii	4	13	1	85.0	5	
Lonicera korolkowii	4	14	1	66.0	5	
Lonicera korolkowii	4	15	1	68.0	5	
Lonicera korolkowii	4	16	1	85.0	5	
Lonicera korolkowii	4	17	1	73.0	5	
Lonicera korolkowii	4	18	1	70.0	6	
Lonicera korolkowii	4	19	1	75.0	6	
Lonicera korolkowii	4	20	1	75.0	5	
Lonicera korolkowii	4	21	1	60.0	5	
Lonicera korolkowii	4	22	0			
Lonicera korolkowii	4	23	0			
Lonicera korolkowii	4	24	0			
Lonicera korolkowii	4	25	1	42.0	8	nearly dead
Lonicera korolkowii	4	26	0			
Lonicera korolkowii	4	27	0			
Lonicera korolkowii	4	28	0			
Lonicera korolkowii	4	29	1	32.0	8	
Lonicera korolkowii	4	30	0			dead
Shepherdia argentea	4	west border				
Shepherdia argentea	5	east border				
Elaeagnus commutata	5	1	1	79.0	4	
Elaeagnus commutata	5	2	1	90.0	4	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Elaeagnus commutata	5	3	1	82.0	4	
Elaeagnus commutata	5	4	1	105.0	3	
Elaeagnus commutata	5	5	1	97.0	3	
Elaeagnus commutata	5	6	1	105.0	3	
Elaeagnus commutata	5	7	1	43.0	7	deer?
Elaeagnus commutata	5	8	1	60.0	6	
Elaeagnus commutata	5	9	1	78.0	4	
Elaeagnus commutata	5	10	1	105.0	3	
Elaeagnus commutata	5	11	1	97.0	3	
Elaeagnus commutata	5	12	1	66.0	5	
Elaeagnus commutata	5	13	1	77.0	6	
Elaeagnus commutata	5	14	1	75.0	5	
Elaeagnus commutata	5	15	1	103.0	5	
Elaeagnus commutata	5	16	1	44.0	6	
Elaeagnus commutata	5	17	1	27.0	8	
Elaeagnus commutata	5	18	1	32.0	7	
Elaeagnus commutata	5	19	1	23.0	8	
Elaeagnus commutata	5	20	0			
Elaeagnus commutata	5	21	1	34.0	7	
Elaeagnus commutata	5	22	0			
Elaeagnus commutata	5	23	1	40.0	6	
Elaeagnus commutata	5	24	0			
Elaeagnus commutata	5	25	0			
Elaeagnus commutata	5	26	1	36.0	8	
Elaeagnus commutata	5	27	1	45.0	7	
Elaeagnus commutata	5	28	1	43.0	7	
Elaeagnus commutata	5	29	0			
Elaeagnus commutata	5	30	0			
Shepherdia argentea	5	west border				
Shepherdia argentea	6	east border				
Ribes aureum	6	1	1	74.0	4	
Ribes aureum	6	2	1	90.0	3	
Ribes aureum	6	3	1	94.0	3	
Ribes aureum	6	4	1	93.0	2	
Ribes aureum	6	5	1	91.0	2	
Ribes aureum	6	6	1	93.0	3	
Ribes aureum	6	7	1	36.0	7	dead top
Ribes aureum	6	8	1	46.0	6	
Ribes aureum	6	9	1	45.0	6	
Ribes aureum	6	10	1	72.0	5	
Ribes aureum	6	11	1	50.0	6	
Ribes aureum	6	12	1	74.0	5	
Ribes aureum	6	13	1	74.0	5	
Ribes aureum	6	14	1	90.0	4	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Ribes aureum	6	15	1	78.0	4	
Ribes aureum	6	16	0			
Ribes aureum	6	17	1	75.0	5	
Ribes aureum	6	18	1	73.0	5	
Ribes aureum	6	19	1	64.0	5	
Ribes aureum	6	20	1	84.0	4	
Ribes aureum	6	21	0			
Ribes aureum	6	22	0			
Ribes aureum	6	23	1	73.0	5	
Ribes aureum	6	24	0			
Ribes aureum	6	25	0			
Ribes aureum	6	26	0			
Ribes aureum	6	27	0			
Ribes aureum	6	28	0			
Ribes aureum	6	29	0			
Ribes aureum	6	30	0			
Shepherdia argentea	6	west border				
Shepherdia argentea	7	east border				
Hippophae rhamnoides	7	1	1	93.0	3	
Hippophae rhamnoides	7	2	1	84.0	4	
Hippophae rhamnoides	7	3	0			dead
Hippophae rhamnoides	7	4	1	79.0	5	
Hippophae rhamnoides	7	5	1	91.0	3	
Hippophae rhamnoides	7	6	1	88.0	4	
Hippophae rhamnoides	7	7	1	89.0	3	
Hippophae rhamnoides	7	8	1	43.0	6	
Hippophae rhamnoides	7	9	1	16.0	8	
Hippophae rhamnoides	7	10	0			
Hippophae rhamnoides	7	11	1	54.0	4	
Hippophae rhamnoides	7	12	1	79.0	5	
Hippophae rhamnoides	7	13	0			
Hippophae rhamnoides	7	14	1	89.0	6	
Hippophae rhamnoides	7	15	1	59.0	7	
Hippophae rhamnoides	7	16	1	92.0	6	
Hippophae rhamnoides	7	17	1	77.0	6	
Hippophae rhamnoides	7	18	1	71.0	5	
Hippophae rhamnoides	7	19	1	94.0	5	
Hippophae rhamnoides	7	20	0			
Hippophae rhamnoides	7	21	1	75.0	5	
Hippophae rhamnoides	7	22	1	81.0	5	
Hippophae rhamnoides	7	23	0			
Hippophae rhamnoides	7	24	1	56.0	6	
Hippophae rhamnoides	7	25	1	36.0	7	
Hippophae rhamnoides	7	26	1	42.0	8	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Hippophae rhamnoides	7	27	1	46.0	7	
Hippophae rhamnoides	7	28	0			
Hippophae rhamnoides	7	29	1	50.0	6	
Hippophae rhamnoides	7	30	0			
Shepherdia argentea	7	west border				
Shepherdia argentea	8	east border				
Elaeagnus angustifolia	8	1	1	181.0	3	
Elaeagnus angustifolia	8	2	1	190.0	3	
Elaeagnus angustifolia	8	3	1	208.0	1	
Elaeagnus angustifolia	8	4	1	219.0	1	
Elaeagnus angustifolia	8	5	1	120.0	5	deer 2006?
Elaeagnus angustifolia	8	6	1	197.0	2	
Elaeagnus angustifolia	8	7	1	185.0	2	
Elaeagnus angustifolia	8	8	1	172.0	4	
Elaeagnus angustifolia	8	9	1	135.0	5	deer 2006?
Elaeagnus angustifolia	8	10	1	84.0	6	deer 2006?
Elaeagnus angustifolia	8	11	1	173.0	3	
Elaeagnus angustifolia	8	12	1	145.0	4	
Elaeagnus angustifolia	8	13	1	186.0	4	
Elaeagnus angustifolia	8	14	1	200.0	4	
Elaeagnus angustifolia	8	15	1	174.0	4	
Elaeagnus angustifolia	8	16	1	208.0	2	
Elaeagnus angustifolia	8	17	1	225.0	3	
Elaeagnus angustifolia	8	18	1	146.0	5	
Elaeagnus angustifolia	8	19	1	141.0	5	
Elaeagnus angustifolia	8	20	1	182.0	2	
Elaeagnus angustifolia	8	21	1	159.0	4	
Elaeagnus angustifolia	8	22	1	194.0	3	
Elaeagnus angustifolia	8	23	1	170.0	4	
Elaeagnus angustifolia	8	24	1	201.0	2	
Elaeagnus angustifolia	8	25	1	234.0	2	
Elaeagnus angustifolia	8	26	1	214.0	3	
Elaeagnus angustifolia	8	27	1	170.0	4	
Elaeagnus angustifolia	8	28	1	155.0	5	
Elaeagnus angustifolia	8	29	1	9.0	8	
Elaeagnus angustifolia	8	30	0			dead
Shepherdia argentea	8	west border				
Shepherdia argentea	9	east border				
Caragana arborescens	9	1	1	69.0	4	
Caragana arborescens	9	2	0			dead
Caragana arborescens	9	3	1	64.0	4	
Caragana arborescens	9	4	1	83.0	3	
Caragana arborescens	9	5	1	63.0	5	
Caragana arborescens	9	6	0			dead

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Caragana arborescens	9	7	1	64.0	5	
Caragana arborescens	9	8	0			dead
Caragana arborescens	9	9	1	65.0	6	
Caragana arborescens	9	10	1	70.0	8	no leaves
Caragana arborescens	9	11	1	91.0	6	
Caragana arborescens	9	12	1	40.0	8	no leaves
Caragana arborescens	9	13	1	68.0	6	
Caragana arborescens	9	14	1	58.0	8	no leaves
Caragana arborescens	9	15	0			dead
Caragana arborescens	9	16	1	92.0	6	
Caragana arborescens	9	17	1	72.0	7	
Caragana arborescens	9	18	1	65.0	6	
Caragana arborescens	9	19	1	46.0	8	
Caragana arborescens	9	20	1	60.0	7	
Caragana arborescens	9	21	1	62.0	7	
Caragana arborescens	9	22	1	49.0	8	
Caragana arborescens	9	23	1	94.0	6	
Caragana arborescens	9	24	1	66.0	7	
Caragana arborescens	9	25	1	45.0	8	
Caragana arborescens	9	26	1	49.0	8	
Caragana arborescens	9	27	1	83.0	7	
Caragana arborescens	9	28	0			
Caragana arborescens	9	29	0			
Caragana arborescens	9	30	0			
Shepherdia argentea	9	west border				
Shepherdia argentea	10	east border				
Ulmus pumila	10	1	1	115.0	3	browsed
Ulmus pumila	10	2	1	104.0	3	
Ulmus pumila	10	3	1	94.0	4	
Ulmus pumila	10	4	1	87.0	4	
Ulmus pumila	10	5	1	95.0	3	
Ulmus pumila	10	6	1	95.0	4	deer damage 07
Ulmus pumila	10	7	1	89.0	4	deer damage 07
Ulmus pumila	10	8	1	90.0	4	deer damage 07
Ulmus pumila	10	9	1	91.0	4	
Ulmus pumila	10	10	1	90.0	5	
Ulmus pumila	10	11	1	95.0	4	
Ulmus pumila	10	12	1	100.0	4	
Ulmus pumila	10	13	1	82.0	4	
Ulmus pumila	10	14	1	93.0	4	
Ulmus pumila	10	15	1	100.0	4	
Ulmus pumila	10	16	1	94.0	4	
Ulmus pumila	10	17	1	95.0	4	
Ulmus pumila	10	18	1	87.0	5	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Ulmus pumila	10	19	1	96.0	4	
Ulmus pumila	10	20	1	89.0	5	
Ulmus pumila	10	21	1	90.0	5	
Ulmus pumila	10	22	1	89.0	5	
Ulmus pumila	10	23	1	104.0	4	
Ulmus pumila	10	24	1	103.0	4	
Ulmus pumila	10	25	1	100.0	4	
Ulmus pumila	10	26	1	40.0	8	
Ulmus pumila	10	27	0			
Ulmus pumila	10	28	0			
Ulmus pumila	10	29	0			
Ulmus pumila	10	30	1	33.0	8	
Shepherdia argentea	10	west border				
Shepherdia argentea	11	east border				
Pinus ponderosa	11	1	1	32	6	
Pinus ponderosa	11	2	1	29.0	4	
Pinus ponderosa	11	3	0			dead
Pinus ponderosa	11	4	1	25.0	5	
Pinus ponderosa	11	5	1	20.0	8	nearly dead
Pinus ponderosa	11	6	1	46.0	2	
Pinus ponderosa	11	7	1	30.0	6	
Pinus ponderosa	11	8	1	24.0	8	
Pinus ponderosa	11	9	1	41.0	8	
Pinus ponderosa	11	10	1	40.0	7	
Pinus ponderosa	11	11	0			
Pinus ponderosa	11	12	1	30.0	6	
Pinus ponderosa	11	13	0			
Pinus ponderosa	11	14	1	44.0	6	
Pinus ponderosa	11	15	1	39.0	8	nearly dead
Pinus ponderosa	11	16	1	41.0	8	
Pinus ponderosa	11	17	1	30.0	7	
Pinus ponderosa	11	18	1	34.0	8	
Pinus ponderosa	11	19	0			browsed
Pinus ponderosa	11	20	1	30.0	6	
Pinus ponderosa	11	21	0			
Pinus ponderosa	11	22	0			
Pinus ponderosa	11	23	0			
Pinus ponderosa	11	24	0			
Pinus ponderosa	11	25	0			
Pinus ponderosa	11	26	0			
Pinus ponderosa	11	27	0			
Pinus ponderosa	11	28	0			
Pinus ponderosa	11	29	0			
Pinus ponderosa	11	30	0			

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Shepherdia argentea	11	west border				
Shepherdia argentea	12	east border				
Symphoricarpos sp.	12	1	1	43.0	6	
Symphoricarpos sp.	12	2	1	69.0	3	
Symphoricarpos sp.	12	3	1	71.0	3	
Symphoricarpos sp.	12	4	1	57.0	6	
Symphoricarpos sp.	12	5	1	61.0	4	
Symphoricarpos sp.	12	6	1	42.0	4	
Symphoricarpos sp.	12	7	1	35.0	5	
Symphoricarpos sp.	12	8	1	43.0	5	
Symphoricarpos sp.	12	9	1	58.0	5	
Symphoricarpos sp.	12	10	1	57.0	4	
Symphoricarpos sp.	12	11	1	60.0	4	
Symphoricarpos sp.	12	12	1	49.0	4	
Symphoricarpos sp.	12	13	1	50.0	4	
Symphoricarpos sp.	12	14	1	66.0	4	
Symphoricarpos sp.	12	15	1	60.0	4	
Symphoricarpos sp.	12	16	1	66.0	4	
Symphoricarpos sp.	12	17	1	64.0	5	
Symphoricarpos sp.	12	18	1	60.0	4	
Symphoricarpos sp.	12	19	1	56.0	5	
Symphoricarpos sp.	12	20	1	64.0	5	
Symphoricarpos sp.	12	21	1	57.0	4	
Symphoricarpos sp.	12	22	1	56.0	5	
Symphoricarpos sp.	12	23	1	60.0	5	
Symphoricarpos sp.	12	24	1	54.0	5	
Symphoricarpos sp.	12	25	1	60.0	4	
Symphoricarpos sp.	12	26	1	53.0	7	
Symphoricarpos sp.	12	27	1	53.0	8	
Symphoricarpos sp.	12	28	1	54.0	6	
Symphoricarpos sp.	12	29	1	52.0	7	
Symphoricarpos sp.	12	30	1	65.0	6	
Shepherdia argentea	12	west border				
Shepherdia argentea	13	east border				
Fraxinus pennsylvanica	13	1	1	99.0	3	
Fraxinus pennsylvanica	13	2	1	103.0	3	
Fraxinus pennsylvanica	13	3	1	98.0	4	
Fraxinus pennsylvanica	13	4	1	93.0	4	
Fraxinus pennsylvanica	13	5	1	106.0	3	
Fraxinus pennsylvanica	13	6	1	90.0	4	
Fraxinus pennsylvanica	13	7	1	78.0	5	browsed
Fraxinus pennsylvanica	13	8	1	100.0	3	
Fraxinus pennsylvanica	13	9	1	96.0	3	
Fraxinus pennsylvanica	13	10	1	104.0	4	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Fraxinus pennsylvanica	13	11	1	123.0	3	severe deer damage
Fraxinus pennsylvanica	13	12	1	104.0	4	
Fraxinus pennsylvanica	13	13	1	79.0	5	
Fraxinus pennsylvanica	13	14	1	90.0	4	
Fraxinus pennsylvanica	13	15	1	85.0	4	
Fraxinus pennsylvanica	13	16	1	96.0	4	
Fraxinus pennsylvanica	13	17	1	10.0	8	severe deer damage
Fraxinus pennsylvanica	13	18	1	84.0	6	
Fraxinus pennsylvanica	13	19	1	94.0	4	
Fraxinus pennsylvanica	13	20	1	94.0	4	
Fraxinus pennsylvanica	13	21	1	69.0	5	
Fraxinus pennsylvanica	13	22	1	96.0	4	
Fraxinus pennsylvanica	13	23	1	108.0	3	
Fraxinus pennsylvanica	13	24	1	108.0	3	
Fraxinus pennsylvanica	13	25	1	80.0	5	
Fraxinus pennsylvanica	13	26	1	109.0	3	
Fraxinus pennsylvanica	13	27	1	65.0	5	
Fraxinus pennsylvanica	13	28	1	100.0	5	
Fraxinus pennsylvanica	13	29	1	85.0	4	
Fraxinus pennsylvanica	13	30	1	46.0	7	
Shepherdia argentea	13	west border				
Shepherdia argentea	14	east border				
Prunus americana	14	1	0			dead
Prunus americana	14	2	1	27.0	6	
Prunus americana	14	3	1	67.0	5	
Prunus americana	14	4	1	99.0	4	deer
Prunus americana	14	5	1	106.0	4	
Prunus americana	14	6	1	91.0	4	
Prunus americana	14	7	1	74.0	5	
Prunus americana	14	8	1	87.0	3	
Prunus americana	14	9	1	90.0	4	
Prunus americana	14	10	1	98.0	4	
Prunus americana	14	11	1	97.0	4	
Prunus americana	14	12	1	109.0	4	
Prunus americana	14	13	1	50.0	6	
Prunus americana	14	14	1	27.0	8	
Prunus americana	14	15	1	70.0	7	
Prunus americana	14	16	0			dead
Prunus americana	14	17	1	60.0	6	
Prunus americana	14	18	1	56.0	6	
Prunus americana	14	19	1	31.0	8	
Prunus americana	14	20	1	84.0	6	
Prunus americana	14	21	1	93.0	5	
Prunus americana	14	22	1	55.0	6	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus americana	14	23	1	65.0	6	
Prunus americana	14	24	1	90.0	6	
Prunus americana	14	25	1	54.0	7	
Prunus americana	14	26	0			dead
Prunus americana	14	27	1	36.0	8	
Prunus americana	14	28	0			dead
Prunus americana	14	29	0			dead
Prunus americana	14	30	0			dead
Shepherdia argentea	14	west border				
Shepherdia argentea	15	east border				
Prunus besseyi	15	1	1	47.0	5	
Prunus besseyi	15	2	1	65.0	3	
Prunus besseyi	15	3	1	75.0	4	
Prunus besseyi	15	4	1	51.0	5	
Prunus besseyi	15	5	1	74.0	4	
Prunus besseyi	15	6	1	85.0	4	
Prunus besseyi	15	7	1	80.0	4	
Prunus besseyi	15	8	1	87.0	4	
Prunus besseyi	15	9	1	85.0	4	
Prunus besseyi	15	10	1	83.0	4	
Prunus besseyi	15	11	1	67.0	5	
Prunus besseyi	15	12	1	60.0	5	
Prunus besseyi	15	13	1	79.0	5	
Prunus besseyi	15	14	1	62.0	5	
Prunus besseyi	15	15	1	59.0	5	
Prunus besseyi	15	16	1	60.0	6	
Prunus besseyi	15	17	0			dead
Prunus besseyi	15	18	0			dead
Prunus besseyi	15	19	1	57.0	5	
Prunus besseyi	15	20	0			dead
Prunus besseyi	15	21	0			dead
Prunus besseyi	15	22	0			dead 2006?
Prunus besseyi	15	23	0			dead
Prunus besseyi	15	24	1	78.0	6	
Prunus besseyi	15	25	1	70.0	6	
Prunus besseyi	15	26	0			dead
Prunus besseyi	15	27	0			dead 2006?
Prunus besseyi	15	28	0			dead 2006?
Prunus besseyi	15	29	0			dead 2006?
Prunus besseyi	15	30	0			dead
Shepherdia argentea	15	west border				
Shepherdia argentea	16	east border				
Rhus trilobata	16	1	1	52.0	5	
Rhus trilobata	16	2	0			dead

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Rhus trilobata	16	3	0			dead
Rhus trilobata	16	4	1	99.0	3	
Rhus trilobata	16	5	1	70.0	4	
Rhus trilobata	16	6	1	66.0	4	
Rhus trilobata	16	7	1	78.0	4	
Rhus trilobata	16	8	1	51.0	5	
Rhus trilobata	16	9	1	105.0	2	
Rhus trilobata	16	10	1	105.0	3	
Rhus trilobata	16	11	1	100.0	3	
Rhus trilobata	16	12	1	80.0	4	
Rhus trilobata	16	13	1	69.0	5	
Rhus trilobata	16	14	1	94.0	3	
Rhus trilobata	16	15	1	54.0	5	
Rhus trilobata	16	16	1	67.0	4	
Rhus trilobata	16	17	1	56.0	4	
Rhus trilobata	16	18	1	26.0	6	
Rhus trilobata	16	19	0			dead
Rhus trilobata	16	20	0			dead
Rhus trilobata	16	21	1	86.0	4	
Rhus trilobata	16	22	1	64.0	4	
Rhus trilobata	16	23	1	33.0	6	
Rhus trilobata	16	24	1	0.0	8	
Rhus trilobata	16	25	0			dead
Rhus trilobata	16	26	0			dead
Rhus trilobata	16	27	0			dead
Rhus trilobata	16	28	1	17.0	9	
Rhus trilobata	16	29	0			dead
Rhus trilobata	16	30	1	80.0	5	
Shepherdia argentea	16	west border				
Shepherdia argentea	17	east border				
Prunus tomentosa	17	1	0			dead
Prunus tomentosa	17	2	0			dead
Prunus tomentosa	17	3	0			dead
Prunus tomentosa	17	4	0			dead
Prunus tomentosa	17	5	0			dead
Prunus tomentosa	17	6	1	47.0	7	
Prunus tomentosa	17	7	1	55.0	6	
Prunus tomentosa	17	8	0			dead
Prunus tomentosa	17	9	1	85.0	6	
Prunus tomentosa	17	10	1	85.0	6	
Prunus tomentosa	17	11	1	50.0	7	
Prunus tomentosa	17	12	0			dead
Prunus tomentosa	17	13	0			dead 2006
Prunus tomentosa	17	14	0			dead 2006

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus tomentosa	17	15	0			dead 2006
Prunus tomentosa	17	16	1	67.0	7	
Prunus tomentosa	17	17	0			dead 2006
Prunus tomentosa	17	18	0			dead 2006
Prunus tomentosa	17	19	0			dead 2006
Prunus tomentosa	17	20	0			dead 2006
Prunus tomentosa	17	21	0			dead
Prunus tomentosa	17	22	0			dead 2006
Prunus tomentosa	17	23	0			dead 2006
Prunus tomentosa	17	24	0			dead
Prunus tomentosa	17	25	0			dead 2006
Prunus tomentosa	17	26	0			dead 2006
Prunus tomentosa	17	27	0			dead 2006
Prunus tomentosa	17	28	0			dead 2006
Prunus tomentosa	17	29	0			dead
Prunus tomentosa	17	30	0			dead 2006
Shepherdia argentea	17	west border				
Shepherdia argentea	18	east border				
Populus deltoides	18	1	1	138.0	4	
Populus deltoides	18	2	1	145.0	4	
Populus deltoides	18	3	1	106.0	4	
Populus deltoides	18	4	1	105.0	4	
Populus deltoides	18	5	1	121.0	4	
Populus deltoides	18	6	1	97.0	5	
Populus deltoides	18	7	1	124.0	4	deer 2007
Populus deltoides	18	8	1	112.0	4	
Populus deltoides	18	9	1	165.0	3	
Populus deltoides	18	10	1	195.0	2	deer 2007
Populus deltoides	18	11	1	223.0	2	
Populus deltoides	18	12	1	113.0	5	
Populus deltoides	18	13	1	185.0	3	
Populus deltoides	18	14	1	207.0	3	
Populus deltoides	18	15	1	175.0	3	
Populus deltoides	18	16	1	195.0	3	
Populus deltoides	18	17	1	197.0	3	
Populus deltoides	18	18	1	169.0	4	
Populus deltoides	18	19	1	208.0	3	
Populus deltoides	18	20	1	198.0	3	
Populus deltoides	18	21	1	192.0	3	
Populus deltoides	18	22	1	220.0	3	
Populus deltoides	18	23	1	207.0	3	
Populus deltoides	18	24	1	194.0	3	
Populus deltoides	18	25	1	163.0	4	
Populus deltoides	18	26	1	171.0	4	

Appendix 3. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	Fall 2007 Survival (0,1)	Fall 2007 Height *cm*	Fall Vigor Rating (1-9)	Comments
Populus deltoides	18	27	1	155.0	4	
Populus deltoides	18	28	1	212.0	3	severe deer 2007
Populus deltoides	18	29	1	212.0	3	severe deer 2007
Populus deltoides	18	30	1	120.0	5	
Shepherdia argentea	18	west border				

North end of plot

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
south end of plot						
Shepherdia argentea	1	east border				
Shepherdia argentea	1	1	0.85	2.55	0.70	2.10
Shepherdia argentea	1	2	0.80	2.40	0.70	2.10
Shepherdia argentea	1	3	0.80	2.40	0.65	1.95
Shepherdia argentea	1	4	0.85	2.55	0.65	1.95
Shepherdia argentea	1	5	0.85	2.55	0.70	2.10
Shepherdia argentea	1	6	1.00	3.00	0.80	2.40
Shepherdia argentea	1	7	1.10	3.30	0.95	2.85
Shepherdia argentea	1	8	1.30	3.90	1.05	3.15
Shepherdia argentea	1	9	1.50	4.50	1.25	3.75
Shepherdia argentea	1	10	1.80	5.40	1.75	5.25
Shepherdia argentea	1	11	1.95	5.85	1.80	5.40
Shepherdia argentea	1	12	2.20	6.60	1.70	5.10
Shepherdia argentea	1	13	2.30	6.90	2.00	6.00
Shepherdia argentea	1	14	2.65	7.95	2.30	6.90
Shepherdia argentea	1	15	0.85	8.50	1.00	10.00
Shepherdia argentea	1	16	1.00	10.00	1.15	11.50
Shepherdia argentea	1	17	1.05	10.50	1.15	11.50
Shepherdia argentea	1	18	1.15	11.50	1.15	11.50
Shepherdia argentea	1	19	1.15	11.50	1.30	13.00
Shepherdia argentea	1	20	1.15	11.50	1.30	13.00
Shepherdia argentea	1	21	1.10	11.00	1.30	13.00
Shepherdia argentea	1	22	1.20	12.00	1.10	11.00
Shepherdia argentea	1	23	1.20	12.00	1.00	10.00
Shepherdia argentea	1	24	1.00	10.00	0.90	9.00
Shepherdia argentea	1	25	1.05	10.50	0.90	9.00
Shepherdia argentea	1	26	0.95	9.50	0.90	9.00
Shepherdia argentea	1	27	0.95	9.50	0.80	8.00
Shepherdia argentea	1	28	0.90	9.00	0.90	9.00
Shepherdia argentea	1	29	1.00	10.00	1.05	10.50
Shepherdia argentea	1	30	1.20	12.00	1.15	11.50
Shepherdia argentea	1	west border				
Shepherdia argentea	2	east border				
Prunus virginiana	2	1	0.80	2.40	0.60	1.80
Prunus virginiana	2	2	0.80	2.40	0.55	1.65
Prunus virginiana	2	3	0.80	2.40	0.55	1.65
Prunus virginiana	2	4	0.75	2.25	0.55	1.65
Prunus virginiana	2	5	0.85	2.55	0.55	1.65
Prunus virginiana	2	6	0.85	2.55	0.75	2.25
Prunus virginiana	2	7	0.90	2.70	0.85	2.55
Prunus virginiana	2	8	0.90	2.70	1.00	3.00
Prunus virginiana	2	9	1.15	3.45	1.00	3.00

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Prunus virginiana	2	10	1.15	3.45	1.00	3.00
Prunus virginiana	2	11	1.20	3.60	1.10	3.30
Prunus virginiana	2	12	1.25	3.75	1.10	3.30
Prunus virginiana	2	13	1.50	4.50	1.20	3.60
Prunus virginiana	2	14	1.90	5.70	1.60	4.80
Prunus virginiana	2	15	2.20	6.60	2.40	7.20
Prunus virginiana	2	16	0.90	9.00	0.90	9.00
Prunus virginiana	2	17	0.95	9.50	1.00	10.00
Prunus virginiana	2	18	0.85	8.50	0.85	8.50
Prunus virginiana	2	19	0.85	8.50	0.80	8.00
Prunus virginiana	2	20	0.80	8.00	0.70	7.00
Prunus virginiana	2	21	0.80	8.00	0.75	7.50
Prunus virginiana	2	22	0.80	8.00	0.85	8.50
Prunus virginiana	2	23	0.85	8.50	0.70	7.00
Prunus virginiana	2	24	0.80	8.00	0.85	8.50
Prunus virginiana	2	25	0.80	8.00	0.80	8.00
Prunus virginiana	2	26	0.95	9.50	0.85	8.50
Prunus virginiana	2	27	0.95	9.50	0.95	9.50
Prunus virginiana	2	28	0.85	8.50	0.85	8.50
Prunus virginiana	2	29	1.05	10.50	0.75	7.50
Prunus virginiana	2	30	1.00	10.00	0.90	9.00
Shepherdia argentea	2	west border				
Shepherdia argentea	3	east border				
Picea pungens	3	1	0.85	2.55	0.65	1.95
Picea pungens	3	2	0.85	2.55	0.60	1.80
Picea pungens	3	3	0.80	2.40	0.55	1.65
Picea pungens	3	4	0.80	2.40	0.55	1.65
Picea pungens	3	5	0.75	2.25	0.60	1.80
Picea pungens	3	6	0.80	2.40	0.60	1.80
Picea pungens	3	7	0.80	2.40	0.60	1.80
Picea pungens	3	8	0.85	2.55	0.65	1.95
Picea pungens	3	9	0.85	2.55	0.70	2.10
Picea pungens	3	10	1.00	3.00	0.65	1.95
Picea pungens	3	11	1.00	3.00	0.85	2.55
Picea pungens	3	12	1.30	3.90	0.95	2.85
Picea pungens	3	13	1.50	4.50	1.45	4.35
Picea pungens	3	14	1.80	5.40	2.05	6.15
Picea pungens	3	15	2.10	6.30	2.15	6.45
Picea pungens	3	16	2.05	6.15	2.00	6.00
Picea pungens	3	17	1.85	5.55	1.70	5.10
Picea pungens	3	18	1.90	5.70	1.35	4.05
Picea pungens	3	19	1.70	5.10	1.70	5.10
Picea pungens	3	20	1.80	5.40	1.80	5.40

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Picea pungens	3	21	1.85	5.55	2.00	6.00
Picea pungens	3	22	2.10	6.30	2.30	6.90
Picea pungens	3	23	2.40	7.20	2.70	8.10
Picea pungens	3	24	2.50	7.50	2.80	8.40
Picea pungens	3	25	2.60	7.80	2.50	7.50
Picea pungens	3	26	2.60	7.80	2.50	7.50
Picea pungens	3	27	0.90	9.00	0.70	7.00
Picea pungens	3	28	0.80	8.00	0.70	7.00
Picea pungens	3	29	0.85	8.50	0.70	7.00
Picea pungens	3	30	0.90	9.00	0.75	7.50
Shepherdia argentea	3	west border				
Shepherdia argentea	4	east border				
Lonicera korolkowii	4	1	0.80	2.40	0.65	1.95
Lonicera korolkowii	4	2	0.80	2.40	0.60	1.80
Lonicera korolkowii	4	3	0.75	2.25	0.55	1.65
Lonicera korolkowii	4	4	0.75	2.25	0.50	1.50
Lonicera korolkowii	4	5	0.75	2.25	0.50	1.50
Lonicera korolkowii	4	6	0.75	2.25	0.60	1.80
Lonicera korolkowii	4	7	0.75	2.25	0.55	1.65
Lonicera korolkowii	4	8	0.80	2.40	0.60	1.80
Lonicera korolkowii	4	9	0.90	2.70	0.70	2.10
Lonicera korolkowii	4	10	0.90	2.70	0.75	2.25
Lonicera korolkowii	4	11	1.00	3.00	0.80	2.40
Lonicera korolkowii	4	12	1.10	3.30	0.85	2.55
Lonicera korolkowii	4	13	1.20	3.60	0.85	2.55
Lonicera korolkowii	4	14	1.20	3.60	0.95	2.85
Lonicera korolkowii	4	15	1.30	3.90	1.10	3.30
Lonicera korolkowii	4	16	1.30	3.90	1.30	3.90
Lonicera korolkowii	4	17	1.45	4.35	1.25	3.75
Lonicera korolkowii	4	18	1.45	4.35	1.40	4.20
Lonicera korolkowii	4	19	1.60	4.80	1.50	4.50
Lonicera korolkowii	4	20	1.50	4.50	1.50	4.50
Lonicera korolkowii	4	21	1.70	5.10	1.50	4.50
Lonicera korolkowii	4	22	2.00	6.00	1.90	5.70
Lonicera korolkowii	4	23	2.00	6.00	2.35	7.05
Lonicera korolkowii	4	24	2.10	6.30	2.50	7.50
Lonicera korolkowii	4	25	2.35	7.05	2.10	6.30
Lonicera korolkowii	4	26	2.35	7.05	2.10	6.30
Lonicera korolkowii	4	27	2.65	7.95	2.25	6.75
Lonicera korolkowii	4	28	2.50	7.50	2.35	7.05
Lonicera korolkowii	4	29	2.50	7.50	2.30	6.90
Lonicera korolkowii	4	30	2.50	7.50	2.20	6.60
Shepherdia argentea	4	west border		0.00		0.00

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Shepherdia argentea	5	east border		0.00		0.00
Elaeagnus commutata	5	1	0.75	2.25	0.65	1.95
Elaeagnus commutata	5	2	0.75	2.25	0.60	1.80
Elaeagnus commutata	5	3	0.70	2.10	0.50	1.50
Elaeagnus commutata	5	4	0.70	2.10	0.50	1.50
Elaeagnus commutata	5	5	0.70	2.10	0.50	1.50
Elaeagnus commutata	5	6	0.70	2.10	0.50	1.50
Elaeagnus commutata	5	7	0.75	2.25	0.60	1.80
Elaeagnus commutata	5	8	0.80	2.40	0.65	1.95
Elaeagnus commutata	5	9	0.80	2.40	0.65	1.95
Elaeagnus commutata	5	10	0.90	2.70	0.70	2.10
Elaeagnus commutata	5	11	0.95	2.85	0.85	2.55
Elaeagnus commutata	5	12	1.10	3.30	1.00	3.00
Elaeagnus commutata	5	13	1.10	3.30	1.15	3.45
Elaeagnus commutata	5	14	1.25	3.75	1.15	3.45
Elaeagnus commutata	5	15	1.35	4.05	1.20	3.60
Elaeagnus commutata	5	16	1.65	4.95	1.35	4.05
Elaeagnus commutata	5	17	1.60	4.80	1.50	4.50
Elaeagnus commutata	5	18	2.00	6.00	1.60	4.80
Elaeagnus commutata	5	19	1.80	5.40	1.85	5.55
Elaeagnus commutata	5	20	2.00	6.00	1.95	5.85
Elaeagnus commutata	5	21	2.10	6.30	2.40	7.20
Elaeagnus commutata	5	22	2.15	6.45	2.45	7.35
Elaeagnus commutata	5	23	2.20	6.60	2.30	6.90
Elaeagnus commutata	5	24	2.00	6.00	2.10	6.30
Elaeagnus commutata	5	25	2.10	6.30	2.15	6.45
Elaeagnus commutata	5	26	2.10	6.30	2.00	6.00
Elaeagnus commutata	5	27	2.00	6.00	2.00	6.00
Elaeagnus commutata	5	28	1.70	5.10	2.00	6.00
Elaeagnus commutata	5	29	2.25	6.75	1.85	5.55
Elaeagnus commutata	5	30	2.40	7.20	2.50	7.50
Shepherdia argentea	5	west border		0.00		0.00
Shepherdia argentea	6	east border		0.00		0.00
Ribes aureum	6	1	0.75	2.25	0.50	1.50
Ribes aureum	6	2	0.70	2.10	0.50	1.50
Ribes aureum	6	3	0.70	2.10	0.50	1.50
Ribes aureum	6	4	0.65	1.95	0.60	1.80
Ribes aureum	6	5	0.75	2.25	0.55	1.65
Ribes aureum	6	6	0.75	2.25	0.55	1.65
Ribes aureum	6	7	0.80	2.40	0.65	1.95
Ribes aureum	6	8	0.85	2.55	0.70	2.10
Ribes aureum	6	9	0.90	2.70	0.75	2.25
Ribes aureum	6	10	1.05	3.15	0.75	2.25

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Ribes aureum	6	11	1.05	3.15	0.85	2.55
Ribes aureum	6	12	1.05	3.15	0.95	2.85
Ribes aureum	6	13	1.15	3.45	1.00	3.00
Ribes aureum	6	14	1.20	3.60	1.10	3.30
Ribes aureum	6	15	1.30	3.90	1.25	3.75
Ribes aureum	6	16	1.35	4.05	1.25	3.75
Ribes aureum	6	17	1.40	4.20	1.25	3.75
Ribes aureum	6	18	1.50	4.50	1.35	4.05
Ribes aureum	6	19	1.50	4.50	1.45	4.35
Ribes aureum	6	20	1.55	4.65	1.40	4.20
Ribes aureum	6	21	1.70	5.10	1.50	4.50
Ribes aureum	6	22	1.60	4.80	1.70	5.10
Ribes aureum	6	23	2.20	6.60	1.60	4.80
Ribes aureum	6	24	1.90	5.70	2.10	6.30
Ribes aureum	6	25	2.05	6.15	2.00	6.00
Ribes aureum	6	26	2.00	6.00	1.80	5.40
Ribes aureum	6	27	2.00	6.00	1.80	5.40
Ribes aureum	6	28	2.30	6.90	2.00	6.00
Ribes aureum	6	29	2.45	7.35	2.20	6.60
Ribes aureum	6	30	2.25	6.75	2.40	7.20
Shepherdia argentea	6	west border		0.00		0.00
Shepherdia argentea	7	east border		0.00		0.00
Hippophae rhamnoides	7	1	0.75	2.25	0.50	1.50
Hippophae rhamnoides	7	2	0.75	2.25	0.55	1.65
Hippophae rhamnoides	7	3	0.75	2.25	0.55	1.65
Hippophae rhamnoides	7	4	0.75	2.25	0.55	1.65
Hippophae rhamnoides	7	5	0.75	2.25	0.60	1.80
Hippophae rhamnoides	7	6	0.80	2.40	0.70	2.10
Hippophae rhamnoides	7	7	0.80	2.40	0.70	2.10
Hippophae rhamnoides	7	8	0.85	2.55	0.70	2.10
Hippophae rhamnoides	7	9	0.90	2.70	0.80	2.40
Hippophae rhamnoides	7	10	0.95	2.85	0.95	2.85
Hippophae rhamnoides	7	11	1.05	3.15	1.00	3.00
Hippophae rhamnoides	7	12	1.15	3.45	1.00	3.00
Hippophae rhamnoides	7	13	1.15	3.45	1.10	3.30
Hippophae rhamnoides	7	14	1.20	3.60	1.10	3.30
Hippophae rhamnoides	7	15	1.25	3.75	1.05	3.15
Hippophae rhamnoides	7	16	1.15	3.45	1.10	3.30
Hippophae rhamnoides	7	17	1.10	3.30	1.05	3.15
Hippophae rhamnoides	7	18	1.20	3.60	1.10	3.30
Hippophae rhamnoides	7	19	1.25	3.75	1.20	3.60
Hippophae rhamnoides	7	20	1.30	3.90	1.25	3.75
Hippophae rhamnoides	7	21	1.45	4.35	1.30	3.90

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Hippophae rhamnoides	7	22	1.50	4.50	1.30	3.90
Hippophae rhamnoides	7	23	1.55	4.65	1.35	4.05
Hippophae rhamnoides	7	24	1.55	4.65	1.35	4.05
Hippophae rhamnoides	7	25	1.70	5.10	1.45	4.35
Hippophae rhamnoides	7	26	1.60	4.80	1.60	4.80
Hippophae rhamnoides	7	27	1.60	4.80	1.50	4.50
Hippophae rhamnoides	7	28	1.65	4.95	1.50	4.50
Hippophae rhamnoides	7	29	1.90	5.70	1.60	4.80
Hippophae rhamnoides	7	30	2.20	6.60	1.85	5.55
Shepherdia argentea	7	west border		0.00		0.00
Shepherdia argentea	8	east border		0.00		0.00
Elaeagnus angustifolia	8	1	0.75	2.25	0.60	1.80
Elaeagnus angustifolia	8	2	0.75	2.25	0.50	1.50
Elaeagnus angustifolia	8	3	0.70	2.10	0.50	1.50
Elaeagnus angustifolia	8	4	0.70	2.10	0.50	1.50
Elaeagnus angustifolia	8	5	0.70	2.10	0.50	1.50
Elaeagnus angustifolia	8	6	0.70	2.10	0.50	1.50
Elaeagnus angustifolia	8	7	0.80	2.40	0.60	1.80
Elaeagnus angustifolia	8	8	1.00	3.00	0.70	2.10
Elaeagnus angustifolia	8	9	1.10	3.30	1.15	3.45
Elaeagnus angustifolia	8	10	1.20	3.60	1.40	4.20
Elaeagnus angustifolia	8	11	1.40	4.20	1.40	4.20
Elaeagnus angustifolia	8	12	1.35	4.05	1.20	3.60
Elaeagnus angustifolia	8	13	1.30	3.90	1.30	3.90
Elaeagnus angustifolia	8	14	1.20	3.60	1.15	3.45
Elaeagnus angustifolia	8	15	1.10	3.30	1.05	3.15
Elaeagnus angustifolia	8	16	1.10	3.30	1.00	3.00
Elaeagnus angustifolia	8	17	1.10	3.30	1.15	3.45
Elaeagnus angustifolia	8	18	1.30	3.90	1.25	3.75
Elaeagnus angustifolia	8	19	1.30	3.90	1.15	3.45
Elaeagnus angustifolia	8	20	1.20	3.60	1.20	3.60
Elaeagnus angustifolia	8	21	1.25	3.75	1.15	3.45
Elaeagnus angustifolia	8	22	1.30	3.90	1.25	3.75
Elaeagnus angustifolia	8	23	1.30	3.90	1.15	3.45
Elaeagnus angustifolia	8	24	1.40	4.20	1.15	3.45
Elaeagnus angustifolia	8	25	1.60	4.80	1.20	3.60
Elaeagnus angustifolia	8	26	1.65	4.95	1.50	4.50
Elaeagnus angustifolia	8	27	1.70	5.10	1.50	4.50
Elaeagnus angustifolia	8	28	1.85	5.55	2.00	6.00
Elaeagnus angustifolia	8	29	2.40	7.20	2.25	6.75
Elaeagnus angustifolia	8	30	0.95	9.50	0.90	9.00
Shepherdia argentea	8	west border				
Shepherdia argentea	9	east border				

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Caragana arborescens	9	1	0.80	2.40	0.55	1.65
Caragana arborescens	9	2	0.75	2.25	0.60	1.80
Caragana arborescens	9	3	0.70	2.10	0.50	1.50
Caragana arborescens	9	4	0.70	2.10	0.50	1.50
Caragana arborescens	9	5	0.75	2.25	0.60	1.80
Caragana arborescens	9	6	0.85	2.55	0.75	2.25
Caragana arborescens	9	7	1.00	3.00	0.95	2.85
Caragana arborescens	9	8	1.10	3.30	0.95	2.85
Caragana arborescens	9	9	1.20	3.60	1.00	3.00
Caragana arborescens	9	10	1.10	3.30	1.10	3.30
Caragana arborescens	9	11	1.10	3.30	0.95	2.85
Caragana arborescens	9	12	1.10	3.30	0.90	2.70
Caragana arborescens	9	13	1.15	3.45	0.90	2.70
Caragana arborescens	9	14	1.05	3.15	0.90	2.70
Caragana arborescens	9	15	1.10	3.30	0.90	2.70
Caragana arborescens	9	16	1.10	3.30	0.95	2.85
Caragana arborescens	9	17	1.15	3.45	1.05	3.15
Caragana arborescens	9	18	1.25	3.75	1.10	3.30
Caragana arborescens	9	19	1.25	3.75	1.10	3.30
Caragana arborescens	9	20	1.30	3.90	1.10	3.30
Caragana arborescens	9	21	1.20	3.60	1.15	3.45
Caragana arborescens	9	22	1.25	3.75	1.10	3.30
Caragana arborescens	9	23	1.40	4.20	1.10	3.30
Caragana arborescens	9	24	1.45	4.35	1.20	3.60
Caragana arborescens	9	25	1.70	5.10	1.30	3.90
Caragana arborescens	9	26	1.55	4.65	1.50	4.50
Caragana arborescens	9	27	1.80	5.40	1.50	4.50
Caragana arborescens	9	28	1.95	5.85	1.90	5.70
Caragana arborescens	9	29	2.45	7.35	2.40	7.20
Caragana arborescens	9	30	0.85	8.50	1.00	10.00
Shepherdia argentea	9	west border				
Shepherdia argentea	10	east border				
Ulmus pumila	10	1	0.70	2.10	0.50	1.50
Ulmus pumila	10	2	0.75	2.25	0.55	1.65
Ulmus pumila	10	3	0.75	2.25	0.60	1.80
Ulmus pumila	10	4	0.80	2.40	0.70	2.10
Ulmus pumila	10	5	0.85	2.55	0.70	2.10
Ulmus pumila	10	6	0.95	2.85	0.75	2.25
Ulmus pumila	10	7	0.90	2.70	0.95	2.85
Ulmus pumila	10	8	0.90	2.70	0.90	2.70
Ulmus pumila	10	9	0.90	2.70	0.80	2.40
Ulmus pumila	10	10	1.00	3.00	0.90	2.70
Ulmus pumila	10	11	1.00	3.00	0.95	2.85

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Ulmus pumila	10	12	1.00	3.00	0.95	2.85
Ulmus pumila	10	13	1.05	3.15	0.95	2.85
Ulmus pumila	10	14	1.05	3.15	1.00	3.00
Ulmus pumila	10	15	1.10	3.30	1.00	3.00
Ulmus pumila	10	16	1.15	3.45	1.05	3.15
Ulmus pumila	10	17	1.10	3.30	1.05	3.15
Ulmus pumila	10	18	1.20	3.60	1.00	3.00
Ulmus pumila	10	19	1.30	3.90	1.10	3.30
Ulmus pumila	10	20	1.30	3.90	1.15	3.45
Ulmus pumila	10	21	1.40	4.20	1.25	3.75
Ulmus pumila	10	22	1.40	4.20	1.25	3.75
Ulmus pumila	10	23	1.40	4.20	1.25	3.75
Ulmus pumila	10	24	1.40	4.20	1.20	3.60
Ulmus pumila	10	25	1.60	4.80	1.35	4.05
Ulmus pumila	10	26	1.70	5.10	1.55	4.65
Ulmus pumila	10	27	1.80	5.40	2.00	6.00
Ulmus pumila	10	28	2.40	7.20	2.20	6.60
Ulmus pumila	10	29	1.95	5.85	2.85	8.55
Ulmus pumila	10	30	2.65	7.95	2.75	8.25
Shepherdia argentea	10	west border		0.00		0.00
Shepherdia argentea	11	east border		0.00		0.00
Pinus ponderosa	11	1	0.75	2.25	0.60	1.80
Pinus ponderosa	11	2	0.80	2.40	0.60	1.80
Pinus ponderosa	11	3	0.80	2.40	0.60	1.80
Pinus ponderosa	11	4	0.80	2.40	0.60	1.80
Pinus ponderosa	11	5	0.75	2.25	0.60	1.80
Pinus ponderosa	11	6	0.80	2.40	0.60	1.80
Pinus ponderosa	11	7	0.85	2.55	0.65	1.95
Pinus ponderosa	11	8	0.90	2.70	0.75	2.25
Pinus ponderosa	11	9	0.90	2.70	0.75	2.25
Pinus ponderosa	11	10	0.90	2.70	0.75	2.25
Pinus ponderosa	11	11	0.95	2.85	0.80	2.40
Pinus ponderosa	11	12	0.90	2.70	0.80	2.40
Pinus ponderosa	11	13	1.00	3.00	0.85	2.55
Pinus ponderosa	11	14	1.00	3.00	0.85	2.55
Pinus ponderosa	11	15	1.00	3.00	0.85	2.55
Pinus ponderosa	11	16	1.10	3.30	0.95	2.85
Pinus ponderosa	11	17	1.10	3.30	1.00	3.00
Pinus ponderosa	11	18	1.20	3.60	1.05	3.15
Pinus ponderosa	11	19	1.30	3.90	1.10	3.30
Pinus ponderosa	11	20	1.40	4.20	1.15	3.45
Pinus ponderosa	11	21	1.40	4.20	1.25	3.75
Pinus ponderosa	11	22	1.40	4.20	1.25	3.75

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Pinus ponderosa	11	23	1.45	4.35	1.20	3.60
Pinus ponderosa	11	24	1.55	4.65	1.30	3.90
Pinus ponderosa	11	25	1.55	4.65	1.50	4.50
Pinus ponderosa	11	26	1.65	4.95	1.50	4.50
Pinus ponderosa	11	27	1.60	4.80	1.55	4.65
Pinus ponderosa	11	28	1.70	5.10	1.50	4.50
Pinus ponderosa	11	29	1.60	4.80	1.50	4.50
Pinus ponderosa	11	30	1.70	5.10	1.55	4.65
Shepherdia argentea	11	west border		0.00		0.00
Shepherdia argentea	12	east border		0.00		0.00
Symphoricarpos sp.	12	1	0.80	2.40	0.70	2.10
Symphoricarpos sp.	12	2	0.85	2.55	0.65	1.95
Symphoricarpos sp.	12	3	0.80	2.40	0.60	1.80
Symphoricarpos sp.	12	4	0.75	2.25	0.60	1.80
Symphoricarpos sp.	12	5	0.75	2.25	0.55	1.65
Symphoricarpos sp.	12	6	0.70	2.10	0.50	1.50
Symphoricarpos sp.	12	7	0.75	2.25	0.50	1.50
Symphoricarpos sp.	12	8	0.75	2.25	0.60	1.80
Symphoricarpos sp.	12	9	0.75	2.25	0.55	1.65
Symphoricarpos sp.	12	10	0.80	2.40	0.65	1.95
Symphoricarpos sp.	12	11	0.90	2.70	0.70	2.10
Symphoricarpos sp.	12	12	0.90	2.70	0.85	2.55
Symphoricarpos sp.	12	13	0.95	2.85	0.85	2.55
Symphoricarpos sp.	12	14	1.00	3.00	0.80	2.40
Symphoricarpos sp.	12	15	1.10	3.30	1.00	3.00
Symphoricarpos sp.	12	16	1.20	3.60	1.05	3.15
Symphoricarpos sp.	12	17	1.30	3.90	1.10	3.30
Symphoricarpos sp.	12	18	1.30	3.90	1.20	3.60
Symphoricarpos sp.	12	19	1.40	4.20	1.20	3.60
Symphoricarpos sp.	12	20	1.35	4.05	1.20	3.60
Symphoricarpos sp.	12	21	1.45	4.35	1.25	3.75
Symphoricarpos sp.	12	22	1.40	4.20	1.25	3.75
Symphoricarpos sp.	12	23	1.45	4.35	1.25	3.75
Symphoricarpos sp.	12	24	1.45	4.35	1.30	3.90
Symphoricarpos sp.	12	25	1.50	4.50	1.30	3.90
Symphoricarpos sp.	12	26	1.55	4.65	1.40	4.20
Symphoricarpos sp.	12	27	1.45	4.35	1.50	4.50
Symphoricarpos sp.	12	28	1.60	4.80	1.50	4.50
Symphoricarpos sp.	12	29	1.50	4.50	1.40	4.20
Symphoricarpos sp.	12	30	1.65	4.95	1.50	4.50
Shepherdia argentea	12	west border		0.00		0.00
Shepherdia argentea	13	east border		0.00		0.00
Fraxinus pennsylvanica	13	1	1.00	3.00	0.95	2.85

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Fraxinus pennsylvanica	13	2	0.90	2.70	0.70	2.10
Fraxinus pennsylvanica	13	3	0.75	2.25	0.60	1.80
Fraxinus pennsylvanica	13	4	0.80	2.40	0.55	1.65
Fraxinus pennsylvanica	13	5	0.75	2.25	0.60	1.80
Fraxinus pennsylvanica	13	6	0.70	2.10	0.50	1.50
Fraxinus pennsylvanica	13	7	0.70	2.10	0.55	1.65
Fraxinus pennsylvanica	13	8	0.75	2.25	0.60	1.80
Fraxinus pennsylvanica	13	9	0.80	2.40	0.60	1.80
Fraxinus pennsylvanica	13	10	0.90	2.70	0.70	2.10
Fraxinus pennsylvanica	13	11	0.90	2.70	0.85	2.55
Fraxinus pennsylvanica	13	12	1.00	3.00	0.90	2.70
Fraxinus pennsylvanica	13	13	1.05	3.15	0.90	2.70
Fraxinus pennsylvanica	13	14	1.10	3.30	0.90	2.70
Fraxinus pennsylvanica	13	15	1.10	3.30	1.05	3.15
Fraxinus pennsylvanica	13	16	1.20	3.60	1.05	3.15
Fraxinus pennsylvanica	13	17	1.20	3.60	1.10	3.30
Fraxinus pennsylvanica	13	18	1.25	3.75	1.10	3.30
Fraxinus pennsylvanica	13	19	1.30	3.90	1.15	3.45
Fraxinus pennsylvanica	13	20	1.30	3.90	1.20	3.60
Fraxinus pennsylvanica	13	21	1.30	3.90	1.20	3.60
Fraxinus pennsylvanica	13	22	1.25	3.75	1.20	3.60
Fraxinus pennsylvanica	13	23	1.30	3.90	1.10	3.30
Fraxinus pennsylvanica	13	24	1.25	3.75	1.10	3.30
Fraxinus pennsylvanica	13	25	1.30	3.90	1.10	3.30
Fraxinus pennsylvanica	13	26	1.30	3.90	1.20	3.60
Fraxinus pennsylvanica	13	27	1.35	4.05	1.25	3.75
Fraxinus pennsylvanica	13	28	1.45	4.35	1.35	4.05
Fraxinus pennsylvanica	13	29	1.60	4.80	1.40	4.20
Fraxinus pennsylvanica	13	30	1.65	4.95	1.50	4.50
Shepherdia argentea	13	west border		0.00		0.00
Shepherdia argentea	14	east border		0.00		0.00
Prunus americana	14	1	1.15	3.45	1.05	3.15
Prunus americana	14	2	0.90	2.70	1.00	3.00
Prunus americana	14	3	0.85	2.55	0.80	2.40
Prunus americana	14	4	0.85	2.55	0.65	1.95
Prunus americana	14	5	0.85	2.55	0.65	1.95
Prunus americana	14	6	0.75	2.25	0.60	1.80
Prunus americana	14	7	0.80	2.40	0.60	1.80
Prunus americana	14	8	0.80	2.40	0.65	1.95
Prunus americana	14	9	0.80	2.40	0.55	1.65
Prunus americana	14	10	0.80	2.40	0.65	1.95
Prunus americana	14	11	0.80	2.40	0.70	2.10
Prunus americana	14	12	0.90	2.70	0.75	2.25

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Prunus americana	14	13	1.00	3.00	0.85	2.55
Prunus americana	14	14	1.10	3.30	1.00	3.00
Prunus americana	14	15	1.10	3.30	1.00	3.00
Prunus americana	14	16	1.15	3.45	1.00	3.00
Prunus americana	14	17	1.10	3.30	1.00	3.00
Prunus americana	14	18	1.20	3.60	1.00	3.00
Prunus americana	14	19	1.10	3.30	1.00	3.00
Prunus americana	14	20	1.15	3.45	0.90	2.70
Prunus americana	14	21	1.00	3.00	0.90	2.70
Prunus americana	14	22	1.10	3.30	0.85	2.55
Prunus americana	14	23	1.10	3.30	0.95	2.85
Prunus americana	14	24	1.30	3.90	1.00	3.00
Prunus americana	14	25	1.30	3.90	1.20	3.60
Prunus americana	14	26	1.55	4.65	1.30	3.90
Prunus americana	14	27	1.60	4.80	1.35	4.05
Prunus americana	14	28	1.60	4.80	1.45	4.35
Prunus americana	14	29	1.80	5.40	1.55	4.65
Prunus americana	14	30	2.20	6.60	1.70	5.10
Shepherdia argentea	14	west border		0.00		0.00
Shepherdia argentea	15	east border		0.00		0.00
Prunus besseyi	15	1	1.20	3.60	1.10	3.30
Prunus besseyi	15	2	1.00	3.00	0.90	2.70
Prunus besseyi	15	3	0.95	2.85	0.80	2.40
Prunus besseyi	15	4	0.90	2.70	0.70	2.10
Prunus besseyi	15	5	0.85	2.55	0.65	1.95
Prunus besseyi	15	6	0.80	2.40	0.65	1.95
Prunus besseyi	15	7	0.80	2.40	0.70	2.10
Prunus besseyi	15	8	0.80	2.40	0.60	1.80
Prunus besseyi	15	9	0.75	2.25	0.60	1.80
Prunus besseyi	15	10	0.80	2.40	0.60	1.80
Prunus besseyi	15	11	0.80	2.40	0.70	2.10
Prunus besseyi	15	12	0.90	2.70	0.80	2.40
Prunus besseyi	15	13	0.90	2.70	0.80	2.40
Prunus besseyi	15	14	0.95	2.85	0.75	2.25
Prunus besseyi	15	15	1.00	3.00	0.85	2.55
Prunus besseyi	15	16	1.00	3.00	0.85	2.55
Prunus besseyi	15	17	1.00	3.00	0.80	2.40
Prunus besseyi	15	18	1.00	3.00	0.80	2.40
Prunus besseyi	15	19	1.05	3.15	0.80	2.40
Prunus besseyi	15	20	1.10	3.30	0.80	2.40
Prunus besseyi	15	21	1.10	3.30	1.00	3.00
Prunus besseyi	15	22	1.20	3.60	1.10	3.30
Prunus besseyi	15	23	1.20	3.60	1.20	3.60

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Prunus besseyi	15	24	1.35	4.05	1.20	3.60
Prunus besseyi	15	25	1.40	4.20	1.30	3.90
Prunus besseyi	15	26	1.60	4.80	1.50	4.50
Prunus besseyi	15	27	1.70	5.10	1.70	5.10
Prunus besseyi	15	28	1.95	5.85	1.75	5.25
Prunus besseyi	15	29	2.15	6.45	1.75	5.25
Prunus besseyi	15	30	2.20	6.60	1.75	5.25
Shepherdia argentea	15	west border		0.00		0.00
Shepherdia argentea	16	east border		0.00		0.00
Rhus trilobata	16	1	1.10	3.30	0.90	2.70
Rhus trilobata	16	2	1.00	3.00	0.75	2.25
Rhus trilobata	16	3	0.90	2.70	0.70	2.10
Rhus trilobata	16	4	0.90	2.70	0.70	2.10
Rhus trilobata	16	5	0.85	2.55	0.75	2.25
Rhus trilobata	16	6	0.90	2.70	0.70	2.10
Rhus trilobata	16	7	0.90	2.70	0.70	2.10
Rhus trilobata	16	8	0.80	2.40	0.60	1.80
Rhus trilobata	16	9	0.80	2.40	0.60	1.80
Rhus trilobata	16	10	0.80	2.40	0.60	1.80
Rhus trilobata	16	11	0.80	2.40	0.60	1.80
Rhus trilobata	16	12	0.85	2.55	0.65	1.95
Rhus trilobata	16	13	0.85	2.55	0.65	1.95
Rhus trilobata	16	14	0.85	2.55	0.65	1.95
Rhus trilobata	16	15	0.90	2.70	0.70	2.10
Rhus trilobata	16	16	1.00	3.00	0.85	2.55
Rhus trilobata	16	17	1.00	3.00	0.85	2.55
Rhus trilobata	16	18	1.05	3.15	0.90	2.70
Rhus trilobata	16	19	1.20	3.60	1.15	3.45
Rhus trilobata	16	20	1.35	4.05	1.30	3.90
Rhus trilobata	16	21	1.30	3.90	1.20	3.60
Rhus trilobata	16	22	1.45	4.35	1.20	3.60
Rhus trilobata	16	23	1.50	4.50	1.40	4.20
Rhus trilobata	16	24	1.60	4.80	1.50	4.50
Rhus trilobata	16	25	1.60	4.80	1.50	4.50
Rhus trilobata	16	26	1.70	5.10	1.50	4.50
Rhus trilobata	16	27	1.95	5.85	1.65	4.95
Rhus trilobata	16	28	1.90	5.70	1.80	5.40
Rhus trilobata	16	29	1.90	5.70	1.70	5.10
Rhus trilobata	16	30	2.00	6.00	1.65	4.95
Shepherdia argentea	16	west border		0.00		0.00
Shepherdia argentea	17	east border		0.00		0.00
Prunus tomentosa	17	1	1.15	3.45	1.10	3.30
Prunus tomentosa	17	2	1.10	3.30	1.00	3.00

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Prunus tomentosa	17	3	1.00	3.00	0.90	2.70
Prunus tomentosa	17	4	0.90	2.70	0.85	2.55
Prunus tomentosa	17	5	0.90	2.70	0.75	2.25
Prunus tomentosa	17	6	0.85	2.55	0.75	2.25
Prunus tomentosa	17	7	0.85	2.55	0.70	2.10
Prunus tomentosa	17	8	0.90	2.70	0.75	2.25
Prunus tomentosa	17	9	0.90	2.70	0.65	1.95
Prunus tomentosa	17	10	0.85	2.55	0.65	1.95
Prunus tomentosa	17	11	0.90	2.70	0.75	2.25
Prunus tomentosa	17	12	1.00	3.00	0.80	2.40
Prunus tomentosa	17	13	1.00	3.00	0.80	2.40
Prunus tomentosa	17	14	1.00	3.00	0.85	2.55
Prunus tomentosa	17	15	1.00	3.00	0.85	2.55
Prunus tomentosa	17	16	1.15	3.45	0.85	2.55
Prunus tomentosa	17	17	1.20	3.60	0.90	2.70
Prunus tomentosa	17	18	1.25	3.75	1.10	3.30
Prunus tomentosa	17	19	1.35	4.05	1.25	3.75
Prunus tomentosa	17	20	1.40	4.20	1.25	3.75
Prunus tomentosa	17	21	1.35	4.05	1.20	3.60
Prunus tomentosa	17	22	1.40	4.20	1.30	3.90
Prunus tomentosa	17	23	1.45	4.35	1.25	3.75
Prunus tomentosa	17	24	1.40	4.20	1.25	3.75
Prunus tomentosa	17	25	1.50	4.50	1.35	4.05
Prunus tomentosa	17	26	1.60	4.80	1.30	3.90
Prunus tomentosa	17	27	1.70	5.10	1.40	4.20
Prunus tomentosa	17	28	1.65	4.95	1.50	4.50
Prunus tomentosa	17	29	1.60	4.80	1.40	4.20
Prunus tomentosa	17	30	1.50	4.50	1.30	3.90
Shepherdia argentea	17	west border		0.00		0.00
Shepherdia argentea	18	east border		0.00		0.00
Populus deltoides	18	1	1.10	3.30	1.05	3.15
Populus deltoides	18	2	1.00	3.00	0.90	2.70
Populus deltoides	18	3	0.90	2.70	0.75	2.25
Populus deltoides	18	4	0.80	2.40	0.75	2.25
Populus deltoides	18	5	0.85	2.55	0.75	2.25
Populus deltoides	18	6	0.80	2.40	0.75	2.25
Populus deltoides	18	7	0.80	2.40	0.75	2.25
Populus deltoides	18	8	0.90	2.70	0.75	2.25
Populus deltoides	18	9	0.90	2.70	0.80	2.40
Populus deltoides	18	10	1.00	3.00	0.85	2.55
Populus deltoides	18	11	1.00	3.00	0.85	2.55
Populus deltoides	18	12	0.95	2.85	0.90	2.70
Populus deltoides	18	13	1.10	3.30	0.90	2.70

Appendix 4. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2007, Bridger, MT.

Species	Row No.	Row Position	2007 EM-38 w/ SVF (0-1 meter) vertical	Actual EC Value w/ SVF (0-1 meter) vertical	2007 EM-38 w/ SVF (0-2 meter) horizontal	Actual EC Value w/SVF (0-2 meter) horizontal
Populus deltoides	18	14	1.05	3.15	0.90	2.70
Populus deltoides	18	15	1.10	3.30	0.90	2.70
Populus deltoides	18	16	1.15	3.45	1.00	3.00
Populus deltoides	18	17	1.15	3.45	1.00	3.00
Populus deltoides	18	18	1.20	3.60	1.05	3.15
Populus deltoides	18	19	1.20	3.60	0.95	2.85
Populus deltoides	18	20	1.10	3.30	0.90	2.70
Populus deltoides	18	21	1.10	3.30	0.85	2.55
Populus deltoides	18	22	1.10	3.30	0.85	2.55
Populus deltoides	18	23	1.15	3.45	0.85	2.55
Populus deltoides	18	24	1.20	3.60	0.80	2.40
Populus deltoides	18	25	1.25	3.75	0.90	2.70
Populus deltoides	18	26	1.30	3.90	1.00	3.00
Populus deltoides	18	27	1.40	4.20	1.05	3.15
Populus deltoides	18	28	1.40	4.20	1.10	3.30
Populus deltoides	18	29	1.25	3.75	1.10	3.30
Populus deltoides	18	30	1.25	3.75	0.90	2.70
Shepherdia argentea	18	west border				

North end of plot

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
south end of plot						
Shepherdia argentea	1	east border				
Shepherdia argentea	1	1	1	28.0	7	deer damage, most severe
Shepherdia argentea	1	2	1	37.5	6	deer damage, most severe
Shepherdia argentea	1	3	1	47.0	7	deer damage, most severe
Shepherdia argentea	1	4	1	32.0	6	deer damage, most severe
Shepherdia argentea	1	5	1	28.0	6	deer damage
Shepherdia argentea	1	6	1	29.0	6	deer damage
Shepherdia argentea	1	7	1	76.5	4	deer damage
Shepherdia argentea	1	8	1	51.0	5	deer damage
Shepherdia argentea	1	9	1	46.0	5	deer damage
Shepherdia argentea	1	10	1	47.5	6	deer damage
Shepherdia argentea	1	11	1	60.0	5	deer damage
Shepherdia argentea	1	12	1	70.0	5	deer damage
Shepherdia argentea	1	13	1	89.0	3	
Shepherdia argentea	1	14	1	110.0	2	
Shepherdia argentea	1	15	0			dead
Shepherdia argentea	1	16	0			
Shepherdia argentea	1	17	0			
Shepherdia argentea	1	18	0			
Shepherdia argentea	1	19	0			
Shepherdia argentea	1	20	0			
Shepherdia argentea	1	21	0			
Shepherdia argentea	1	22	0			
Shepherdia argentea	1	23	1	88.0	3	
Shepherdia argentea	1	24	0			
Shepherdia argentea	1	25	1	94.0	3	
Shepherdia argentea	1	26	0			
Shepherdia argentea	1	27	1	81.5	3	
Shepherdia argentea	1	28	1	80.0	4	
Shepherdia argentea	1	29	0			
Shepherdia argentea	1	30	0			
Shepherdia argentea	1	west border				
Shepherdia argentea	2	east border				
Prunus virginiana	2	1	0			dead; deer?
Prunus virginiana	2	2	0			dead; deer?
Prunus virginiana	2	3	0			dead; deer?
Prunus virginiana	2	4	1	50.0	6	severe deer browse
Prunus virginiana	2	5	1	48.0	6	severe deer browse
Prunus virginiana	2	6	1	36.0	6	severe deer browse
Prunus virginiana	2	7	0			dead
Prunus virginiana	2	8	1	61.0	7	deer
Prunus virginiana	2	9	1	62.0	6	deer
Prunus virginiana	2	10	1	62.0	6	deer

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus virginiana	2	11	1	41.0	7	severe deer browse
Prunus virginiana	2	12	1	63.0	6	deer
Prunus virginiana	2	13	1	63.0	5	deer
Prunus virginiana	2	14	0			dead
Prunus virginiana	2	15	0			dead
Prunus virginiana	2	16	0			dead
Prunus virginiana	2	17	0			dead
Prunus virginiana	2	18	0			dead
Prunus virginiana	2	19	0			dead
Prunus virginiana	2	20	0			dead
Prunus virginiana	2	21	0			dead
Prunus virginiana	2	22	0			dead
Prunus virginiana	2	23	0			dead
Prunus virginiana	2	24	0			dead
Prunus virginiana	2	25	0			dead
Prunus virginiana	2	26	0			dead
Prunus virginiana	2	27	0			dead
Prunus virginiana	2	28	0			dead
Prunus virginiana	2	29	0			dead
Prunus virginiana	2	30	0			dead
Shepherdia argentea	2	west border				
Shepherdia argentea	3	east border				
Picea pungens	3	1	0			dead
Picea pungens	3	2	0			dead
Picea pungens	3	3	0			dead
Picea pungens	3	4	0			dead
Picea pungens	3	5	0			dead
Picea pungens	3	6	0			dead
Picea pungens	3	7	0			dead
Picea pungens	3	8	0			dead
Picea pungens	3	9	0			dead
Picea pungens	3	10	0			dead
Picea pungens	3	11	0			dead
Picea pungens	3	12	0			dead
Picea pungens	3	13	0			dead
Picea pungens	3	14	0			dead
Picea pungens	3	15	0			dead
Picea pungens	3	16	0			dead
Picea pungens	3	17	0			dead
Picea pungens	3	18	0			dead
Picea pungens	3	19	0			dead
Picea pungens	3	20	0			dead
Picea pungens	3	21	0			dead
Picea pungens	3	22	0			dead

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Picea pungens	3	23	0			dead
Picea pungens	3	24	0			dead
Picea pungens	3	25	0			dead
Picea pungens	3	26	0			dead
Picea pungens	3	27	0			dead
Picea pungens	3	28	0			dead
Picea pungens	3	29	0			dead
Picea pungens	3	30	0			dead
Shepherdia argentea	3	west border				
Shepherdia argentea	4	east border				
Lonicera korolkowii	4	1	1	86.0	4	
Lonicera korolkowii	4	2	1	165.0	1	
Lonicera korolkowii	4	3	1	116.0	2	
Lonicera korolkowii	4	4	1	121.0	2	
Lonicera korolkowii	4	5	1	140.0	2	
Lonicera korolkowii	4	6	1	116.0	2	
Lonicera korolkowii	4	7	1	129.0	2	
Lonicera korolkowii	4	8	1	175.0	1	
Lonicera korolkowii	4	9	1	93.0	3	
Lonicera korolkowii	4	10	1	115.0	4	deer?
Lonicera korolkowii	4	11	1	125.0	2	
Lonicera korolkowii	4	12	1	160.0	1	
Lonicera korolkowii	4	13	1	147.0	2	fruit
Lonicera korolkowii	4	14	1	151.0	2	fruit
Lonicera korolkowii	4	15	1	64.0	5	heavy fruit
Lonicera korolkowii	4	16	1	125.0	3	heavy fruit
Lonicera korolkowii	4	17	1	95.0	4	fruit
Lonicera korolkowii	4	18	1	73.0	5	fruit
Lonicera korolkowii	4	19	1	69.0	5	fruit
Lonicera korolkowii	4	20	1	100.0	4	fruit
Lonicera korolkowii	4	21	1	80.0	5	fruit
Lonicera korolkowii	4	22	0			dead
Lonicera korolkowii	4	23	0			dead
Lonicera korolkowii	4	24	0			dead
Lonicera korolkowii	4	25	0			dead
Lonicera korolkowii	4	26	0			dead
Lonicera korolkowii	4	27	0			dead
Lonicera korolkowii	4	28	0			dead
Lonicera korolkowii	4	29	0			dead
Lonicera korolkowii	4	30	0			dead
Shepherdia argentea	4	west border				
Shepherdia argentea	5	east border				
Elaeagnus commutata	5	1	1	75.0	4	browse
Elaeagnus commutata	5	2	1	89.0	4	browse

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Elaeagnus commutata	5	3	1	69.0	4	browse
Elaeagnus commutata	5	4	1	62.0	5	dead leader
Elaeagnus commutata	5	5	1	42.0	5	dead leader; deer browse
Elaeagnus commutata	5	6	1	116.0	2	browse
Elaeagnus commutata	5	7	1	31.0	7	
Elaeagnus commutata	5	8	1	87.0	4	
Elaeagnus commutata	5	9	1	84.0	4	browse
Elaeagnus commutata	5	10	1	69.0	4	browse
Elaeagnus commutata	5	11	1	117.0	2	light browse
Elaeagnus commutata	5	12	1	69.0	4	browse
Elaeagnus commutata	5	13	1	67.0	6	browse
Elaeagnus commutata	5	14	1	72.0	4	browse
Elaeagnus commutata	5	15	1	86.0	4	browse
Elaeagnus commutata	5	16	1	56.0	5	browse
Elaeagnus commutata	5	17	0			dead
Elaeagnus commutata	5	18	1	89.0	4	
Elaeagnus commutata	5	19	0			dead
Elaeagnus commutata	5	20	0			dead
Elaeagnus commutata	5	21	1	42.0	6	
Elaeagnus commutata	5	22	0			dead
Elaeagnus commutata	5	23	1	45.0	6	
Elaeagnus commutata	5	24	0			dead
Elaeagnus commutata	5	25	0			dead
Elaeagnus commutata	5	26	1	39.0	7	
Elaeagnus commutata	5	27	1	56.0	5	
Elaeagnus commutata	5	28	1	62.0	6	
Elaeagnus commutata	5	29	0			dead
Elaeagnus commutata	5	30	0			dead
Shepherdia argentea	5	west border				
Shepherdia argentea	6	east border				
Ribes aureum	6	1	1	56.0	6	deer injury; browse
Ribes aureum	6	2	1	86.0	6	deer injury; browse; dead leader
Ribes aureum	6	3	1	85.0	4	deer injury
Ribes aureum	6	4	1	89.0	4	light browse
Ribes aureum	6	5	1	87.0	5	deer injury; browse
Ribes aureum	6	6	1	82.0	4	browse
Ribes aureum	6	7	0			dead; deer?
Ribes aureum	6	8	1	80.0	4	
Ribes aureum	6	9	0			dead
Ribes aureum	6	10	0			dead
Ribes aureum	6	11	1	41.0	5	heavy browse
Ribes aureum	6	12	1	72.0	5	heavy browse
Ribes aureum	6	13	1	63.0	4	heavy browse
Ribes aureum	6	14	1	84.0	4	heavy browse

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Ribes aureum	6	15	1	63.0	4	heavy browse
Ribes aureum	6	16	0			dead
Ribes aureum	6	17	1	62.0	4	browse
Ribes aureum	6	18	1	53.0	4	
Ribes aureum	6	19	1	48.0	5	heavy browse
Ribes aureum	6	20	1	78.0	4	heavy browse
Ribes aureum	6	21	0			dead
Ribes aureum	6	22	0			dead
Ribes aureum	6	23	1	48.0	5	heavy browse
Ribes aureum	6	24	0			dead
Ribes aureum	6	25	0			dead
Ribes aureum	6	26	0			dead
Ribes aureum	6	27	0			dead
Ribes aureum	6	28	0			dead
Ribes aureum	6	29	0			dead
Ribes aureum	6	30	0			
Shepherdia argentea	6	west border				
Shepherdia argentea	7	east border				
Hippophae rhamnoides	7	1	1	82.0	4	deer
Hippophae rhamnoides	7	2	1	67.0	4	deer
Hippophae rhamnoides	7	3	0			dead
Hippophae rhamnoides	7	4	1	89.0	3	
Hippophae rhamnoides	7	5	1	83.0	4	browse
Hippophae rhamnoides	7	6	1	94.0	3	light browse
Hippophae rhamnoides	7	7	1	95.0	2	tip browse
Hippophae rhamnoides	7	8	1	89.0	5	
Hippophae rhamnoides	7	9	0			dead
Hippophae rhamnoides	7	10	0			dead
Hippophae rhamnoides	7	11	1	38.0	6	deer
Hippophae rhamnoides	7	12	1	75.0	4	browse
Hippophae rhamnoides	7	13	0			dead
Hippophae rhamnoides	7	14	1	55.0	5	browse
Hippophae rhamnoides	7	15	1	42.0	6	
Hippophae rhamnoides	7	16	1	52.0	5	tip browse
Hippophae rhamnoides	7	17	1	43.0	6	
Hippophae rhamnoides	7	18	1	85.0	4	tip browse
Hippophae rhamnoides	7	19	1	48.0	6	heavy browse
Hippophae rhamnoides	7	20	0			dead
Hippophae rhamnoides	7	21	1	63.0	**5**	browse
Hippophae rhamnoides	7	22	1	57.0	5	browse
Hippophae rhamnoides	7	23	0			dead
Hippophae rhamnoides	7	24	1	93.0	3	
Hippophae rhamnoides	7	25	1	51.0	6	
Hippophae rhamnoides	7	26	1	55.0	6	

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Hippophae rhamnoides	7	27	1	43.0	6	tip browse
Hippophae rhamnoides	7	28	0			dead
Hippophae rhamnoides	7	29	1	51.0	6	
Hippophae rhamnoides	7	30	0			dead
Shepherdia argentea	7	west border				
Shepherdia argentea	8	east border				
Elaeagnus angustifolia	8	1	1	250.0	1	
Elaeagnus angustifolia	8	2	1	255.0	1	
Elaeagnus angustifolia	8	3	1	265.0	1	
Elaeagnus angustifolia	8	4	1	255.0	2	old deer injury
Elaeagnus angustifolia	8	5	1	200.0	4	old deer injury
Elaeagnus angustifolia	8	6	1	275.0	2	
Elaeagnus angustifolia	8	7	1	280.0	2	
Elaeagnus angustifolia	8	8	1	255.0	4	deer?
Elaeagnus angustifolia	8	9	1	165.0	5	deer?
Elaeagnus angustifolia	8	10	1	143.0	6	deer?
Elaeagnus angustifolia	8	11	1	250.0	4	fruit
Elaeagnus angustifolia	8	12	1	205.0	4	
Elaeagnus angustifolia	8	13	1	250.0	4	fruit
Elaeagnus angustifolia	8	14	1	285.0	4	fruit
Elaeagnus angustifolia	8	15	1	250.0	4	
Elaeagnus angustifolia	8	16	1	310.0	3	fruit
Elaeagnus angustifolia	8	17	1	310.0	3	
Elaeagnus angustifolia	8	18	1	245.0	5	
Elaeagnus angustifolia	8	19	1	225.0	5	
Elaeagnus angustifolia	8	20	1	285.0	1	fruit
Elaeagnus angustifolia	8	21	1	265.0	3	
Elaeagnus angustifolia	8	22	1	290.0	2	fruit
Elaeagnus angustifolia	8	23	1	245.0	3	fruit
Elaeagnus angustifolia	8	24	1	340.0	1	fruit
Elaeagnus angustifolia	8	25	1	350.0	1	fruit
Elaeagnus angustifolia	8	26	1	295.0	2	fruit
Elaeagnus angustifolia	8	27	1	270.0	4	
Elaeagnus angustifolia	8	28	1	250.0	5	
Elaeagnus angustifolia	8	29	0			dead
Elaeagnus angustifolia	8	30	0			dead
Shepherdia argentea	8	west border				
Shepherdia argentea	9	east border				
Caragana arborescens	9	1	1	77.0	5	
Caragana arborescens	9	2	0			
Caragana arborescens	9	3	1	85.0	4	
Caragana arborescens	9	4	1	68.0	4	
Caragana arborescens	9	5	1	72.0	4	
Caragana arborescens	9	6	0			

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Caragana arborescens	9	7	1	64.0	5	
Caragana arborescens	9	8	0			
Caragana arborescens	9	9	1	61.0	5	
Caragana arborescens	9	10	0			
Caragana arborescens	9	11	1	53.0	5	
Caragana arborescens	9	12	0			
Caragana arborescens	9	13	1	49.0	6	deer
Caragana arborescens	9	14	0			
Caragana arborescens	9	15	0			
Caragana arborescens	9	16	1	93.0	3	
Caragana arborescens	9	17	1	70.0	5	
Caragana arborescens	9	18	1	66.0	6	deer
Caragana arborescens	9	19	1	48.0	6	
Caragana arborescens	9	20	1	52.0	5	deer
Caragana arborescens	9	21	1	60.0	6	deer
Caragana arborescens	9	22	1	48.0	5	
Caragana arborescens	9	23	1	41.0	6	deer; leader dead
Caragana arborescens	9	24	1	84.0	3	
Caragana arborescens	9	25	0			
Caragana arborescens	9	26	1	44.0	6	
Caragana arborescens	9	27	1	77.0	5	
Caragana arborescens	9	28	0			
Caragana arborescens	9	29	0			
Caragana arborescens	9	30	0			
Shepherdia argentea	9	west border				
Shepherdia argentea	10	east border				
Ulmus pumila	10	1	1	111.0	5	
Ulmus pumila	10	2	1	76.0	7	
Ulmus pumila	10	3	1	90.0	6	
Ulmus pumila	10	4	1	79.0	6	
Ulmus pumila	10	5	1	53.0	7	
Ulmus pumila	10	6	1	79.0	7	
Ulmus pumila	10	7	1	50.0	7	
Ulmus pumila	10	8	1	70.0	7	
Ulmus pumila	10	9	1	76.0	7	
Ulmus pumila	10	10	1	82.0	6	
Ulmus pumila	10	11	1	84.0	6	
Ulmus pumila	10	12	1	89.0	6	
Ulmus pumila	10	13	1	56.0	6	
Ulmus pumila	10	14	1	76.0	6	
Ulmus pumila	10	15	1	79.0	6	
Ulmus pumila	10	16	1	79.0	7	
Ulmus pumila	10	17	1	76.0	7	
Ulmus pumila	10	18	1	65.0	7	

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Ulmus pumila	10	19	1	43.0	7	
Ulmus pumila	10	20	1	82.0	6	
Ulmus pumila	10	21	1	65.0	6	
Ulmus pumila	10	22	1	86.0	6	
Ulmus pumila	10	23	1	95.0	6	
Ulmus pumila	10	24	1	56.0	6	
Ulmus pumila	10	25	1	88.0	5	
Ulmus pumila	10	26	0			
Ulmus pumila	10	27	0			
Ulmus pumila	10	28	0			
Ulmus pumila	10	29	0			
Ulmus pumila	10	30	0			
Shepherdia argentea	10	west border				
Shepherdia argentea	11	east border				
Pinus ponderosa	11	1	1	33.0	8	
Pinus ponderosa	11	2	0			
Pinus ponderosa	11	3	0			
Pinus ponderosa	11	4	1	33.0	8	
Pinus ponderosa	11	5	0			
Pinus ponderosa	11	6	1	72.0	4	
Pinus ponderosa	11	7	0			
Pinus ponderosa	11	8	0			
Pinus ponderosa	11	9	0			
Pinus ponderosa	11	10	0			
Pinus ponderosa	11	11	0			
Pinus ponderosa	11	12	0			
Pinus ponderosa	11	13	0			
Pinus ponderosa	11	14	0			
Pinus ponderosa	11	15	0			
Pinus ponderosa	11	16	0			
Pinus ponderosa	11	17	0			
Pinus ponderosa	11	18	0			
Pinus ponderosa	11	19	0			
Pinus ponderosa	11	20	0			
Pinus ponderosa	11	21	0			
Pinus ponderosa	11	22	0			
Pinus ponderosa	11	23	0			
Pinus ponderosa	11	24	0			
Pinus ponderosa	11	25	0			
Pinus ponderosa	11	26	0			
Pinus ponderosa	11	27	0			
Pinus ponderosa	11	28	0			
Pinus ponderosa	11	29	0			
Pinus ponderosa	11	30	0			

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Shepherdia argentea	11	west border				
Shepherdia argentea	12	east border				
Symphoricarpos sp.	12	1	0			
Symphoricarpos sp.	12	2	1	62.0	5	
Symphoricarpos sp.	12	3	1	72.0	5	
Symphoricarpos sp.	12	4	0			
Symphoricarpos sp.	12	5	1	60.0	5	
Symphoricarpos sp.	12	6	1	31.0	7	
Symphoricarpos sp.	12	7	0			
Symphoricarpos sp.	12	8	1	39.0	6	
Symphoricarpos sp.	12	9	1	40.0	8	
Symphoricarpos sp.	12	10	1	52.0	5	
Symphoricarpos sp.	12	11	1	51.0	8	
Symphoricarpos sp.	12	12	1	33.0	8	
Symphoricarpos sp.	12	13	1	45.0	5	
Symphoricarpos sp.	12	14	1	56.0	5	
Symphoricarpos sp.	12	15	1	51.0	5	deer
Symphoricarpos sp.	12	16	1	58.0	7	
Symphoricarpos sp.	12	17	1	22.0	8	
Symphoricarpos sp.	12	18	1	56.0	5	
Symphoricarpos sp.	12	19	1	33.0	8	
Symphoricarpos sp.	12	20	1	61.0	8	
Symphoricarpos sp.	12	21	1	43.0	6	
Symphoricarpos sp.	12	22	0			
Symphoricarpos sp.	12	23	1	46.0	7	
Symphoricarpos sp.	12	24	0			
Symphoricarpos sp.	12	25	1	55.0	6	
Symphoricarpos sp.	12	26	0			
Symphoricarpos sp.	12	27	0			
Symphoricarpos sp.	12	28	1	43.0	7	
Symphoricarpos sp.	12	29	0			
Symphoricarpos sp.	12	30	1	56.0	7	
Shepherdia argentea	12	west border				
Shepherdia argentea	13	east border				
Fraxinus pennsylvanica	13	1	1	115.0	5	
Fraxinus pennsylvanica	13	2	1	156.0	4	
Fraxinus pennsylvanica	13	3	1	120.0	5	
Fraxinus pennsylvanica	13	4	1	85.0	7	
Fraxinus pennsylvanica	13	5	1	79.0	8	
Fraxinus pennsylvanica	13	6	1	120.0	8	
Fraxinus pennsylvanica	13	7	1	60.0	6	
Fraxinus pennsylvanica	13	8	1	85.0	6	
Fraxinus pennsylvanica	13	9	1	69.0	**8**	
Fraxinus pennsylvanica	13	10	1	56.0	8	

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Fraxinus pennsylvanica	13	11	1	50.0	6	
Fraxinus pennsylvanica	13	12	1	66.0	**6**	
Fraxinus pennsylvanica	13	13	1	90.0	5	
Fraxinus pennsylvanica	13	14	1	94.0	8	
Fraxinus pennsylvanica	13	15	1	86.0	8	
Fraxinus pennsylvanica	13	16	1	71.0	8	
Fraxinus pennsylvanica	13	17	0			
Fraxinus pennsylvanica	13	18	1	90.0	5	
Fraxinus pennsylvanica	13	19	1	84.0	6	
Fraxinus pennsylvanica	13	20	1	85.0	5	
Fraxinus pennsylvanica	13	21	1	75.0	5	
Fraxinus pennsylvanica	13	22	1	92.0	8	
Fraxinus pennsylvanica	13	23	1	110.0	4	
Fraxinus pennsylvanica	13	24	1	65.0	5	
Fraxinus pennsylvanica	13	25	1	95.0	5	
Fraxinus pennsylvanica	13	26	1	112.0	7	
Fraxinus pennsylvanica	13	27	1	86.0	5	
Fraxinus pennsylvanica	13	28	1	61.0	5	
Fraxinus pennsylvanica	13	29	0			
Fraxinus pennsylvanica	13	30	1	48.0	7	
Shepherdia argentea	13	west border				
Shepherdia argentea	14	east border				
Prunus americana	14	1	0			
Prunus americana	14	2	0			
Prunus americana	14	3	1	69.0	6	
Prunus americana	14	4	0			
Prunus americana	14	5	1	52.0	8	
Prunus americana	14	6	0			
Prunus americana	14	7	0			
Prunus americana	14	8	1	74.0	4	
Prunus americana	14	9	1	23.0	8	
Prunus americana	14	10	0			
Prunus americana	14	11	1	49.0	6	
Prunus americana	14	12	0			
Prunus americana	14	13	0			
Prunus americana	14	14	0			
Prunus americana	14	15	1	70.0	7	
Prunus americana	14	16	0			
Prunus americana	14	17	0			
Prunus americana	14	18	0			
Prunus americana	14	19	0			
Prunus americana	14	20	1	79.0	4	
Prunus americana	14	21	0			
Prunus americana	14	22	1	39.0	9	

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus americana	14	23	1	38.0	9	
Prunus americana	14	24	1	88.0	8	
Prunus americana	14	25	0			
Prunus americana	14	26	0			
Prunus americana	14	27	0			
Prunus americana	14	28	0			
Prunus americana	14	29	0			
Prunus americana	14	30	0			
Shepherdia argentea	14	west border				
Shepherdia argentea	15	east border				
Prunus besseyi	15	1	0			
Prunus besseyi	15	2	1	27.0	8	
Prunus besseyi	15	3	0			
Prunus besseyi	15	4	0			
Prunus besseyi	15	5	1	62.0	7	
Prunus besseyi	15	6	1	65.0	6	
Prunus besseyi	15	7	1	17.0	8	
Prunus besseyi	15	8	1	42.0	8	
Prunus besseyi	15	9	1	21.0	8	
Prunus besseyi	15	10	0			
Prunus besseyi	15	11	1	31.0	8	
Prunus besseyi	15	12	0			
Prunus besseyi	15	13	1	38.0	8	
Prunus besseyi	15	14	0			
Prunus besseyi	15	15	0			
Prunus besseyi	15	16	0			
Prunus besseyi	15	17	0			
Prunus besseyi	15	18	0			
Prunus besseyi	15	19	0			
Prunus besseyi	15	20	0			
Prunus besseyi	15	21	0			
Prunus besseyi	15	22	0			
Prunus besseyi	15	23	0			
Prunus besseyi	15	24	0			
Prunus besseyi	15	25	0			
Prunus besseyi	15	26	0			
Prunus besseyi	15	27	0			
Prunus besseyi	15	28	0			
Prunus besseyi	15	29	0			
Prunus besseyi	15	30	0			
Shepherdia argentea	15	west border				
Shepherdia argentea	16	east border				
Rhus trilobata	16	1	1	58.0	5	
Rhus trilobata	16	2	0			

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Rhus trilobata	16	3	0			
Rhus trilobata	16	4	1	95.0	4	
Rhus trilobata	16	5	1	64.0	5	
Rhus trilobata	16	6	1	28.0	6	
Rhus trilobata	16	7	1	67.0	5	
Rhus trilobata	16	8	1	69.0	5	
Rhus trilobata	16	9	1	97.0	4	
Rhus trilobata	16	10	1	128.0	3	
Rhus trilobata	16	11	1	100.0	4	
Rhus trilobata	16	12	1	81.0	4	
Rhus trilobata	16	13	1	75.0	5	
Rhus trilobata	16	14	1	90.0	4	
Rhus trilobata	16	15	1	80.0	6	
Rhus trilobata	16	16	1	84.0	5	
Rhus trilobata	16	17	1	96.0	4	
Rhus trilobata	16	18	1	30.0	5	
Rhus trilobata	16	19	0			
Rhus trilobata	16	20	0			
Rhus trilobata	16	21	1	97.0	4	
Rhus trilobata	16	22	1	88.0	4	
Rhus trilobata	16	23	1	48.0	5	
Rhus trilobata	16	24	1	16.0	8	
Rhus trilobata	16	25	0			
Rhus trilobata	16	26	0			
Rhus trilobata	16	27	0			
Rhus trilobata	16	28	0			
Rhus trilobata	16	29	0			
Rhus trilobata	16	30	1	80.0	4	
Shepherdia argentea	16	west border				
Shepherdia argentea	17	east border				
Prunus tomentosa	17	1	0			
Prunus tomentosa	17	2	0			
Prunus tomentosa	17	3	0			
Prunus tomentosa	17	4	0			
Prunus tomentosa	17	5	0			
Prunus tomentosa	17	6	0			
Prunus tomentosa	17	7	1	44.0	8	
Prunus tomentosa	17	8	0			
Prunus tomentosa	17	9	1	57.0	7	
Prunus tomentosa	17	10	1	72.0	7	
Prunus tomentosa	17	11	1	43.0	8	
Prunus tomentosa	17	12	0			
Prunus tomentosa	17	13	0			
Prunus tomentosa	17	14	0			

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus tomentosa	17	15	0			
Prunus tomentosa	17	16	1	55.0	7	
Prunus tomentosa	17	17	0			
Prunus tomentosa	17	18	0			
Prunus tomentosa	17	19	0			
Prunus tomentosa	17	20	0			
Prunus tomentosa	17	21	0			
Prunus tomentosa	17	22	0			
Prunus tomentosa	17	23	0			
Prunus tomentosa	17	24	0			
Prunus tomentosa	17	25	0			
Prunus tomentosa	17	26	0			
Prunus tomentosa	17	27	0			
Prunus tomentosa	17	28	0			
Prunus tomentosa	17	29	0			
Prunus tomentosa	17	30	0			
Shepherdia argentea	17	west border				
Shepherdia argentea	18	east border				
Populus deltoides	18	1	1	80.0	8	
Populus deltoides	18	2	1	115.0	7	
Populus deltoides	18	3	1	141.0	6	
Populus deltoides	18	4	1	120.0	6	
Populus deltoides	18	5	1	179.0	5	
Populus deltoides	18	6	1	140.0	6	
Populus deltoides	18	7	1	160.0	6	
Populus deltoides	18	8	1	135.0	6	
Populus deltoides	18	9	1	136.0	6	
Populus deltoides	18	10	1	185.0	5	
Populus deltoides	18	11	1	166.0	6	
Populus deltoides	18	12	1	180.0	7	
Populus deltoides	18	13	1	125.0	6	
Populus deltoides	18	14	1	113.0	6	
Populus deltoides	18	15	1	140.0	6	
Populus deltoides	18	16	1	140.0	6	
Populus deltoides	18	17	1	155.0	6	
Populus deltoides	18	18	1	169.0	5	
Populus deltoides	18	19	1	193.0	5	
Populus deltoides	18	20	1	128.0	6	
Populus deltoides	18	21	1	187.0	5	
Populus deltoides	18	22	1	290.0	4	
Populus deltoides	18	23	1	115.0	5	
Populus deltoides	18	24	1	285.0	4	
Populus deltoides	18	25	1	168.0	6	
Populus deltoides	18	26	1	145.0	6	

Appendix 5. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Populus deltoides	18	27	1	165.0	6	
Populus deltoides	18	28	1	150.0	6	
Populus deltoides	18	29	1	116.0	7	
Populus deltoides	18	30	1	155.0	6	
Shepherdia argentea	18	west border				

North end of plot

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
south end of plot						
Shepherdia argentea	1	east border				
Shepherdia argentea	1	1		0.20	0.20	1000
Shepherdia argentea	1	2		0.20	0.20	
Shepherdia argentea	1	3		0.22	0.20	
Shepherdia argentea	1	4		0.22	0.20	
Shepherdia argentea	1	5		0.22	0.20	
Shepherdia argentea	1	6		0.25	0.22	
Shepherdia argentea	1	7		0.30	0.25	
Shepherdia argentea	1	8		0.32	0.30	
Shepherdia argentea	1	9		0.40	0.35	
Shepherdia argentea	1	10		0.45	0.40	
Shepherdia argentea	1	11		0.45	0.45	
Shepherdia argentea	1	12		0.52	0.45	
Shepherdia argentea	1	13		0.50	0.45	
Shepherdia argentea	1	14		0.62	0.50	
Shepherdia argentea	1	15		0.62	0.70	
Shepherdia argentea	1	16		0.74	0.85	
Shepherdia argentea	1	17		0.80	0.85	
Shepherdia argentea	1	18		0.95	0.80	
Shepherdia argentea	1	19		0.90	0.85	
Shepherdia argentea	1	20		1.00	0.80	
Shepherdia argentea	1	21		0.95	0.85	
Shepherdia argentea	1	22		1.00	0.75	
Shepherdia argentea	1	23		0.90	0.65	
Shepherdia argentea	1	24		0.80	0.65	
Shepherdia argentea	1	25		0.78	0.65	
Shepherdia argentea	1	26		0.70	0.55	
Shepherdia argentea	1	27		0.65	0.55	
Shepherdia argentea	1	28		0.70	0.60	
Shepherdia argentea	1	29		0.66	0.70	
Shepherdia argentea	1	30		0.90	0.75	
Shepherdia argentea	1	west border				
Shepherdia argentea	2	east border				
Prunus virginiana	2	1		0.20	0.15	1000.00
Prunus virginiana	2	2		0.20	0.15	
Prunus virginiana	2	3		0.20	0.15	
Prunus virginiana	2	4		0.20	0.17	
Prunus virginiana	2	5		0.22	0.15	
Prunus virginiana	2	6		0.24	0.20	
Prunus virginiana	2	7		0.22	0.18	
Prunus virginiana	2	8		0.25	0.20	
Prunus virginiana	2	9		0.29	0.22	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Prunus virginiana	2	10		0.29	0.22	
Prunus virginiana	2	11		0.29	0.25	
Prunus virginiana	2	12		0.30	0.25	
Prunus virginiana	2	13		0.38	0.25	
Prunus virginiana	2	14		0.45	0.30	
Prunus virginiana	2	15		0.51	0.45	
Prunus virginiana	2	16		0.71	0.55	
Prunus virginiana	2	17		0.72	0.60	
Prunus virginiana	2	18		0.69	0.50	
Prunus virginiana	2	19		0.65	0.45	
Prunus virginiana	2	20		0.61	0.44	
Prunus virginiana	2	21		0.60	0.46	
Prunus virginiana	2	22		0.61	0.45	
Prunus virginiana	2	23		0.65	0.43	
Prunus virginiana	2	24		0.62	0.48	
Prunus virginiana	2	25		0.64	0.52	
Prunus virginiana	2	26		0.72	0.50	
Prunus virginiana	2	27		0.72	0.55	
Prunus virginiana	2	28		0.68	0.50	
Prunus virginiana	2	29		0.80	0.50	
Prunus virginiana	2	30		0.73	0.58	
Shepherdia argentea	2	west border				
Shepherdia argentea	3	east border				
Picea pungens	3	1		0.22	0.18	1000
Picea pungens	3	2		0.21	0.20	
Picea pungens	3	3		0.21	0.15	
Picea pungens	3	4		0.21	0.15	
Picea pungens	3	5		0.21	0.15	
Picea pungens	3	6		0.22	0.17	
Picea pungens	3	7		0.22	0.18	
Picea pungens	3	8		0.24	0.15	
Picea pungens	3	9		0.23	0.20	
Picea pungens	3	10		0.25	0.20	
Picea pungens	3	11		0.25	0.20	
Picea pungens	3	12		0.30	0.24	
Picea pungens	3	13		0.37	0.30	
Picea pungens	3	14		0.49	0.46	
Picea pungens	3	15		0.51	0.58	
Picea pungens	3	16		0.52	0.53	
Picea pungens	3	17		0.48	0.44	
Picea pungens	3	18		0.46	0.35	
Picea pungens	3	19		0.49	0.37	
Picea pungens	3	20		0.45	0.46	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Picea pungens	3	21		0.45	0.44	
Picea pungens	3	22		0.53	0.48	
Picea pungens	3	23		0.58	0.53	
Picea pungens	3	24		0.62	0.56	
Picea pungens	3	25		0.61	0.52	
Picea pungens	3	26		0.62	0.48	
Picea pungens	3	27		0.64	0.47	
Picea pungens	3	28		0.62	0.40	
Picea pungens	3	29		0.62	0.44	
Picea pungens	3	30		0.70	0.43	
Shepherdia argentea	3	west border				
Shepherdia argentea	4	east border				
Lonicera korolkowii	4	1		0.22	0.20	1000
Lonicera korolkowii	4	2		0.21	0.19	
Lonicera korolkowii	4	3		0.21	0.19	
Lonicera korolkowii	4	4		0.21	0.19	
Lonicera korolkowii	4	5		0.22	0.19	
Lonicera korolkowii	4	6		0.21	0.19	
Lonicera korolkowii	4	7		0.21	0.19	
Lonicera korolkowii	4	8		0.21	0.20	
Lonicera korolkowii	4	9		0.23	0.21	
Lonicera korolkowii	4	10		0.25	0.21	
Lonicera korolkowii	4	11		0.27	0.24	
Lonicera korolkowii	4	12		0.30	0.29	
Lonicera korolkowii	4	13		0.30	0.29	
Lonicera korolkowii	4	14		0.31	0.27	
Lonicera korolkowii	4	15		0.33	0.29	
Lonicera korolkowii	4	16		0.32	0.32	
Lonicera korolkowii	4	17		0.37	0.32	
Lonicera korolkowii	4	18		0.39	0.34	
Lonicera korolkowii	4	19		0.40	0.39	
Lonicera korolkowii	4	20		0.39	0.40	
Lonicera korolkowii	4	21		0.41	0.40	
Lonicera korolkowii	4	22		0.51	0.43	
Lonicera korolkowii	4	23		0.50	0.50	
Lonicera korolkowii	4	24		0.54	0.50	
Lonicera korolkowii	4	25		0.60	0.50	
Lonicera korolkowii	4	26		0.59	0.49	
Lonicera korolkowii	4	27		0.62	0.51	
Lonicera korolkowii	4	28		0.62	0.50	
Lonicera korolkowii	4	29		0.59	0.49	
Lonicera korolkowii	4	30		0.58	0.47	
Shepherdia argentea	4	west border				

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Shepherdia argentea	5	east border				
Elaeagnus commutata	5	1		0.21	0.15	
Elaeagnus commutata	5	2		0.21	0.18	
Elaeagnus commutata	5	3		0.21	0.18	
Elaeagnus commutata	5	4		0.20	0.18	
Elaeagnus commutata	5	5		0.21	0.19	
Elaeagnus commutata	5	6		0.21	0.17	
Elaeagnus commutata	5	7		0.22	0.18	
Elaeagnus commutata	5	8		0.22	0.19	
Elaeagnus commutata	5	9		0.23	0.20	
Elaeagnus commutata	5	10		0.26	0.20	
Elaeagnus commutata	5	11		0.26	0.22	
Elaeagnus commutata	5	12		0.30	0.24	
Elaeagnus commutata	5	13		0.29	0.29	
Elaeagnus commutata	5	14		0.33	0.30	
Elaeagnus commutata	5	15		0.33	0.31	
Elaeagnus commutata	5	16		0.39	0.31	
Elaeagnus commutata	5	17		0.39	0.38	
Elaeagnus commutata	5	18		0.47	0.39	
Elaeagnus commutata	5	19		0.43	0.40	
Elaeagnus commutata	5	20		0.51	0.42	
Elaeagnus commutata	5	21		0.51	0.50	
Elaeagnus commutata	5	22		0.50	0.59	
Elaeagnus commutata	5	23		0.53	0.52	
Elaeagnus commutata	5	24		0.51	0.45	
Elaeagnus commutata	5	25		0.53	0.49	
Elaeagnus commutata	5	26		0.51	0.43	
Elaeagnus commutata	5	27		0.52	0.40	
Elaeagnus commutata	5	28		0.48	0.40	
Elaeagnus commutata	5	29		0.51	0.41	
Elaeagnus commutata	5	30		0.59	0.50	
Shepherdia argentea	5	west border				
Shepherdia argentea	6	east border				
Ribes aureum	6	1		0.19	0.14	
Ribes aureum	6	2		0.20	0.16	
Ribes aureum	6	3		0.21	0.18	
Ribes aureum	6	4		0.21	0.20	
Ribes aureum	6	5		0.22	0.19	
Ribes aureum	6	6		0.23	0.18	
Ribes aureum	6	7		0.23	0.20	
Ribes aureum	6	8		0.24	0.21	
Ribes aureum	6	9		0.25	0.21	
Ribes aureum	6	10		0.29	0.21	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Ribes aureum	6	11		0.30	0.21	
Ribes aureum	6	12		0.29	0.26	
Ribes aureum	6	13		0.30	0.29	
Ribes aureum	6	14		0.31	0.29	
Ribes aureum	6	15		0.32	0.30	
Ribes aureum	6	16		0.35	0.30	
Ribes aureum	6	17		0.35	0.30	
Ribes aureum	6	18		0.38	0.31	
Ribes aureum	6	19		0.39	0.32	
Ribes aureum	6	20		0.40	0.31	
Ribes aureum	6	21		0.41	0.32	
Ribes aureum	6	22		0.41	0.38	
Ribes aureum	6	23		0.50	0.38	
Ribes aureum	6	24		0.51	0.43	
Ribes aureum	6	25		0.51	0.45	
Ribes aureum	6	26		0.52	0.39	
Ribes aureum	6	27		0.51	0.38	
Ribes aureum	6	28		0.55	0.41	
Ribes aureum	6	29		0.59	0.49	
Ribes aureum	6	30		0.56	0.50	
Shepherdia argentea	6	west border				
Shepherdia argentea	7	east border				
Hippophae rhamnoides	7	1		0.19	0.14	
Hippophae rhamnoides	7	2		0.21	0.18	
Hippophae rhamnoides	7	3		0.22	0.18	
Hippophae rhamnoides	7	4		0.22	0.19	
Hippophae rhamnoides	7	5		0.22	0.19	
Hippophae rhamnoides	7	6		0.23	0.20	
Hippophae rhamnoides	7	7		0.24	0.20	
Hippophae rhamnoides	7	8		0.26	0.21	
Hippophae rhamnoides	7	9		0.26	0.22	
Hippophae rhamnoides	7	10		0.29	0.23	
Hippophae rhamnoides	7	11		0.30	0.24	
Hippophae rhamnoides	7	12		0.31	0.25	
Hippophae rhamnoides	7	13		0.30	0.27	
Hippophae rhamnoides	7	14		0.31	0.29	
Hippophae rhamnoides	7	15		0.31	0.28	
Hippophae rhamnoides	7	16		0.31	0.29	
Hippophae rhamnoides	7	17		0.31	0.29	
Hippophae rhamnoides	7	18		0.32	0.29	
Hippophae rhamnoides	7	19		0.31	0.29	
Hippophae rhamnoides	7	20		0.37	0.29	
Hippophae rhamnoides	7	21		0.39	0.30	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Hippophae rhamnoides	7	22		0.39	0.31	
Hippophae rhamnoides	7	23		0.41	0.32	
Hippophae rhamnoides	7	24		0.41	0.32	
Hippophae rhamnoides	7	25		0.42	0.35	
Hippophae rhamnoides	7	26		0.43	0.36	
Hippophae rhamnoides	7	27		0.44	0.38	
Hippophae rhamnoides	7	28		0.45	0.38	
Hippophae rhamnoides	7	29		0.48	0.40	
Hippophae rhamnoides	7	30		0.55	0.40	
Shepherdia argentea	7	west border				
Shepherdia argentea	8	east border				
Elaeagnus angustifolia	8	1		0.21	0.20	
Elaeagnus angustifolia	8	2		0.21	0.20	
Elaeagnus angustifolia	8	3		0.22	0.20	
Elaeagnus angustifolia	8	4		0.21	0.19	
Elaeagnus angustifolia	8	5		0.21	0.19	
Elaeagnus angustifolia	8	6		0.22	0.19	
Elaeagnus angustifolia	8	7		0.21	0.20	
Elaeagnus angustifolia	8	8		0.25	0.22	
Elaeagnus angustifolia	8	9		0.29	0.28	
Elaeagnus angustifolia	8	10		0.29	0.33	
Elaeagnus angustifolia	8	11		0.30	0.41	
Elaeagnus angustifolia	8	12		0.30	0.45	
Elaeagnus angustifolia	8	13		0.32	0.38	
Elaeagnus angustifolia	8	14		0.32	0.31	
Elaeagnus angustifolia	8	15		0.30	0.32	
Elaeagnus angustifolia	8	16		0.31	0.30	
Elaeagnus angustifolia	8	17		0.31	0.31	
Elaeagnus angustifolia	8	18		0.32	0.32	
Elaeagnus angustifolia	8	19		0.33	0.31	
Elaeagnus angustifolia	8	20		0.31	0.34	
Elaeagnus angustifolia	8	21		0.34	0.33	
Elaeagnus angustifolia	8	22		0.38	0.38	
Elaeagnus angustifolia	8	23		0.38	0.34	
Elaeagnus angustifolia	8	24		0.38	0.39	
Elaeagnus angustifolia	8	25		0.39	0.40	
Elaeagnus angustifolia	8	26		0.39	0.42	
Elaeagnus angustifolia	8	27		0.48	0.42	
Elaeagnus angustifolia	8	28		0.45	0.51	
Elaeagnus angustifolia	8	29		0.59	0.51	
Elaeagnus angustifolia	8	30		0.69	0.68	
Shepherdia argentea	8	west border				
Shepherdia argentea	9	east border				

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Caragana arborescens	9	1		0.21	0.20	1000
Caragana arborescens	9	2		0.21	0.20	
Caragana arborescens	9	3		0.20	0.19	
Caragana arborescens	9	4		0.21	0.19	
Caragana arborescens	9	5		0.22	0.20	
Caragana arborescens	9	6		0.25	0.22	
Caragana arborescens	9	7		0.28	0.24	
Caragana arborescens	9	8		0.29	0.27	
Caragana arborescens	9	9		0.31	0.28	
Caragana arborescens	9	10		0.28	0.26	
Caragana arborescens	9	11		0.28	0.25	
Caragana arborescens	9	12		0.28	0.26	
Caragana arborescens	9	13		0.30	0.24	
Caragana arborescens	9	14		0.29	0.25	
Caragana arborescens	9	15		0.29	0.23	
Caragana arborescens	9	16		0.29	0.23	
Caragana arborescens	9	17		0.30	0.27	
Caragana arborescens	9	18		0.32	0.29	
Caragana arborescens	9	19		0.32	0.29	
Caragana arborescens	9	20		0.33	0.29	
Caragana arborescens	9	21		0.31	0.30	
Caragana arborescens	9	22		0.32	0.30	
Caragana arborescens	9	23		0.36	0.30	
Caragana arborescens	9	24		0.37	0.31	
Caragana arborescens	9	25		0.39	0.30	
Caragana arborescens	9	26		0.40	0.35	
Caragana arborescens	9	27		0.42	0.37	
Caragana arborescens	9	28		0.49	0.40	
Caragana arborescens	9	29		0.59	0.53	
Caragana arborescens	9	30		0.70	0.70	
Shepherdia argentea	9	west border				
Shepherdia argentea	10	east border				
Ulmus pumila	10	1		0.21	0.18	
Ulmus pumila	10	2		0.21	0.20	
Ulmus pumila	10	3		0.22	0.20	
Ulmus pumila	10	4		0.22	0.21	
Ulmus pumila	10	5		0.24	0.22	
Ulmus pumila	10	6		0.27	0.24	
Ulmus pumila	10	7		0.26	0.25	
Ulmus pumila	10	8		0.27	0.25	
Ulmus pumila	10	9		0.27	0.26	
Ulmus pumila	10	10		0.28	0.26	
Ulmus pumila	10	11		0.29	0.29	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading elevated and vertical	EM-38 Reading vertical ground	EM-38 Reading horizontal ground	Scale
Ulmus pumila	10	12		0.27	0.29	
Ulmus pumila	10	13		0.28	0.30	
Ulmus pumila	10	14		0.30	0.30	
Ulmus pumila	10	15		0.29	0.30	
Ulmus pumila	10	16		0.29	0.30	
Ulmus pumila	10	17		0.29	0.30	
Ulmus pumila	10	18		0.31	0.30	
Ulmus pumila	10	19		0.32	0.30	
Ulmus pumila	10	20		0.34	0.30	
Ulmus pumila	10	21		0.35	0.31	
Ulmus pumila	10	22		0.36	0.34	
Ulmus pumila	10	23		0.35	0.33	
Ulmus pumila	10	24		0.37	0.32	
Ulmus pumila	10	25		0.40	0.34	
Ulmus pumila	10	26		0.43	0.39	
Ulmus pumila	10	27		0.44	0.49	
Ulmus pumila	10	28		0.54	0.50	
Ulmus pumila	10	29		0.48	0.70	
Ulmus pumila	10	30		0.61	0.58	
Shepherdia argentea	10	west border				
Shepherdia argentea	11	east border				
Pinus ponderosa	11	1		0.20	0.18	
Pinus ponderosa	11	2		0.22	0.19	
Pinus ponderosa	11	3		0.23	0.19	
Pinus ponderosa	11	4		0.22	0.20	
Pinus ponderosa	11	5		0.23	0.20	
Pinus ponderosa	11	6		0.23	0.21	
Pinus ponderosa	11	7		0.23	0.21	
Pinus ponderosa	11	8		0.23	0.22	
Pinus ponderosa	11	9		0.23	0.22	
Pinus ponderosa	11	10		0.24	0.22	
Pinus ponderosa	11	11		0.25	0.23	
Pinus ponderosa	11	12		0.24	0.23	
Pinus ponderosa	11	13		0.25	0.22	
Pinus ponderosa	11	14		0.26	0.22	
Pinus ponderosa	11	15		0.25	0.23	
Pinus ponderosa	11	16		0.28	0.24	
Pinus ponderosa	11	17		0.29	0.25	
Pinus ponderosa	11	18		0.30	0.26	
Pinus ponderosa	11	19		0.31	0.28	
Pinus ponderosa	11	20		0.32	0.29	
Pinus ponderosa	11	21		0.34	0.30	
Pinus ponderosa	11	22		0.35	0.32	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading elevated and vertical	EM-38 Reading vertical ground	EM-38 Reading horizontal ground	Scale
Pinus ponderosa	11	23		0.36	0.32	
Pinus ponderosa	11	24		0.37	0.32	
Pinus ponderosa	11	25		0.37	0.34	
Pinus ponderosa	11	26		0.39	0.34	
Pinus ponderosa	11	27		0.39	0.36	
Pinus ponderosa	11	28		0.40	0.35	
Pinus ponderosa	11	29		0.39	0.35	
Pinus ponderosa	11	30		0.40	0.36	
Shepherdia argentea	11	west border				
Shepherdia argentea	12	east border				
Symphoricarpos sp.	12	1		0.22	0.21	
Symphoricarpos sp.	12	2		0.22	0.21	
Symphoricarpos sp.	12	3		0.23	0.21	
Symphoricarpos sp.	12	4		0.23	0.21	
Symphoricarpos sp.	12	5		0.22	0.21	
Symphoricarpos sp.	12	6		0.22	0.20	
Symphoricarpos sp.	12	7		0.22	0.19	
Symphoricarpos sp.	12	8		0.21	0.19	
Symphoricarpos sp.	12	9		0.21	0.18	
Symphoricarpos sp.	12	10		0.21	0.20	
Symphoricarpos sp.	12	11		0.23	0.20	
Symphoricarpos sp.	12	12		0.25	0.24	
Symphoricarpos sp.	12	13		0.25	0.25	
Symphoricarpos sp.	12	14		0.26	0.24	
Symphoricarpos sp.	12	15		0.28	0.24	
Symphoricarpos sp.	12	16		0.30	0.28	
Symphoricarpos sp.	12	17		0.31	0.30	
Symphoricarpos sp.	12	18		0.32	0.31	
Symphoricarpos sp.	12	19		0.37	0.32	
Symphoricarpos sp.	12	20		0.36	0.30	
Symphoricarpos sp.	12	21		0.35	0.33	
Symphoricarpos sp.	12	22		0.38	0.32	
Symphoricarpos sp.	12	23		0.38	0.33	
Symphoricarpos sp.	12	24		0.36	0.33	
Symphoricarpos sp.	12	25		0.38	0.34	
Symphoricarpos sp.	12	26		0.38	0.36	
Symphoricarpos sp.	12	27		0.36	0.35	
Symphoricarpos sp.	12	28		0.40	0.38	
Symphoricarpos sp.	12	29		0.38	0.37	
Symphoricarpos sp.	12	30		0.39	0.35	
Shepherdia argentea	12	west border				
Shepherdia argentea	13	east border				
Fraxinus pennsylvanica	13	1		0.25	0.25	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading elevated and vertical	EM-38 Reading vertical ground	EM-38 Reading horizontal ground	Scale
Fraxinus pennsylvanica	13	2		0.25	0.24	
Fraxinus pennsylvanica	13	3		0.23	0.21	
Fraxinus pennsylvanica	13	4		0.23	0.21	
Fraxinus pennsylvanica	13	5		0.21	0.20	
Fraxinus pennsylvanica	13	6		0.21	0.20	
Fraxinus pennsylvanica	13	7		0.21	0.20	
Fraxinus pennsylvanica	13	8		0.21	0.20	
Fraxinus pennsylvanica	13	9		0.22	0.21	
Fraxinus pennsylvanica	13	10		0.23	0.21	
Fraxinus pennsylvanica	13	11		0.23	0.24	
Fraxinus pennsylvanica	13	12		0.25	0.28	
Fraxinus pennsylvanica	13	13		0.27	0.25	
Fraxinus pennsylvanica	13	14		0.28	0.24	
Fraxinus pennsylvanica	13	15		0.29	0.28	
Fraxinus pennsylvanica	13	16		0.30	0.28	
Fraxinus pennsylvanica	13	17		0.31	0.30	
Fraxinus pennsylvanica	13	18		0.32	0.30	
Fraxinus pennsylvanica	13	19		0.33	0.31	
Fraxinus pennsylvanica	13	20		0.33	0.31	
Fraxinus pennsylvanica	13	21		0.35	0.32	
Fraxinus pennsylvanica	13	22		0.35	0.32	
Fraxinus pennsylvanica	13	23		0.34	0.30	
Fraxinus pennsylvanica	13	24		0.33	0.30	
Fraxinus pennsylvanica	13	25		0.37	0.32	
Fraxinus pennsylvanica	13	26		0.33	0.32	
Fraxinus pennsylvanica	13	27		0.34	0.32	
Fraxinus pennsylvanica	13	28		0.38	0.33	
Fraxinus pennsylvanica	13	29		0.38	0.35	
Fraxinus pennsylvanica	13	30		0.40	0.36	
Shepherdia argentea	13	west border				
Shepherdia argentea	14	east border				
Prunus americana	14	1		0.30	0.25	
Prunus americana	14	2		0.25	0.25	
Prunus americana	14	3		0.26	0.25	
Prunus americana	14	4		0.26	0.23	
Prunus americana	14	5		0.25	0.22	
Prunus americana	14	6		0.22	0.20	
Prunus americana	14	7		0.22	0.19	
Prunus americana	14	8		0.22	0.20	
Prunus americana	14	9		0.23	0.20	
Prunus americana	14	10		0.23	0.21	
Prunus americana	14	11		0.24	0.21	
Prunus americana	14	12		0.24	0.22	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Prunus americana	14	13		0.27	0.26	
Prunus americana	14	14		0.28	0.26	
Prunus americana	14	15		0.30	0.30	
Prunus americana	14	16		0.32	0.30	
Prunus americana	14	17		0.30	0.31	
Prunus americana	14	18		0.31	0.31	
Prunus americana	14	19		0.32	0.31	
Prunus americana	14	20		0.31	0.30	
Prunus americana	14	21		0.30	0.28	
Prunus americana	14	22		0.30	0.29	
Prunus americana	14	23		0.32	0.30	
Prunus americana	14	24		0.33	0.32	
Prunus americana	14	25		0.37	0.33	
Prunus americana	14	26		0.40	0.34	
Prunus americana	14	27		0.40	0.35	
Prunus americana	14	28		0.40	0.37	
Prunus americana	14	29		0.47	0.36	
Prunus americana	14	30		0.48	0.40	
Shepherdia argentea	14	west border				
Shepherdia argentea	15	east border				
Prunus besseyi	15	1		0.26	0.24	1000
Prunus besseyi	15	2		0.24	0.23	
Prunus besseyi	15	3		0.23	0.22	
Prunus besseyi	15	4		0.23	0.21	
Prunus besseyi	15	5		0.22	0.21	
Prunus besseyi	15	6		0.23	0.22	
Prunus besseyi	15	7		0.23	0.21	
Prunus besseyi	15	8		0.23	0.20	
Prunus besseyi	15	9		0.23	0.21	
Prunus besseyi	15	10		0.24	0.23	
Prunus besseyi	15	11		0.25	0.19	
Prunus besseyi	15	12		0.28	0.24	
Prunus besseyi	15	13		0.29	0.25	
Prunus besseyi	15	14		0.29	0.24	
Prunus besseyi	15	15		0.30	0.24	
Prunus besseyi	15	16		0.30	0.25	
Prunus besseyi	15	17		0.30	0.25	
Prunus besseyi	15	18		0.31	0.29	
Prunus besseyi	15	19		0.32	0.28	
Prunus besseyi	15	20		0.31	0.28	
Prunus besseyi	15	21		0.31	0.30	
Prunus besseyi	15	22		0.34	0.32	
Prunus besseyi	15	23		0.37	0.34	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading elevated and vertical	EM-38 Reading vertical ground	EM-38 Reading horizontal ground	Scale
Prunus besseyi	15	24		0.38	0.30	
Prunus besseyi	15	25		0.39	0.34	
Prunus besseyi	15	26		0.41	0.38	
Prunus besseyi	15	27		0.43	0.39	
Prunus besseyi	15	28		0.50	0.40	
Prunus besseyi	15	29		0.51	0.40	
Prunus besseyi	15	30		0.54	0.40	
Shepherdia argentea	15	west border				
Shepherdia argentea	16	east border				
Rhus trilobata	16	1		0.28	0.22	
Rhus trilobata	16	2		0.25	0.21	
Rhus trilobata	16	3		0.24	0.23	
Rhus trilobata	16	4		0.25	0.25	
Rhus trilobata	16	5		0.27	0.24	
Rhus trilobata	16	6		0.27	0.24	
Rhus trilobata	16	7		0.28	0.22	
Rhus trilobata	16	8		0.26	0.22	
Rhus trilobata	16	9		0.26	0.22	
Rhus trilobata	16	10		0.27	0.22	
Rhus trilobata	16	11		0.27	0.24	
Rhus trilobata	16	12		0.28	0.24	
Rhus trilobata	16	13		0.28	0.24	
Rhus trilobata	16	14		0.29	0.25	
Rhus trilobata	16	15		0.29	0.25	
Rhus trilobata	16	16		0.31	0.26	
Rhus trilobata	16	17		0.31	0.27	
Rhus trilobata	16	18		0.31	0.30	
Rhus trilobata	16	19		0.34	0.32	
Rhus trilobata	16	20		0.39	0.35	
Rhus trilobata	16	21		0.39	0.38	
Rhus trilobata	16	22		0.40	0.34	
Rhus trilobata	16	23		0.41	0.38	
Rhus trilobata	16	24		0.45	0.39	
Rhus trilobata	16	25		0.43	0.39	
Rhus trilobata	16	26		0.47	0.40	
Rhus trilobata	16	27		0.50	0.40	
Rhus trilobata	16	28		0.50	0.40	
Rhus trilobata	16	29		0.49	0.39	
Rhus trilobata	16	30		0.49	0.40	
Shepherdia argentea	16	west border				
Shepherdia argentea	17	east border				
Prunus tomentosa	17	1		0.30	0.25	
Prunus tomentosa	17	2		0.29	0.25	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading elevated and vertical	EM-38 Reading vertical ground	EM-38 Reading horizontal ground	Scale
Prunus tomentosa	17	3		0.27	0.24	
Prunus tomentosa	17	4		0.27	0.24	
Prunus tomentosa	17	5		0.27	0.24	
Prunus tomentosa	17	6		0.27	0.22	
Prunus tomentosa	17	7		0.26	0.23	
Prunus tomentosa	17	8		0.28	0.23	
Prunus tomentosa	17	9		0.27	0.24	
Prunus tomentosa	17	10		0.28	0.25	
Prunus tomentosa	17	11		0.29	0.25	
Prunus tomentosa	17	12		0.30	0.26	
Prunus tomentosa	17	13		0.32	0.28	
Prunus tomentosa	17	14		0.32	0.29	
Prunus tomentosa	17	15		0.33	0.30	
Prunus tomentosa	17	16		0.33	0.30	
Prunus tomentosa	17	17		0.35	0.30	
Prunus tomentosa	17	18		0.35	0.31	
Prunus tomentosa	17	19		0.39	0.33	
Prunus tomentosa	17	20		0.40	0.35	
Prunus tomentosa	17	21		0.40	0.32	
Prunus tomentosa	17	22		0.40	0.35	
Prunus tomentosa	17	23		0.40	0.34	
Prunus tomentosa	17	24		0.40	0.33	
Prunus tomentosa	17	25		0.40	0.35	
Prunus tomentosa	17	26		0.41	0.37	
Prunus tomentosa	17	27		0.43	0.36	
Prunus tomentosa	17	28		0.43	0.38	
Prunus tomentosa	17	29		0.40	0.37	
Prunus tomentosa	17	30		0.40	0.33	
Shepherdia argentea	17	west border				
Shepherdia argentea	18	east border				
Populus deltoides	18	1		0.27	0.22	
Populus deltoides	18	2		0.24	0.25	
Populus deltoides	18	3		0.26	0.22	
Populus deltoides	18	4		0.24	0.22	
Populus deltoides	18	5		0.23	0.22	
Populus deltoides	18	6		0.25	0.22	
Populus deltoides	18	7		0.24	0.23	
Populus deltoides	18	8		0.28	0.22	
Populus deltoides	18	9		0.27	0.25	
Populus deltoides	18	10		0.30	0.23	
Populus deltoides	18	11		0.31	0.25	
Populus deltoides	18	12		0.30	0.25	
Populus deltoides	18	13		0.31	0.28	

Appendix 6. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2008, Bridger, MT.

Species	Row No	Row Position	EM-38 Reading	EM-38 Reading	EM-38 Reading	Scale
			elevated and vertical	vertical ground	horizontal ground	
Populus deltoides	18	14		0.32	0.30	
Populus deltoides	18	15		0.33	0.30	
Populus deltoides	18	16		0.35	0.31	
Populus deltoides	18	17		0.33	0.32	
Populus deltoides	18	18		0.34	0.31	
Populus deltoides	18	19		0.36	0.30	
Populus deltoides	18	20		0.33	0.29	
Populus deltoides	18	21		0.31	0.30	
Populus deltoides	18	22		0.32	0.28	
Populus deltoides	18	23		0.31	0.26	
Populus deltoides	18	24		0.31	0.27	
Populus deltoides	18	25		0.31	0.27	
Populus deltoides	18	26		0.33	0.29	
Populus deltoides	18	27		0.35	0.30	
Populus deltoides	18	28		0.33	0.30	
Populus deltoides	18	29		0.31	0.29	
Populus deltoides	18	30		0.31	0.26	
Shepherdia argentea	18	west border				

North end of plot

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
south end of plot						
Shepherdia argentea	1	east border	0			
Shepherdia argentea	1	1	0			
Shepherdia argentea	1	2	1	32.0	7	deer damage
Shepherdia argentea	1	3	0			
Shepherdia argentea	1	4	0			
Shepherdia argentea	1	5	1	13.0	8	deer damage
Shepherdia argentea	1	6	0			
Shepherdia argentea	1	7	1	62.0	5	deer damage
Shepherdia argentea	1	8	1	43.0	5	deer damage
Shepherdia argentea	1	9	1	40.0	6	deer damage
Shepherdia argentea	1	10	0			deer damage
Shepherdia argentea	1	11	1	58.0	5	deer damage
Shepherdia argentea	1	12	1	69.0	5	deer damage
Shepherdia argentea	1	13	1	88.0	4	
Shepherdia argentea	1	14	1	119.0	3	
Shepherdia argentea	1	15	0			dead
Shepherdia argentea	1	16	0			
Shepherdia argentea	1	17	0			
Shepherdia argentea	1	18	0			
Shepherdia argentea	1	19	0			
Shepherdia argentea	1	20	0			
Shepherdia argentea	1	21	0			
Shepherdia argentea	1	22	0			
Shepherdia argentea	1	23	1	85.0	5	
Shepherdia argentea	1	24	0			
Shepherdia argentea	1	25	1	88.0	4	
Shepherdia argentea	1	26	0			
Shepherdia argentea	1	27	1	94.0	4	
Shepherdia argentea	1	28	1	80.0	5	
Shepherdia argentea	1	29	0			
Shepherdia argentea	1	30	0			
Shepherdia argentea	1	west border	0			
Shepherdia argentea	2	east border	1	37	8	
Prunus virginiana	2	1	0			dead; deer?
Prunus virginiana	2	2	0			dead; deer?
Prunus virginiana	2	3	0			dead; deer?
Prunus virginiana	2	4	0			severe deer browse
Prunus virginiana	2	5	0			severe deer browse
Prunus virginiana	2	6	0			severe deer browse
Prunus virginiana	2	7	0			dead
Prunus virginiana	2	8	0			deer
Prunus virginiana	2	9	1	57.0	9	near death, stunted leaves
Prunus virginiana	2	10	0			deer

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus virginiana	2	11	0			severe deer browse
Prunus virginiana	2	12	0			deer
Prunus virginiana	2	13	1	59.0	5	deer
Prunus virginiana	2	14	0			dead
Prunus virginiana	2	15	0			dead
Prunus virginiana	2	16	0			dead
Prunus virginiana	2	17	0			dead
Prunus virginiana	2	18	0			dead
Prunus virginiana	2	19	0			dead
Prunus virginiana	2	20	0			dead
Prunus virginiana	2	21	0			dead
Prunus virginiana	2	22	0			dead
Prunus virginiana	2	23	0			dead
Prunus virginiana	2	24	0			dead
Prunus virginiana	2	25	0			dead
Prunus virginiana	2	26	0			dead
Prunus virginiana	2	27	0			dead
Prunus virginiana	2	28	0			dead
Prunus virginiana	2	29	0			dead
Prunus virginiana	2	30	0			dead
Shepherdia argentea	2	west border	0			
Shepherdia argentea	3	east border				
Picea pungens	3	1	0			dead
Picea pungens	3	2	0			dead
Picea pungens	3	3	0			dead
Picea pungens	3	4	0			dead
Picea pungens	3	5	0			dead
Picea pungens	3	6	0			dead
Picea pungens	3	7	0			dead
Picea pungens	3	8	0			dead
Picea pungens	3	9	0			dead
Picea pungens	3	10	0			dead
Picea pungens	3	11	0			dead
Picea pungens	3	12	0			dead
Picea pungens	3	13	0			dead
Picea pungens	3	14	0			dead
Picea pungens	3	15	0			dead
Picea pungens	3	16	0			dead
Picea pungens	3	17	0			dead
Picea pungens	3	18	0			dead
Picea pungens	3	19	0			dead
Picea pungens	3	20	0			dead
Picea pungens	3	21	0			dead
Picea pungens	3	22	0			dead

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Picea pungens	3	23	0			dead
Picea pungens	3	24	0			dead
Picea pungens	3	25	0			dead
Picea pungens	3	26	0			dead
Picea pungens	3	27	0			dead
Picea pungens	3	28	0			dead
Picea pungens	3	29	0			dead
Picea pungens	3	30	0			dead
Shepherdia argentea	3	west border	0			
Shepherdia argentea	4	east border	0			
Lonicera korolkowii	4	1	1	104.0	5	fruit, light browse
Lonicera korolkowii	4	2	1	191.0	2	fruit, light browse
Lonicera korolkowii	4	3	1	178.0	2	fruit, light browse
Lonicera korolkowii	4	4	1	161.0	2	fruit, light browse
Lonicera korolkowii	4	5	1	161.0	3	fruit, light browse
Lonicera korolkowii	4	6	1	170.0	2	fruit, light browse
Lonicera korolkowii	4	7	1	151.0	4	fruit, light browse
Lonicera korolkowii	4	8	1	200.0	1	fruit, light browse
Lonicera korolkowii	4	9	1	158.0	4	deer, fruit, light browse
Lonicera korolkowii	4	10	1	120.0	6	fruit, stunted leaves
Lonicera korolkowii	4	11	1	135.0	4	fruit, some stunted leaves
Lonicera korolkowii	4	12	1	165.0	2	fruit, light browse
Lonicera korolkowii	4	13	1	157.0	3	fruit, light browse
Lonicera korolkowii	4	14	1	156.0	3	fruit, light browse
Lonicera korolkowii	4	15	1	96.0	5	fruit, light browse
Lonicera korolkowii	4	16	1	127.0	4	fruit, light browse
Lonicera korolkowii	4	17	1	88.0	4	fruit, some stunted leaves
Lonicera korolkowii	4	18	1	79.0	6	no fruit, stunted leaves
Lonicera korolkowii	4	19	1	70.0	6	fruit, stunting, lt browse
Lonicera korolkowii	4	20	1	104.0	5	fruit, stunting, lt browse
Lonicera korolkowii	4	21	1	80.0	6	no fruit, stunting, lt browse
Lonicera korolkowii	4	22	0			dead
Lonicera korolkowii	4	23	0			dead
Lonicera korolkowii	4	24	0			dead
Lonicera korolkowii	4	25	0			dead
Lonicera korolkowii	4	26	0			dead
Lonicera korolkowii	4	27	0			dead
Lonicera korolkowii	4	28	0			dead
Lonicera korolkowii	4	29	0			dead
Lonicera korolkowii	4	30	0			dead
Shepherdia argentea	4	west border	1	54	5	heavily browsed
Shepherdia argentea	5	east border	0			
Elaeagnus commutata	5	1	1	70.0	5	browsed, fruit
Elaeagnus commutata	5	2	1	87.0	5	browsed

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Elaeagnus commutata	5	3	1	70.0	4	browsed, fruit
Elaeagnus commutata	5	4	1	76.0	4	browsed
Elaeagnus commutata	5	5	1	42.0	6	dead leader; browsed
Elaeagnus commutata	5	6	1	111.0	3	browsed fruit
Elaeagnus commutata	5	7	1	0.0		
Elaeagnus commutata	5	8	1	86.0	4	fruit
Elaeagnus commutata	5	9	1	67.0	6	browsed
Elaeagnus commutata	5	10	1	58.0	5	browsed/fruit
Elaeagnus commutata	5	11	1	107.0	3	light browsed/fruit
Elaeagnus commutata	5	12	1	66.0	4	browsed
Elaeagnus commutata	5	13	1	68.0	5	browsed
Elaeagnus commutata	5	14	1	74.0	5	browsed
Elaeagnus commutata	5	15	1	85.0	6	browsed
Elaeagnus commutata	5	16	1	49.0	5	browsed
Elaeagnus commutata	5	17	0			dead
Elaeagnus commutata	5	18	1	92.0	4	browsed
Elaeagnus commutata	5	19	0			dead
Elaeagnus commutata	5	20	0			dead
Elaeagnus commutata	5	21	1	41.0	7	
Elaeagnus commutata	5	22	0			dead
Elaeagnus commutata	5	23	1	52.0	6	
Elaeagnus commutata	5	24	0			dead
Elaeagnus commutata	5	25	0			dead
Elaeagnus commutata	5	26	1	57.0	5	
Elaeagnus commutata	5	27	0			
Elaeagnus commutata	5	28	1	80.0	4	browsed
Elaeagnus commutata	5	29	0			dead
Elaeagnus commutata	5	30	0			dead
Shepherdia argentea	5	west border	0			dead
Shepherdia argentea	6	east border	0			dead
Ribes aureum	6	1	1	55.0	7	deer injury; browsed
Ribes aureum	6	2	1	34.0	9	injury; brows.; nearly dead
Ribes aureum	6	3	1	55.0	6	deer browsed
Ribes aureum	6	4	1	92.0	6	browsed
Ribes aureum	6	5	1	78.0	7	deer browsed
Ribes aureum	6	6	1	81.0	5	browsed
Ribes aureum	6	7	0			dead; deer?
Ribes aureum	6	8	0			
Ribes aureum	6	9	0			dead
Ribes aureum	6	10	0			dead
Ribes aureum	6	11	1	41.0	6	browsed
Ribes aureum	6	12	1	70.0	6	browsed
Ribes aureum	6	13	1	74.0	6	browsed
Ribes aureum	6	14	1	79.0	6	browsed

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Ribes aureum	6	15	1	63.0	6	browsed
Ribes aureum	6	16	0			dead
Ribes aureum	6	17	1	63.0	4	fruit
Ribes aureum	6	18	1	50.0	5	browsed/fruit
Ribes aureum	6	19	1	47.0	7	heavy browsed
Ribes aureum	6	20	1	70.0	6	heavy browsed
Ribes aureum	6	21	0			dead
Ribes aureum	6	22	0			dead
Ribes aureum	6	23	1	47.0	5	heavy browsed
Ribes aureum	6	24	0			dead
Ribes aureum	6	25	0			dead
Ribes aureum	6	26	0			dead
Ribes aureum	6	27	0			dead
Ribes aureum	6	28	0			dead
Ribes aureum	6	29	0			dead
Ribes aureum	6	30	0			
Shepherdia argentea	6	west border	1	50	5	browsed
Shepherdia argentea	7	east border	1	51	5	browsed
Hippophae rhamnoides	7	1	1	57.0	6	dead leader
Hippophae rhamnoides	7	2	1	71.0	4	deer browsed
Hippophae rhamnoides	7	3	0			dead
Hippophae rhamnoides	7	4	1	87.0	4	browsed
Hippophae rhamnoides	7	5	1	83.0	4	browsed
Hippophae rhamnoides	7	6	1	91.0	3	browsed heavily
Hippophae rhamnoides	7	7	1	91.0	3	browsed
Hippophae rhamnoides	7	8	1	87.0	5	browsed
Hippophae rhamnoides	7	9	0			dead
Hippophae rhamnoides	7	10	0			dead
Hippophae rhamnoides	7	11	1	40.0	6	deer browsed
Hippophae rhamnoides	7	12	1	65.0	6	browsed
Hippophae rhamnoides	7	13	0			dead
Hippophae rhamnoides	7	14	1	49.0	7	browsed
Hippophae rhamnoides	7	15	1	36.0	6	browsed
Hippophae rhamnoides	7	16	1	47.0	6	tip browse
Hippophae rhamnoides	7	17	1	46.0	7	
Hippophae rhamnoides	7	18	1	84.0	5	browsed
Hippophae rhamnoides	7	19	1	44.0	7	heavy browse/sickly
Hippophae rhamnoides	7	20	0			dead
Hippophae rhamnoides	7	21	1	56.0	8	browsed/sickly
Hippophae rhamnoides	7	22	1	51.0	7	browsed/tip dieback
Hippophae rhamnoides	7	23	0			dead
Hippophae rhamnoides	7	24	1	104.0	4	browsed
Hippophae rhamnoides	7	25	0			dead
Hippophae rhamnoides	7	26	1	65.0	6	

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Hippophae rhamnoides	7	27	1	50.0	5	
Hippophae rhamnoides	7	28	0			dead
Hippophae rhamnoides	7	29	1	50.0	5	
Hippophae rhamnoides	7	30	0			dead
Shepherdia argentea	7	west border	1	44	4	
Shepherdia argentea	8	east border				gone
Elaeagnus angustifolia	8	1	1	320.0	2	fruit
Elaeagnus angustifolia	8	2	1	310.0	2	fruit
Elaeagnus angustifolia	8	3	1	330.0	1	fruit
Elaeagnus angustifolia	8	4	1	320.0	2	fruit
Elaeagnus angustifolia	8	5	1	300.0	4	old deer injury,stunted
Elaeagnus angustifolia	8	6	1	340.0	2	fruit
Elaeagnus angustifolia	8	7	1	325.0	1	fruit
Elaeagnus angustifolia	8	8	1	290.0	3	fruit
Elaeagnus angustifolia	8	9	1	230.0	5	deer?
Elaeagnus angustifolia	8	10	1	175.0	7	deer?
Elaeagnus angustifolia	8	11	1	290.0	2	fruit
Elaeagnus angustifolia	8	12	1	265.0	3	fruit
Elaeagnus angustifolia	8	13	1	320.0	2	fruit
Elaeagnus angustifolia	8	14	1	340.0	1	fruit
Elaeagnus angustifolia	8	15	1	310.0	1	fruit
Elaeagnus angustifolia	8	16	1	360.0	1	heavy fruit
Elaeagnus angustifolia	8	17	1	340.0	1	fruit
Elaeagnus angustifolia	8	18	1	315.0	2	no fruit
Elaeagnus angustifolia	8	19	1	300.0	2	fruit
Elaeagnus angustifolia	8	20	1	335.0	1	fruit
Elaeagnus angustifolia	8	21	1	320.0	1	fruit
Elaeagnus angustifolia	8	22	1	330.0	1	fruit
Elaeagnus angustifolia	8	23	1	320.0	1	fruit
Elaeagnus angustifolia	8	24	1	330.0	1	heavy fruit
Elaeagnus angustifolia	8	25	1	330.0	1	heavy fruit
Elaeagnus angustifolia	8	26	1	325.0	1	heavy fruit
Elaeagnus angustifolia	8	27	1	305.0	3	fruit
Elaeagnus angustifolia	8	28	1	265.0	4	fruit
Elaeagnus angustifolia	8	29	0			dead
Elaeagnus angustifolia	8	30	0			dead
Shepherdia argentea	8	west border	0			dead
Shepherdia argentea	9	east border	1	38	6	
Caragana arborescens	9	1	1	70.0	8	no leaves/green cambium
Caragana arborescens	9	2	0			gone
Caragana arborescens	9	3	1	90.0	5	
Caragana arborescens	9	4	1	82.0	4	
Caragana arborescens	9	5	1	90.0	4	
Caragana arborescens	9	6	0			gone

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Caragana arborescens	9	7	1	65.0	5	
Caragana arborescens	9	8	0			gone
Caragana arborescens	9	9	1	56.0	5	
Caragana arborescens	9	10	0			gone
Caragana arborescens	9	11	1	64.0	4	
Caragana arborescens	9	12	0			
Caragana arborescens	9	13	1	50.0	5	deer
Caragana arborescens	9	14	0			dead
Caragana arborescens	9	15	0			gone
Caragana arborescens	9	16	1	105.0	4	
Caragana arborescens	9	17	1	75.0	4	
Caragana arborescens	9	18	1	70.0	5	deer
Caragana arborescens	9	19	1	52.0	6	
Caragana arborescens	9	20	1	60.0	5	deer
Caragana arborescens	9	21	1	60.0	5	deer
Caragana arborescens	9	22	1	70.0	5	
Caragana arborescens	9	23	0			deer; leader dead
Caragana arborescens	9	24	1	94.0	4	
Caragana arborescens	9	25	0			
Caragana arborescens	9	26	1	40.0	9	nearly dead
Caragana arborescens	9	27	1	81.0	5	
Caragana arborescens	9	28	0			
Caragana arborescens	9	29	0			
Caragana arborescens	9	30	0			
Shepherdia argentea	9	west border	0			
Shepherdia argentea	10	east border	1	45	5	
Ulmus pumila	10	1	1	131.0	2	all heavily deer browsed
Ulmus pumila	10	2	1	87.0	3	
Ulmus pumila	10	3	1	91.0	3	
Ulmus pumila	10	4	1	86.0	2	
Ulmus pumila	10	5	1	103.0	4	
Ulmus pumila	10	6	1	85.0	4	
Ulmus pumila	10	7	1	69.0	4	
Ulmus pumila	10	8	1	75.0	6	
Ulmus pumila	10	9	1	80.0	3	
Ulmus pumila	10	10	1	93.0	4	
Ulmus pumila	10	11	1	100.0	3	
Ulmus pumila	10	12	1	105.0	3	
Ulmus pumila	10	13	1	90.0	3	
Ulmus pumila	10	14	1	89.0	3	
Ulmus pumila	10	15	1	96.0	3	
Ulmus pumila	10	16	1	88.0	3	
Ulmus pumila	10	17	1	84.0	5	chlorotic
Ulmus pumila	10	18	1	80.0	5	

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Ulmus pumila	10	19	1	73.0	4	
Ulmus pumila	10	20	1	87.0	4	
Ulmus pumila	10	21	1	70.0	5	
Ulmus pumila	10	22	1	88.0	4	
Ulmus pumila	10	23	1	93.0	3	
Ulmus pumila	10	24	1	57.0	4	
Ulmus pumila	10	25	1	91.0	3	
Ulmus pumila	10	26	0			
Ulmus pumila	10	27	0			
Ulmus pumila	10	28	0			
Ulmus pumila	10	29	0			
Ulmus pumila	10	30	0			
Shepherdia argentea	10	west border	1	41	5	heavily browsed
Shepherdia argentea	11	east border	1	33	6	
Pinus ponderosa	11	1	0			
Pinus ponderosa	11	2	0			
Pinus ponderosa	11	3	0			
Pinus ponderosa	11	4	0			
Pinus ponderosa	11	5	0			
Pinus ponderosa	11	6	1	77.0	5	tip burn/chlorotic
Pinus ponderosa	11	7	0			dead
Pinus ponderosa	11	8	0			
Pinus ponderosa	11	9	0			
Pinus ponderosa	11	10	0			
Pinus ponderosa	11	11	0			
Pinus ponderosa	11	12	0			
Pinus ponderosa	11	13	0			
Pinus ponderosa	11	14	0			
Pinus ponderosa	11	15	0			
Pinus ponderosa	11	16	0			
Pinus ponderosa	11	17	0			
Pinus ponderosa	11	18	0			
Pinus ponderosa	11	19	0			
Pinus ponderosa	11	20	0			
Pinus ponderosa	11	21	0			
Pinus ponderosa	11	22	0			
Pinus ponderosa	11	23	0			
Pinus ponderosa	11	24	0			
Pinus ponderosa	11	25	0			
Pinus ponderosa	11	26	0			
Pinus ponderosa	11	27	0			
Pinus ponderosa	11	28	0			
Pinus ponderosa	11	29	0			
Pinus ponderosa	11	30	0			

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Shepherdia argentea	11	west border	1	66	4	
Shepherdia argentea	12	east border	1	50	4	
Symphoricarpos sp.	12	1	0			all leaves very dwarfed
Symphoricarpos sp.	12	2	1	62.0	7	all leaves very dwarfed
Symphoricarpos sp.	12	3	1	71.0	7	all leaves very dwarfed
Symphoricarpos sp.	12	4	0			all leaves very dwarfed
Symphoricarpos sp.	12	5	1	55.0	9	barely alive, leaves dwarfed
Symphoricarpos sp.	12	6	0			all leaves very dwarfed
Symphoricarpos sp.	12	7	0			all leaves very dwarfed
Symphoricarpos sp.	12	8	0			all leaves very dwarfed
Symphoricarpos sp.	12	9	0			all leaves very dwarfed
Symphoricarpos sp.	12	10	1	52.0	9	barely alive, leaves dwarfed
Symphoricarpos sp.	12	11	0			all leaves very dwarfed
Symphoricarpos sp.	12	12	0			all leaves very dwarfed
Symphoricarpos sp.	12	13	1	41.0	9	barely alive, leaves dwarfed
Symphoricarpos sp.	12	14	1	56.0	9	barely alive, leaves dwarfed
Symphoricarpos sp.	12	15	1	55.0	5	deer
Symphoricarpos sp.	12	16	1	56.0	9	barely alive
Symphoricarpos sp.	12	17	0			
Symphoricarpos sp.	12	18	1	52.0	6	
Symphoricarpos sp.	12	19	0			
Symphoricarpos sp.	12	20	1	60.0	9	barely alive
Symphoricarpos sp.	12	21	1	25.0	9	barely alive
Symphoricarpos sp.	12	22	0			
Symphoricarpos sp.	12	23	0			
Symphoricarpos sp.	12	24	0			
Symphoricarpos sp.	**12**	**25**	**0**		**7**	
Symphoricarpos sp.	12	26	0			
Symphoricarpos sp.	12	27	0			
Symphoricarpos sp.	12	28	0			
Symphoricarpos sp.	12	29	1	47.0	8	
Symphoricarpos sp.	12	30	0			
Shepherdia argentea	12	west border	1	46.0	4	
Shepherdia argentea	13	east border	1	55	4	*all species heavy browse*
Fraxinus pennsylvanica	13	1	1	36.0	8	stunted leaves
Fraxinus pennsylvanica	13	2	1	200.0	2	browsed
Fraxinus pennsylvanica	13	3	1	115.0	4	
Fraxinus pennsylvanica	13	4	1	93.0	4	
Fraxinus pennsylvanica	13	5	1	56.0	5	
Fraxinus pennsylvanica	13	6	1	122.0	4	
Fraxinus pennsylvanica	13	7	1	55.0	9	barely alive
Fraxinus pennsylvanica	13	8	1	86.0	4	
Fraxinus pennsylvanica	13	9	1	70.0	**5**	some leaf stunting
Fraxinus pennsylvanica	13	10	1	42.0	9	barely alive

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Fraxinus pennsylvanica	13	11	0			
Fraxinus pennsylvanica	13	12	1	84.0	**5**	
Fraxinus pennsylvanica	13	13	1	90.0	7	stunting leaf
Fraxinus pennsylvanica	13	14	1	96.0	7	stunting leaf
Fraxinus pennsylvanica	13	15	1	91.0	4	
Fraxinus pennsylvanica	13	16	1	76.0	8	stunting leaf
Fraxinus pennsylvanica	13	17	0			
Fraxinus pennsylvanica	13	18	1	92.0	5	
Fraxinus pennsylvanica	13	19	1	88.0	4	
Fraxinus pennsylvanica	13	20	1	101.0	4	
Fraxinus pennsylvanica	13	21	1	76.0	5	
Fraxinus pennsylvanica	13	22	1	95.0	5	
Fraxinus pennsylvanica	13	23	1	121.0	4	
Fraxinus pennsylvanica	13	24	1	68.0	4	
Fraxinus pennsylvanica	13	25	1	99.0	4	
Fraxinus pennsylvanica	13	26	1	112.0	4	
Fraxinus pennsylvanica	13	27	1	90.0	4	
Fraxinus pennsylvanica	13	28	1	68.0	5	
Fraxinus pennsylvanica	13	29	1	97.0	5	
Fraxinus pennsylvanica	13	30	1	66.0	6	
Shepherdia argentea	13	west border	1	52.0	4	browsed
Shepherdia argentea	14	east border	0			dead
Prunus americana	14	1	0			
Prunus americana	14	2	0			
Prunus americana	14	3	1	75.0	6	
Prunus americana	14	4	0			
Prunus americana	14	5	0			
Prunus americana	14	6	0			
Prunus americana	14	7	0			
Prunus americana	14	8	1	73.0	6	
Prunus americana	14	9	0			
Prunus americana	14	10	0			
Prunus americana	14	11	1	43.0	7	
Prunus americana	14	12	0			
Prunus americana	14	13	0			
Prunus americana	14	14	0			
Prunus americana	14	15	0			
Prunus americana	14	16	0			
Prunus americana	14	17	0			
Prunus americana	14	18	1	65.0	8	
Prunus americana	14	19	0			
Prunus americana	14	20	1	78.0	5	
Prunus americana	14	21	0			
Prunus americana	14	22	0			

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus americana	14	23	1	35.0	9	barely alive
Prunus americana	14	24	1	23.0	7	basal sprout
Prunus americana	14	25	0			
Prunus americana	14	26	0			
Prunus americana	14	27	0			
Prunus americana	14	28	0			
Prunus americana	14	29	0			
Prunus americana	14	30	0			
Shepherdia argentea	14	west border	0			
Shepherdia argentea	15	east border	NA			
Prunus besseyi	15	1	0			dead
Prunus besseyi	15	2	0			dead
Prunus besseyi	15	3	0			dead
Prunus besseyi	15	4	0			dead
Prunus besseyi	15	5	0			dead
Prunus besseyi	15	6	0			dead
Prunus besseyi	15	7	0			dead
Prunus besseyi	15	8	0			dead
Prunus besseyi	15	9	0			dead
Prunus besseyi	15	10	0			dead
Prunus besseyi	15	11	0			dead
Prunus besseyi	15	12	0			dead
Prunus besseyi	15	13	0			dead
Prunus besseyi	15	14	0			dead
Prunus besseyi	15	15	0			dead
Prunus besseyi	15	16	0			dead
Prunus besseyi	15	17	0			dead
Prunus besseyi	15	18	0			dead
Prunus besseyi	15	19	0			dead
Prunus besseyi	15	20	0			dead
Prunus besseyi	15	21	0			dead
Prunus besseyi	15	22	0			dead
Prunus besseyi	15	23	0			dead
Prunus besseyi	15	24	0			dead
Prunus besseyi	15	25	0			dead
Prunus besseyi	15	26	0			dead
Prunus besseyi	15	27	0			dead
Prunus besseyi	15	28	0			dead
Prunus besseyi	15	29	0			dead
Prunus besseyi	15	30	0			dead
Shepherdia argentea	15	west border	0			dead
Shepherdia argentea	16	east border	NA			
Rhus trilobata	16	1	1	25.0	7	stunted
Rhus trilobata	16	2	0			

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Rhus trilobata	16	3	0			all heavily browsed
Rhus trilobata	16	4	1	99.0	4	
Rhus trilobata	16	5	1	60.0	5	
Rhus trilobata	16	6	0			
Rhus trilobata	16	7	1	66.0	5	
Rhus trilobata	16	8	1	90.0	4	
Rhus trilobata	16	9	1	99.0	4	
Rhus trilobata	16	10	1	101.0	5	
Rhus trilobata	16	11	1	100.0	4	
Rhus trilobata	16	12	1	94.0	4	
Rhus trilobata	16	13	1	85.0	4	
Rhus trilobata	16	14	1	93.0	3	heavy browsing
Rhus trilobata	16	15	1	85.0	5	
Rhus trilobata	16	16	1	96.0	4	
Rhus trilobata	16	17	1	96.0	4	
Rhus trilobata	16	18	1	12.0	7	mowed/basal sprout
Rhus trilobata	16	19	0			
Rhus trilobata	16	20	0			
Rhus trilobata	16	21	1	95.0	4	
Rhus trilobata	16	22	1	84.0	4	
Rhus trilobata	16	23	1	49.0	5	
Rhus trilobata	16	24	1	6.0	8	basal sprout stunted
Rhus trilobata	16	25	0			
Rhus trilobata	16	26	0			
Rhus trilobata	16	27	0			
Rhus trilobata	16	28	0			
Rhus trilobata	16	29	0			
Rhus trilobata	16	30	1	70.0	4	
Shepherdia argentea	16	west border	1	46.0	4	
Shepherdia argentea	17	east border	NA			
Prunus tomentosa	17	1	0			
Prunus tomentosa	17	2	0			
Prunus tomentosa	17	3	0			
Prunus tomentosa	17	4	0			
Prunus tomentosa	17	5	0			
Prunus tomentosa	17	6	0			
Prunus tomentosa	17	7	1	40.0	9	barely alive
Prunus tomentosa	17	8	0			
Prunus tomentosa	17	9	1	32.0	8	
Prunus tomentosa	17	10	1	70.0	7	
Prunus tomentosa	17	11	1	15.0	9	barely alive
Prunus tomentosa	17	12	0			
Prunus tomentosa	17	13	0			
Prunus tomentosa	17	14	0			

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Prunus tomentosa	17	15	0			
Prunus tomentosa	17	16	1	16.0	9	barely alive
Prunus tomentosa	17	17	0			
Prunus tomentosa	17	18	0			dead
Prunus tomentosa	17	19	0			dead
Prunus tomentosa	17	20	0			dead
Prunus tomentosa	17	21	0			dead
Prunus tomentosa	17	22	0			dead
Prunus tomentosa	17	23	0			dead
Prunus tomentosa	17	24	0			dead
Prunus tomentosa	17	25	0			dead
Prunus tomentosa	17	26	0			dead
Prunus tomentosa	17	27	0			dead
Prunus tomentosa	17	28	0			dead
Prunus tomentosa	17	29	0			dead
Prunus tomentosa	17	30	0			dead
Shepherdia argentea	17	west border	1	40.0	5	
Shepherdia argentea	18	east border	NA			
Populus deltoides	18	1	0			dead
Populus deltoides	18	2	1	75.0	6	
Populus deltoides	18	3	1	165.0	4	
Populus deltoides	18	4	1	125.0	4	
Populus deltoides	18	5	1	146.0	4	
Populus deltoides	18	6	1	205.0	3	
Populus deltoides	18	7	1	220.0	3	
Populus deltoides	18	8	1	186.0	3	
Populus deltoides	18	9	1	210.0	3	
Populus deltoides	18	10	1	180.0	4	
Populus deltoides	18	11	1	240.0	2	
Populus deltoides	18	12	1	107.0	5	
Populus deltoides	18	13	1	195.0	3	
Populus deltoides	18	14	1	192.0	3	
Populus deltoides	18	15	1	180.0	4	
Populus deltoides	18	16	1	153.0	4	
Populus deltoides	18	17	1	200.0	3	
Populus deltoides	18	18	1	160.0	4	
Populus deltoides	18	19	1	95.0	5	
Populus deltoides	18	20	1	115.0	5	
Populus deltoides	18	21	1	230.0	3	
Populus deltoides	18	22	1	380.0	1	
Populus deltoides	18	23	1	310.0	1	
Populus deltoides	18	24	1	380.0	1	
Populus deltoides	18	25	1	240.0	3	
Populus deltoides	18	26	1	145.0	5	

Appendix 7. Plant evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	Fall Survival (0,1)	Fall Height *cm*	Fall Vigor Rating (1-9)	Comments
Populus deltoides	18	27	1	275.0	2	
Populus deltoides	18	28	1	245.0	3	
Populus deltoides	18	29	1	130.0	5	
Populus deltoides	18	30	1	145.0	4	
Shepherdia argentea	18	west border	1	53.0	5	heavily browsed

North end of plot

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
south end of plot				
Shepherdia argentea	1	east		
Shepherdia argentea	1	1	0.20	0.12
Shepherdia argentea	1	2	0.79	0.12
Shepherdia argentea	1	3	0.20	0.17
Shepherdia argentea	1	4	0.20	0.17
Shepherdia argentea	1	5	0.21	0.18
Shepherdia argentea	1	6	0.22	0.20
Shepherdia argentea	1	7	0.26	0.20
Shepherdia argentea	1	8	0.29	0.21
Shepherdia argentea	1	9	0.34	0.24
Shepherdia argentea	1	10	0.39	0.30
Shepherdia argentea	1	11	0.40	0.32
Shepherdia argentea	1	12	0.42	0.33
Shepherdia argentea	1	13	0.42	0.35
Shepherdia argentea	1	14	0.51	0.40
Shepherdia argentea	1	15	0.58	0.56
Shepherdia argentea	1	16	0.69	0.63
Shepherdia argentea	1	17	0.71	0.70
Shepherdia argentea	1	18	0.80	0.68
Shepherdia argentea	1	19	0.78	0.69
Shepherdia argentea	1	20	0.81	0.65
Shepherdia argentea	1	21	0.78	0.65
Shepherdia argentea	1	22	0.85	0.60
Shepherdia argentea	1	23	0.78	0.50
Shepherdia argentea	1	24	0.70	0.50
Shepherdia argentea	1	25	0.68	0.46
Shepherdia argentea	1	26	0.61	0.42
Shepherdia argentea	1	27	0.59	0.40
Shepherdia argentea	1	28	0.59	0.41
Shepherdia argentea	1	29	0.67	0.47
Shepherdia argentea	1	30	0.78	0.52
Shepherdia argentea	1	west		
Shepherdia argentea	2	east		
Prunus virginiana	2	1	0.19	0.15
Prunus virginiana	2	2	0.20	0.13
Prunus virginiana	2	3	0.20	0.13
Prunus virginiana	2	4	0.19	0.12
Prunus virginiana	2	5	0.20	0.13
Prunus virginiana	2	6	0.21	0.15
Prunus virginiana	2	7	0.20	0.16
Prunus virginiana	2	8	0.21	0.19
Prunus virginiana	2	9	0.23	0.20
Prunus virginiana	2	10	0.23	0.20

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Prunus virginiana	2	11	0.28	0.21
Prunus virginiana	2	12	0.29	0.22
Prunus virginiana	2	13	0.32	0.22
Prunus virginiana	2	14	0.39	0.29
Prunus virginiana	2	15	0.48	0.40
Prunus virginiana	2	16	0.61	0.49
Prunus virginiana	2	17	0.60	0.57
Prunus virginiana	2	18	0.60	0.42
Prunus virginiana	2	19	0.57	0.40
Prunus virginiana	2	20	0.51	0.39
Prunus virginiana	2	21	0.51	0.39
Prunus virginiana	2	22	0.51	0.40
Prunus virginiana	2	23	0.51	0.39
Prunus virginiana	2	24	0.51	0.40
Prunus virginiana	2	25	0.51	0.42
Prunus virginiana	2	26	0.61	0.40
Prunus virginiana	2	27	0.61	0.44
Prunus virginiana	2	28	0.54	0.40
Prunus virginiana	2	29	0.63	0.38
Prunus virginiana	2	30	0.61	0.42
Shepherdia argentea	2	west		
Shepherdia argentea	3	east		
Picea pungens	3	1	0.20	0.18
Picea pungens	3	2	0.19	0.18
Picea pungens	3	3	0.20	0.16
Picea pungens	3	4	0.20	0.12
Picea pungens	3	5	0.20	0.15
Picea pungens	3	6	0.21	0.18
Picea pungens	3	7	0.21	0.17
Picea pungens	3	8	0.21	0.20
Picea pungens	3	9	0.21	0.19
Picea pungens	3	10	0.22	0.20
Picea pungens	3	11	0.23	0.20
Picea pungens	3	12	0.29	0.20
Picea pungens	3	13	0.34	0.27
Picea pungens	3	14	0.41	0.39
Picea pungens	3	15	0.48	0.41
Picea pungens	3	16	0.46	0.39
Picea pungens	3	17	0.41	0.33
Picea pungens	3	18	0.40	0.28
Picea pungens	3	19	0.41	0.30
Picea pungens	3	20	0.39	0.33
Picea pungens	3	21	0.39	0.38
Picea pungens	3	22	0.46	0.42

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Picea pungens	3	23	0.49	0.50
Picea pungens	3	24	0.51	0.50
Picea pungens	3	25	0.51	0.49
Picea pungens	3	26	0.51	0.40
Picea pungens	3	27	0.55	0.40
Picea pungens	3	28	0.55	0.41
Picea pungens	3	29	0.50	0.41
Picea pungens	3	30	0.51	0.41
Shepherdia argentea	3	west		
Shepherdia argentea	4	east		
Lonicera korolkowii	4	1	0.20	0.15
Lonicera korolkowii	4	2	0.20	0.14
Lonicera korolkowii	4	3	0.20	0.14
Lonicera korolkowii	4	4	0.21	0.18
Lonicera korolkowii	4	5	0.21	0.17
Lonicera korolkowii	4	6	0.21	0.18
Lonicera korolkowii	4	7	0.21	0.17
Lonicera korolkowii	4	8	0.21	0.18
Lonicera korolkowii	4	9	0.21	0.18
Lonicera korolkowii	4	10	0.22	0.19
Lonicera korolkowii	4	11	0.23	0.20
Lonicera korolkowii	4	12	0.28	0.21
Lonicera korolkowii	4	13	0.28	0.20
Lonicera korolkowii	4	14	0.29	0.21
Lonicera korolkowii	4	15	0.30	0.22
Lonicera korolkowii	4	16	0.30	0.26
Lonicera korolkowii	4	17	0.31	0.26
Lonicera korolkowii	4	18	0.32	0.29
Lonicera korolkowii	4	19	0.32	0.32
Lonicera korolkowii	4	20	0.35	0.30
Lonicera korolkowii	4	21	0.39	0.33
Lonicera korolkowii	4	22	0.42	0.38
Lonicera korolkowii	4	23	0.45	0.41
Lonicera korolkowii	4	24	0.49	0.41
Lonicera korolkowii	4	25	0.51	0.40
Lonicera korolkowii	4	26	0.49	0.40
Lonicera korolkowii	4	27	0.53	0.38
Lonicera korolkowii	4	28	0.51	0.40
Lonicera korolkowii	4	29	0.51	0.37
Lonicera korolkowii	4	30	0.49	0.33
Shepherdia argentea	4	west		
Shepherdia argentea	5	east		
Elaeagnus commutata	5	1	0.19	0.15
Elaeagnus commutata	5	2	0.19	0.16

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Elaeagnus commutata	5	3	0.20	0.13
Elaeagnus commutata	5	4	0.19	0.13
Elaeagnus commutata	5	5	0.20	0.15
Elaeagnus commutata	5	6	0.20	0.13
Elaeagnus commutata	5	7	0.21	0.15
Elaeagnus commutata	5	8	0.21	0.17
Elaeagnus commutata	5	9	0.21	0.18
Elaeagnus commutata	5	10	0.22	0.18
Elaeagnus commutata	5	11	0.22	0.19
Elaeagnus commutata	5	12	0.25	0.20
Elaeagnus commutata	5	13	0.25	0.22
Elaeagnus commutata	5	14	0.29	0.24
Elaeagnus commutata	5	15	0.30	0.29
Elaeagnus commutata	5	16	0.32	0.29
Elaeagnus commutata	5	17	0.35	0.30
Elaeagnus commutata	5	18	0.41	0.31
Elaeagnus commutata	5	19	0.39	0.39
Elaeagnus commutata	5	20	0.42	0.40
Elaeagnus commutata	5	21	0.49	0.42
Elaeagnus commutata	5	22	0.49	0.47
Elaeagnus commutata	5	23	0.48	0.47
Elaeagnus commutata	5	24	0.43	0.40
Elaeagnus commutata	5	25	0.47	0.40
Elaeagnus commutata	5	26	0.46	0.37
Elaeagnus commutata	5	27	0.46	0.32
Elaeagnus commutata	5	28	0.41	0.30
Elaeagnus commutata	5	29	0.43	0.30
Elaeagnus commutata	5	30	0.48	0.39
Shepherdia argentea	5	west		
Shepherdia argentea	6	east		
Ribes aureum	6	1	0.16	0.11
Ribes aureum	6	2	0.18	0.12
Ribes aureum	6	3	0.19	0.14
Ribes aureum	6	4	0.19	0.18
Ribes aureum	6	5	0.20	0.15
Ribes aureum	6	6	0.20	0.15
Ribes aureum	6	7	0.21	0.17
Ribes aureum	6	8	0.21	0.18
Ribes aureum	6	9	0.21	0.19
Ribes aureum	6	10	0.23	0.19
Ribes aureum	6	11	0.24	0.19
Ribes aureum	6	12	0.26	0.21
Ribes aureum	6	13	0.28	0.21
Ribes aureum	6	14	0.29	0.21

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Ribes aureum	6	15	0.29	0.23
Ribes aureum	6	16	0.31	0.25
Ribes aureum	6	17	0.30	0.22
Ribes aureum	6	18	0.31	0.27
Ribes aureum	6	19	0.32	0.24
Ribes aureum	6	20	0.33	0.24
Ribes aureum	6	21	0.35	0.28
Ribes aureum	6	22	0.38	0.30
Ribes aureum	6	23	0.41	0.30
Ribes aureum	6	24	0.41	0.33
Ribes aureum	6	25	0.41	0.38
Ribes aureum	6	26	0.42	0.30
Ribes aureum	6	27	0.41	0.29
Ribes aureum	6	28	0.45	0.33
Ribes aureum	6	29	0.49	0.39
Ribes aureum	6	30	0.45	0.38
Shepherdia argentea	6	west		
Shepherdia argentea	7	east		
Hippophae rhamnoides	7	1	0.17	0.11
Hippophae rhamnoides	7	2	0.19	0.12
Hippophae rhamnoides	7	3	0.20	0.14
Hippophae rhamnoides	7	4	0.20	0.15
Hippophae rhamnoides	7	5	0.21	0.16
Hippophae rhamnoides	7	6	0.21	0.17
Hippophae rhamnoides	7	7	0.21	0.18
Hippophae rhamnoides	7	8	0.21	0.19
Hippophae rhamnoides	7	9	0.22	0.20
Hippophae rhamnoides	7	10	0.22	0.21
Hippophae rhamnoides	7	11	0.25	0.21
Hippophae rhamnoides	7	12	0.27	0.21
Hippophae rhamnoides	7	13	0.25	0.20
Hippophae rhamnoides	7	14	0.26	0.20
Hippophae rhamnoides	7	15	0.28	0.20
Hippophae rhamnoides	7	16	0.25	0.20
Hippophae rhamnoides	7	17	0.26	0.20
Hippophae rhamnoides	7	18	0.25	0.20
Hippophae rhamnoides	7	19	0.29	0.19
Hippophae rhamnoides	7	20	0.29	0.20
Hippophae rhamnoides	7	21	0.30	0.21
Hippophae rhamnoides	7	22	0.30	0.20
Hippophae rhamnoides	7	23	0.31	0.20
Hippophae rhamnoides	7	24	0.31	0.20
Hippophae rhamnoides	7	25	0.30	0.21
Hippophae rhamnoides	7	26	0.31	0.20

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Hippophae rhamnoides	7	27	0.31	0.20
Hippophae rhamnoides	7	28	0.33	0.22
Hippophae rhamnoides	7	29	0.35	0.28
Hippophae rhamnoides	7	30	0.42	0.31
Shepherdia argentea	7	west		
Shepherdia argentea	8	east		
Elaeagnus angustifolia	8	1	0.19	0.13
Elaeagnus angustifolia	8	2	0.20	0.15
Elaeagnus angustifolia	8	3	0.19	0.17
Elaeagnus angustifolia	8	4	0.20	0.18
Elaeagnus angustifolia	8	5	0.19	0.18
Elaeagnus angustifolia	8	6	0.21	0.14
Elaeagnus angustifolia	8	7	0.20	0.13
Elaeagnus angustifolia	8	8	0.20	0.16
Elaeagnus angustifolia	8	9	0.22	0.20
Elaeagnus angustifolia	8	10	0.27	0.21
Elaeagnus angustifolia	8	11	0.28	0.23
Elaeagnus angustifolia	8	12	0.28	0.28
Elaeagnus angustifolia	8	13	0.29	0.23
Elaeagnus angustifolia	8	14	0.28	0.22
Elaeagnus angustifolia	8	15	0.28	0.21
Elaeagnus angustifolia	8	16	0.26	0.18
Elaeagnus angustifolia	8	17	0.28	0.20
Elaeagnus angustifolia	8	18	0.28	0.20
Elaeagnus angustifolia	8	19	0.28	0.20
Elaeagnus angustifolia	8	20	0.29	0.20
Elaeagnus angustifolia	8	21	0.29	0.20
Elaeagnus angustifolia	8	22	0.28	0.19
Elaeagnus angustifolia	8	23	0.29	0.20
Elaeagnus angustifolia	8	24	0.29	0.21
Elaeagnus angustifolia	8	25	0.30	0.20
Elaeagnus angustifolia	8	26	0.30	0.20
Elaeagnus angustifolia	8	27	0.31	0.22
Elaeagnus angustifolia	8	28	0.38	0.29
Elaeagnus angustifolia	8	29	0.42	0.38
Elaeagnus angustifolia	8	30	0.51	0.49
Shepherdia argentea	8	west		
Shepherdia argentea	9	east		
Caragana arborescens	9	1	0.19	0.15
Caragana arborescens	9	2	0.20	0.16
Caragana arborescens	9	3	0.19	0.13
Caragana arborescens	9	4	0.19	0.12
Caragana arborescens	9	5	0.19	0.16
Caragana arborescens	9	6	0.20	0.16

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Caragana arborescens	9	7	0.21	0.19
Caragana arborescens	9	8	0.21	0.20
Caragana arborescens	9	9	0.22	0.20
Caragana arborescens	9	10	0.21	0.20
Caragana arborescens	9	11	0.22	0.19
Caragana arborescens	9	12	0.22	0.19
Caragana arborescens	9	13	0.25	0.19
Caragana arborescens	9	14	0.22	0.20
Caragana arborescens	9	15	0.24	0.20
Caragana arborescens	9	16	0.22	0.19
Caragana arborescens	9	17	0.24	0.20
Caragana arborescens	9	18	0.28	0.21
Caragana arborescens	9	19	0.27	0.20
Caragana arborescens	9	20	0.29	0.19
Caragana arborescens	9	21	0.29	0.19
Caragana arborescens	9	22	0.29	0.20
Caragana arborescens	9	23	0.29	0.21
Caragana arborescens	9	24	0.30	0.21
Caragana arborescens	9	25	0.30	0.21
Caragana arborescens	9	26	0.32	0.26
Caragana arborescens	9	27	0.35	0.27
Caragana arborescens	9	28	0.40	0.29
Caragana arborescens	9	29	0.48	0.40
Caragana arborescens	9	30	0.52	0.51
Shepherdia argentea	9	west		
Shepherdia argentea	10	east		
Ulmus pumila	10	1	0.19	0.11
Ulmus pumila	10	2	0.19	0.12
Ulmus pumila	10	3	0.20	0.16
Ulmus pumila	10	4	0.20	0.17
Ulmus pumila	10	5	0.21	0.18
Ulmus pumila	10	6	0.21	0.18
Ulmus pumila	10	7	0.21	0.20
Ulmus pumila	10	8	0.21	0.20
Ulmus pumila	10	9	0.21	0.20
Ulmus pumila	10	10	0.22	0.20
Ulmus pumila	10	11	0.21	0.21
Ulmus pumila	10	12	0.21	0.21
Ulmus pumila	10	13	0.22	0.21
Ulmus pumila	10	14	0.23	0.21
Ulmus pumila	10	15	0.23	0.22
Ulmus pumila	10	16	0.25	0.22
Ulmus pumila	10	17	0.25	0.22
Ulmus pumila	10	18	0.28	0.23

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Ulmus pumila	10	19	0.28	0.21
Ulmus pumila	10	20	0.29	0.22
Ulmus pumila	10	21	0.30	0.24
Ulmus pumila	10	22	0.30	0.27
Ulmus pumila	10	23	0.30	0.27
Ulmus pumila	10	24	0.30	0.23
Ulmus pumila	10	25	0.31	0.25
Ulmus pumila	10	26	0.35	0.30
Ulmus pumila	10	27	0.38	0.37
Ulmus pumila	10	28	0.42	0.40
Ulmus pumila	10	29	0.47	0.47
Ulmus pumila	10	30	0.48	0.40
Shepherdia argentea	10	west		
Shepherdia argentea	11	east		
Pinus ponderosa	11	1	0.18	0.12
Pinus ponderosa	11	2	0.20	0.12
Pinus ponderosa	11	3	0.20	0.17
Pinus ponderosa	11	4	0.20	0.19
Pinus ponderosa	11	5	0.21	0.19
Pinus ponderosa	11	6	0.21	0.18
Pinus ponderosa	11	7	0.21	0.18
Pinus ponderosa	11	8	0.21	0.18
Pinus ponderosa	11	9	0.22	0.19
Pinus ponderosa	11	10	0.22	0.18
Pinus ponderosa	11	11	0.21	0.19
Pinus ponderosa	11	12	0.21	0.18
Pinus ponderosa	11	13	0.21	0.19
Pinus ponderosa	11	14	0.22	0.20
Pinus ponderosa	11	15	0.23	0.19
Pinus ponderosa	11	16	0.26	0.20
Pinus ponderosa	11	17	0.25	0.21
Pinus ponderosa	11	18	0.29	0.21
Pinus ponderosa	11	19	0.29	0.21
Pinus ponderosa	11	20	0.30	0.22
Pinus ponderosa	11	21	0.31	0.24
Pinus ponderosa	11	22	0.30	0.28
Pinus ponderosa	11	23	0.31	0.24
Pinus ponderosa	11	24	0.32	0.26
Pinus ponderosa	11	25	0.32	0.28
Pinus ponderosa	11	26	0.33	0.28
Pinus ponderosa	11	27	0.33	0.30
Pinus ponderosa	11	28	0.38	0.28
Pinus ponderosa	11	29	0.37	0.30
Pinus ponderosa	11	30	0.35	0.30

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Shepherdia argentea	11	west		
Shepherdia argentea	12	east		
Symphoricarpos sp.	12	1	0.19	0.19
Symphoricarpos sp.	12	2	0.20	0.19
Symphoricarpos sp.	12	3	0.21	0.19
Symphoricarpos sp.	12	4	0.21	0.18
Symphoricarpos sp.	12	5	0.20	0.18
Symphoricarpos sp.	12	6	0.20	0.19
Symphoricarpos sp.	12	7	0.21	0.14
Symphoricarpos sp.	12	8	0.21	0.15
Symphoricarpos sp.	12	9	0.20	0.15
Symphoricarpos sp.	12	10	0.21	0.15
Symphoricarpos sp.	12	11	0.21	0.17
Symphoricarpos sp.	12	12	0.21	0.20
Symphoricarpos sp.	12	13	0.22	0.20
Symphoricarpos sp.	12	14	0.23	0.19
Symphoricarpos sp.	12	15	0.25	0.20
Symphoricarpos sp.	12	16	0.27	0.21
Symphoricarpos sp.	12	17	0.29	0.23
Symphoricarpos sp.	12	18	0.30	0.24
Symphoricarpos sp.	12	19	0.30	0.25
Symphoricarpos sp.	12	20	0.31	0.25
Symphoricarpos sp.	12	21	0.31	0.25
Symphoricarpos sp.	12	22	0.31	0.25
Symphoricarpos sp.	12	23	0.32	0.27
Symphoricarpos sp.	12	24	0.31	0.27
Symphoricarpos sp.	12	25	0.31	0.27
Symphoricarpos sp.	12	26	0.32	0.27
Symphoricarpos sp.	12	27	0.33	0.24
Symphoricarpos sp.	12	28	0.32	0.23
Symphoricarpos sp.	12	29	0.31	0.25
Symphoricarpos sp.	12	30	0.31	0.26
Shepherdia argentea	12	west		
Shepherdia argentea	13	east		
Fraxinus pennsylvanica	13	1	0.20	0.20
Fraxinus pennsylvanica	13	2	0.21	0.19
Fraxinus pennsylvanica	13	3	0.20	0.18
Fraxinus pennsylvanica	13	4	0.21	0.18
Fraxinus pennsylvanica	13	5	0.21	0.18
Fraxinus pennsylvanica	13	6	0.20	0.17
Fraxinus pennsylvanica	13	7	0.20	0.15
Fraxinus pennsylvanica	13	8	0.21	0.17
Fraxinus pennsylvanica	13	9	0.21	0.18
Fraxinus pennsylvanica	13	10	0.21	0.19

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Fraxinus pennsylvanica	13	11	0.21	0.20
Fraxinus pennsylvanica	13	12	0.21	0.20
Fraxinus pennsylvanica	13	13	0.23	0.20
Fraxinus pennsylvanica	13	14	0.25	0.20
Fraxinus pennsylvanica	13	15	0.25	0.20
Fraxinus pennsylvanica	13	16	0.28	0.22
Fraxinus pennsylvanica	13	17	0.28	0.22
Fraxinus pennsylvanica	13	18	0.29	0.23
Fraxinus pennsylvanica	13	19	0.30	0.23
Fraxinus pennsylvanica	13	20	0.30	0.22
Fraxinus pennsylvanica	13	21	0.31	0.22
Fraxinus pennsylvanica	13	22	0.31	0.22
Fraxinus pennsylvanica	13	23	0.30	0.21
Fraxinus pennsylvanica	13	24	0.30	0.21
Fraxinus pennsylvanica	13	25	0.30	0.21
Fraxinus pennsylvanica	13	26	0.31	0.21
Fraxinus pennsylvanica	13	27	0.31	0.21
Fraxinus pennsylvanica	13	28	0.30	0.21
Fraxinus pennsylvanica	13	29	0.31	0.22
Fraxinus pennsylvanica	13	30	0.36	0.23
Shepherdia argentea	13	west		
Shepherdia argentea	14	east		
Prunus americana	14	1	0.25	0.20
Prunus americana	14	2	0.22	0.21
Prunus americana	14	3	0.23	0.21
Prunus americana	14	4	0.25	0.21
Prunus americana	14	5	0.21	0.20
Prunus americana	14	6	0.20	0.18
Prunus americana	14	7	0.20	0.17
Prunus americana	14	8	0.21	0.18
Prunus americana	14	9	0.20	0.17
Prunus americana	14	10	0.20	0.17
Prunus americana	14	11	0.21	0.18
Prunus americana	14	12	0.21	0.19
Prunus americana	14	13	0.23	0.20
Prunus americana	14	14	0.25	0.21
Prunus americana	14	15	0.26	0.22
Prunus americana	14	16	0.28	0.22
Prunus americana	14	17	0.28	0.22
Prunus americana	14	18	0.29	0.21
Prunus americana	14	19	0.29	0.22
Prunus americana	14	20	0.29	0.21
Prunus americana	14	21	0.29	0.21
Prunus americana	14	22	0.28	0.20

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Prunus americana	14	23	0.29	0.20
Prunus americana	14	24	0.30	0.21
Prunus americana	14	25	0.30	0.21
Prunus americana	14	26	0.32	0.22
Prunus americana	14	27	0.31	0.25
Prunus americana	14	28	0.34	0.23
Prunus americana	14	29	0.36	0.23
Prunus americana	14	30	0.40	0.25
Shepherdia argentea	14	west		
Shepherdia argentea	15	east		
Prunus besseyi	15	1	0.21	0.19
Prunus besseyi	15	2	0.21	0.18
Prunus besseyi	15	3	0.21	0.18
Prunus besseyi	15	4	0.20	0.15
Prunus besseyi	15	5	0.21	0.16
Prunus besseyi	15	6	0.21	0.18
Prunus besseyi	15	7	0.21	0.18
Prunus besseyi	15	8	0.21	0.18
Prunus besseyi	15	9	0.21	0.19
Prunus besseyi	15	10	0.21	0.19
Prunus besseyi	15	11	0.21	0.20
Prunus besseyi	15	12	0.23	0.20
Prunus besseyi	15	13	0.27	0.20
Prunus besseyi	15	14	0.27	0.20
Prunus besseyi	15	15	0.28	0.21
Prunus besseyi	15	16	0.27	0.21
Prunus besseyi	15	17	0.28	0.23
Prunus besseyi	15	18	0.28	0.20
Prunus besseyi	15	19	0.28	0.20
Prunus besseyi	15	20	0.29	0.21
Prunus besseyi	15	21	0.29	0.21
Prunus besseyi	15	22	0.30	0.22
Prunus besseyi	15	23	0.30	0.25
Prunus besseyi	15	24	0.31	0.25
Prunus besseyi	15	25	0.34	0.25
Prunus besseyi	15	26	0.38	0.29
Prunus besseyi	15	27	0.39	0.30
Prunus besseyi	15	28	0.40	0.30
Prunus besseyi	15	29	0.42	0.30
Prunus besseyi	15	30	0.42	0.30
Shepherdia argentea	15	west		
Shepherdia argentea	16	east		
Rhus trilobata	16	1	0.21	0.20
Rhus trilobata	16	2	0.21	0.20

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Rhus trilobata	16	3	0.21	0.19
Rhus trilobata	16	4	0.21	0.19
Rhus trilobata	16	5	0.21	0.20
Rhus trilobata	16	6	0.21	0.21
Rhus trilobata	16	7	0.21	0.21
Rhus trilobata	16	8	0.21	0.20
Rhus trilobata	16	9	0.22	0.21
Rhus trilobata	16	10	0.22	0.20
Rhus trilobata	16	11	0.22	0.21
Rhus trilobata	16	12	0.22	0.20
Rhus trilobata	16	13	0.25	0.20
Rhus trilobata	16	14	0.25	0.20
Rhus trilobata	16	15	0.26	0.21
Rhus trilobata	16	16	0.27	0.21
Rhus trilobata	16	17	0.28	0.21
Rhus trilobata	16	18	0.28	0.21
Rhus trilobata	16	19	0.30	0.22
Rhus trilobata	16	20	0.31	0.26
Rhus trilobata	16	21	0.32	0.27
Rhus trilobata	16	22	0.32	0.28
Rhus trilobata	16	23	0.38	0.29
Rhus trilobata	16	24	0.38	0.30
Rhus trilobata	16	25	0.39	0.29
Rhus trilobata	16	26	0.40	0.30
Rhus trilobata	16	27	0.43	0.32
Rhus trilobata	16	28	0.41	0.31
Rhus trilobata	16	29	0.41	0.31
Rhus trilobata	16	30	0.42	0.31
Shepherdia argentea	16	west		
Shepherdia argentea	17	east		
Prunus tomentosa	17	1	0.21	0.21
Prunus tomentosa	17	2	0.21	0.21
Prunus tomentosa	17	3	0.22	0.21
Prunus tomentosa	17	4	0.21	0.20
Prunus tomentosa	17	5	0.21	0.20
Prunus tomentosa	17	6	0.21	0.20
Prunus tomentosa	17	7	0.21	0.20
Prunus tomentosa	17	8	0.22	0.20
Prunus tomentosa	17	9	0.22	0.21
Prunus tomentosa	17	10	0.22	0.21
Prunus tomentosa	17	11	0.23	0.21
Prunus tomentosa	17	12	0.25	0.21
Prunus tomentosa	17	13	0.28	0.21
Prunus tomentosa	17	14	0.29	0.21

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Prunus tomentosa	17	15	0.29	0.21
Prunus tomentosa	17	16	0.30	0.22
Prunus tomentosa	17	17	0.30	0.22
Prunus tomentosa	17	18	0.31	0.25
Prunus tomentosa	17	19	0.34	0.28
Prunus tomentosa	17	20	0.33	0.28
Prunus tomentosa	17	21	0.33	0.28
Prunus tomentosa	17	22	0.35	0.28
Prunus tomentosa	17	23	0.35	0.28
Prunus tomentosa	17	24	0.33	0.30
Prunus tomentosa	17	25	0.38	0.28
Prunus tomentosa	17	26	0.38	0.29
Prunus tomentosa	17	27	0.39	0.30
Prunus tomentosa	17	28	0.39	0.30
Prunus tomentosa	17	29	0.39	0.30
Prunus tomentosa	17	30	0.39	0.30
Shepherdia argentea	17	west		
Shepherdia argentea	18	east		
Populus deltoides	18	1	0.21	0.20
Populus deltoides	18	2	0.21	0.19
Populus deltoides	18	3	0.21	0.19
Populus deltoides	18	4	0.21	0.19
Populus deltoides	18	5	0.21	0.19
Populus deltoides	18	6	0.21	0.19
Populus deltoides	18	7	0.22	0.20
Populus deltoides	18	8	0.22	0.20
Populus deltoides	18	9	0.23	0.22
Populus deltoides	18	10	0.27	0.21
Populus deltoides	18	11	0.28	0.21
Populus deltoides	18	12	0.28	0.22
Populus deltoides	18	13	0.30	0.23
Populus deltoides	18	14	0.29	0.23
Populus deltoides	18	15	0.30	0.21
Populus deltoides	18	16	0.30	0.22
Populus deltoides	18	17	0.30	0.22
Populus deltoides	18	18	0.30	0.27
Populus deltoides	18	19	0.31	0.24
Populus deltoides	18	20	0.30	0.23
Populus deltoides	18	21	0.30	0.21
Populus deltoides	18	22	0.30	0.22
Populus deltoides	18	23	0.30	0.23
Populus deltoides	18	24	0.30	0.21
Populus deltoides	18	25	0.30	0.22
Populus deltoides	18	26	0.31	0.22

Appendix 8. Soil evaluation data, woody plant salinity tolerance study MT-06-0002, 2009, Bridger, MT.

Species	Row No.	Row Position	EM-38 Reading vertical ground	EM-38 Reading horizontal ground
Populus deltoides	18	27	0.31	0.26
Populus deltoides	18	28	0.32	0.27
Populus deltoides	18	29	0.31	0.28
Populus deltoides	18	30	0.32	0.23
Shepherdia argentea	18	west		

North end of plot

Study Title: Effects of Pre- and Post-Emergence Herbicides on the Establishment and Seed Production of Native Wildflowers

Study Number: MT-06-0001

Objective: Evaluate the effects of pre- and post-emergence herbicides on seedling emergence, stand establishment, and seed production of desirable wildflower species and control of undesirable broadleaf species

Project Description: There is great interest in incorporating native wildflowers into seed mixtures for conservation plantings and disturbed land revegetation projects. Wildflower seed traditionally has been unavailable or wildland-collected from limited locations in the U.S., as well as introduced from foreign sources. The increase in demand for improving species diversity by utilizing locally adapted material has resulted in large-scale agronomic seed production of native wildflowers. Along with the effort to supply wildflower seed from the commercial seed industry to the end users comes the requirement to provide information on the cultivation and management of these species.

The successful establishment of many of these species is difficult, in part due to competition with weeds for water, sunlight, and nourishment, exasperated by the slow germination, emergence, and establishment of most native species. Weed competition during establishment is an important factor in the failure of wildflower seed production fields. One of the biggest problems associated with growing herbaceous species is a lack of chemical herbicides labeled specifically for broadleaf weed control in wildflower seed production fields. Testing pre-emergence herbicide management specific to wildflower species is important in the critical early establishment period. In addition, the repeated use of a specific active ingredient may result in weed tolerance and resistance to chemical applications. Herbicide products must be adequately tested and proven effective prior to applying for 24C special-use herbicide labeling.

Unlike the marketing of non-native species by the commercial floriculture industry, seed producers need to gain scientific, technical, and practical knowledge on a great number of native wildflowers for their successful seed production. There is a lack of species-specific seed production information in many aspects of native forb seed production such as seed dormancy, seeding techniques, seedling emergence, plant growth and development, biomass and seed production characteristics, stand management, and seed handling and storage.

As private, state, and federal entities strive to meet ever-more stringent regulations in re-establishing native plant communities, there is a need to assess the long-term impacts of herbicides on the environment. This includes, but is not limited to, the processes associated with ecological structure and function, nutrient cycling, edaphic stability, plant community dynamics, and resilience to invasive species.

Since 1998, the Bridger PMC has field- and greenhouse-tested a variety of herbicides to control broadleaf weeds in wildflower seed production fields. The results of these previous experiments have led to the implementation of a two-phase field study—the first will evaluate the effect of pre-emergence herbicides on seedling establishment; and the second will evaluate the effects of post-emergence herbicides on seed production and the long-term control of undesirable species. The second study phase addresses the environmental issues by examining a variety of herbicide treatments, their effects on several native wildflower species and successive crops.

Methods and Materials: In spring 2005, a fallow area at the PMC in Field 1 was seeded to barley, periodically irrigated, sprayed with chemicals to control weeds, and harvested as a hay crop. In the fall, the area was prepared for planting with a disk, roller-harrow, and land plane. On November 22, a Kincaid Precision Cone Planter was used to install two adjacent plots, pre-emergence (Phase I, see detailed information in BPMC's Technical Reports 2004-2005 and 2006-2007) and post-emergence (Phase II), each layout a mirror-image of the other.

The six native wildflowers were each seeded in four rows with 1-ft. (0.3-m) spacing at 25 PLS seeds/ft. (82 PLS seeds/m) and are listed in Table 1**.** Seeding depth of the western yarrow was 0.35 in. (9 mm), while the other six species were seeded at a depth of 0.45 in. (11 mm).

Table 1. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The seven wildflower species, seed viability, purity, and percentage pure-live-seed used in the pre- and post-emergence herbicide study; planted November 22, 2005, in Field 1 at the Bridger PMC.

Genus and Species	Common Name	Viability	Purity	PLS[†]
		%	*%*	*%*
Achillea millefolium var. *occidentalis*	western yarrow	86	93.91	80.76
Dalea candida	white prairieclover	90	99.65	89.68
Gaillardia aristata	blanketflower	83	86.81	72.10
Liatris punctata 2005 seed lot[‡]	dotted gayfeather	83	93.11	77.28
Liatris punctata 2004 seed lot[‡]	dotted gayfeather	79	97.30	76.87
Penstemon eriantherus	fuzzytongue penstemon	64	91.20	58.37
Phacelia hastata	silverleaf phacelia	84	97.41	81.82
Ratibida columnifera	prairie coneflower	98	99.11	97.13

[†] Pure-Live-Seed.
[‡] Approximately 50%.

Phase II North Half—2008. The post-emergence herbicides were recommended by weed scientists, and efficacy rates for the target weeds were determined in collaboration with representatives of several major chemical companies (Table 2). On May 28, 2008, each chemical was added to 540 ml (0.14 gal) water and the post-emergence herbicide treatments were applied on the north plots using a CO_2 backpack sprayer with a 2.1-meter (7-ft) wide boom at an approximate pressure of 20 pounds-per-square-inch (Figure 1). On the same day, clethodim was applied at the rate of 0.56 kg/ha (8 oz/acre) to control grassy weeds.

Table 2. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The trade names, active ingredients, modes of action, and application rates of the six post-emergence herbicides applied May 28, 2008, in Field 1 at the Bridger PMC.

Trade Name	Active Ingredient	Mechanism of Action	Application Rate
Lorox®	linuron 50%	Photosynthetic inhibitor	1.7 kg a.i. $^{-}$ha (1.5 lb/ac)
Pennant Magnum™	*S*-metolachlor 87.3%	Mitosis (root and shoot) inhibitor	2.3 l a.i. $^{-}$ha (2 pt/ac)
Permit®	halsulfuron 75%	Acetolactate synthase inhibitor	0.07 kg a.i. $^{-}$ha (1 oz/ac)
Plateau®	imazapic 23.6%	Acetolactate synthase inhibitor	0.42 kg a.i. $^{-}$ha (6 oz/ac)
Prowl® H_2O	pendimethalin 38.7%	Microtubule assembly inhibitor	2.3 l a.i. $^{-}$ha (2 pt/ac)
Mix Plateau® and	imazapic 23.6%	Acetolactate synthase inhibitor	0.28 kg a.i. $^{-}$ha (4 oz/ac)
	pendimethalin 38.7%	Microtubule assembly inhibitor	2.3 l a.i. $^{-}$ha (2 pt/ac)

Multiple seed harvest days per species began with silverleaf phacelia on July 16, and progressed to blanketflower and fuzzytongue penstemon on August 4, prairie coneflower on August 25, slender white prairie clover on September 17, and dotted gayfeather on September 30. On September 30, an evaluation was conducted to determine densities of desirable and undesirable species. The counts were performed on 1 meter (3.3 ft.) of row length in each of the middle two rows. An evaluation was not conducted on *Achillea millefolium* var. *occidentalis* as establishment remained extremely low. Seed harvest of *Liatris punctata* was concluded on October 27.

The experimental design was a randomized complete block design with three replications. The Linear Model procedure in the Statistix 8.0 system was used to conduct an analysis of variance (ANOVA). Mean separation was conducted with the LSD test, a less conservative measure.

Results: In 2008, 147 plots were treated with post-emergent herbicides. Seed was harvested in 112 plots. Density data for desirable and non-desirable species, and seed weights, are reported in Appendix Table 1. Tetrazolium tests were not conducted due to budgetary constraints. Mean data for all treatments and all species are reported in Appendix Table 2. Relative comparisons of the 2008 results are made in the following graphs to data from 2007. For additional information refer to the Bridger PMC's 2006-2007 Technical Report, pages 134-167.

Dalea candida DACA7 white prairie clover. There were no significant differences in white prairie clover (Table 3) or weedy grass (shown in Appendix Table 2) mean seedling densities among treatments. Broadleaf weed densities were lowest in plots treated with imazapic and weeds were significantly higher in plots treated with s-metolachlor (Figure 2). The plots treated with imazapic and linuron had significantly lower seed production than in the other treatments (Figure 3).

Table 3. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half mean plant densities and seed production for *Dalea candida* in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment	DACA7	Broadleaf Weed	Seed Production
	plt/0.3 m^2	*plt/0.3 m^2*	*gr/0.3 m^2*
Control	6.5 a*	3.6 ab*	9.0 ab*
Linuron	8.8 a	4.5 ab	5.6 b
S-metolachlor	6.0 a	5.1 b	6.7 ab
Halsulfuron	5.8 a	3.3 ab	11.3 a
Imazapic	4.7 a	2.6 a	6.1 b
Pendimethalin	7.8 a	4.1 ab	9.2 ab
Mix: Imazapic +pendimethalin	6.8 a	3.5 ab	8.0 ab
% CV	43.61	35.77	34.71

* LSD test—means not significantly different at p<0.05 confidence level.

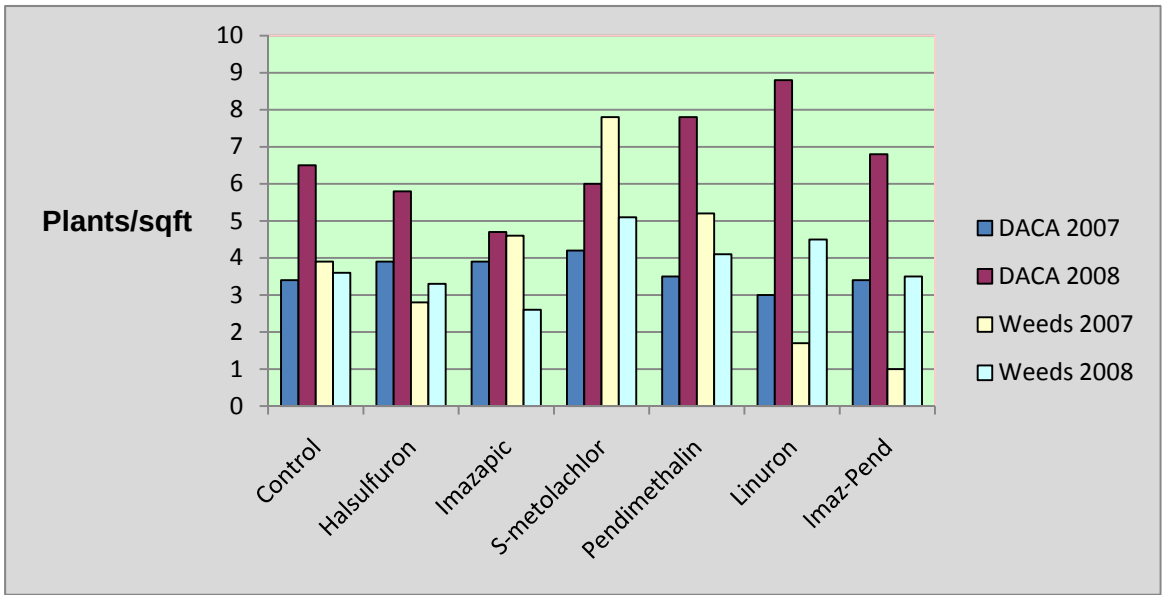


Figure 2. The 2007 and 2008 seedling densities of *Dalea candida* and broadleaf weeds as affected by herbicide treatment.

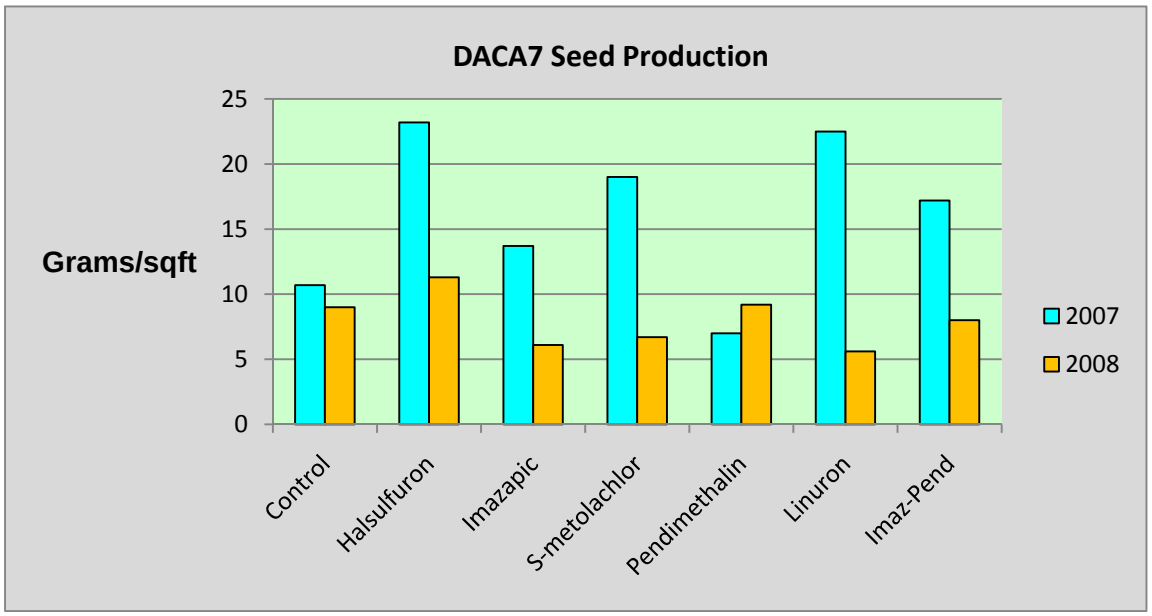


Figure 3. The 2007 and 2008 seed production of *Dalea candida* as affected by herbicide treatment.

Gaillardia aristata GAAR blanketflower. There were no significant differences in blanketflower (Table 4) or weedy grass (shown in Appendix Table 2) mean seedling densities among treatments. Broadleaf weed densities were lowest in plots treated with s-metolachlor and weeds were significantly greater in plots treated with pendimethalin (Figure 4). Plots treated with s-metolachlor had significantly less seed production (Figure 5).

Table 4. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half mean plant densities and seed production for *Gaillardia aristata* in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment	GAAR	Broadleaf Weed	Seed Production
	plt/0.3 m^2	*plt/0.3 m^2*	*gr/0.3 m^2*
Control	6.5 a*	3.5 ab*	17.6 abc*
Linuron	8.5 a	4.6 ab	18.2 abc
S-metolachlor	6.5 a	3.3 a	10.9 c
Halsulfuron	9.8 a	4.9 ab	22.3 ab
Imazapic	9.5 a	4.9 ab	12.5 bc
Pendimethalin	9.8 a	5.0 b	23.4 a
Mix: Imazapic +pendimethalin	9.3 a	4.8 ab	13.1 bc
% CV	22.59	22.02	33.92

* LSD test--means followed by the same letter are not significantly different at p<0.05.

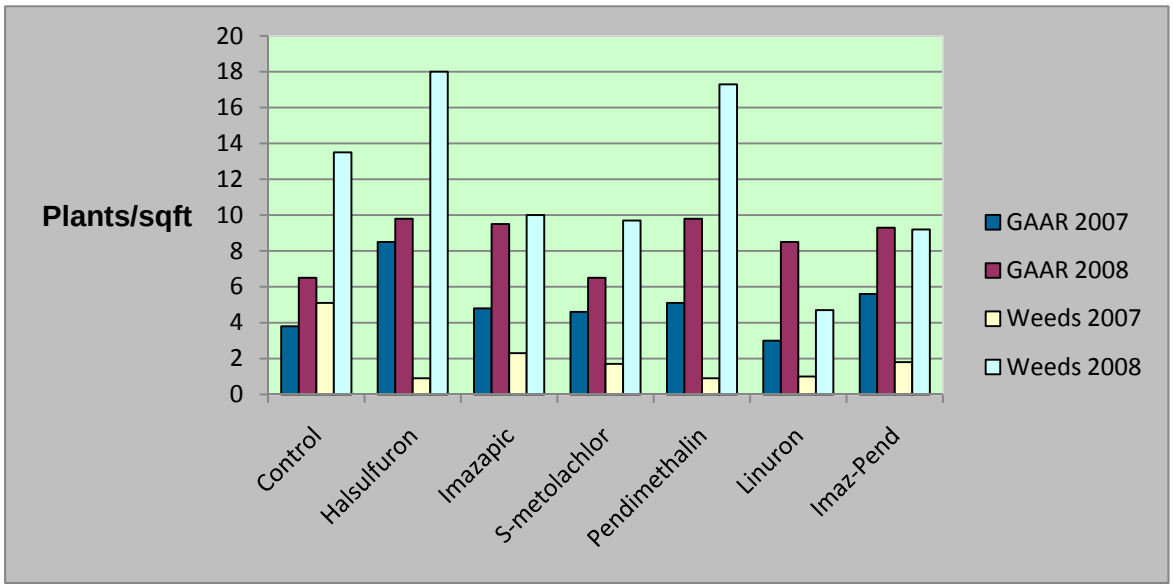


Figure 4. The 2007 and 2008 seedling densities of *Gaillardia aristata* and broadleaf weeds as affected by herbicide treatment.

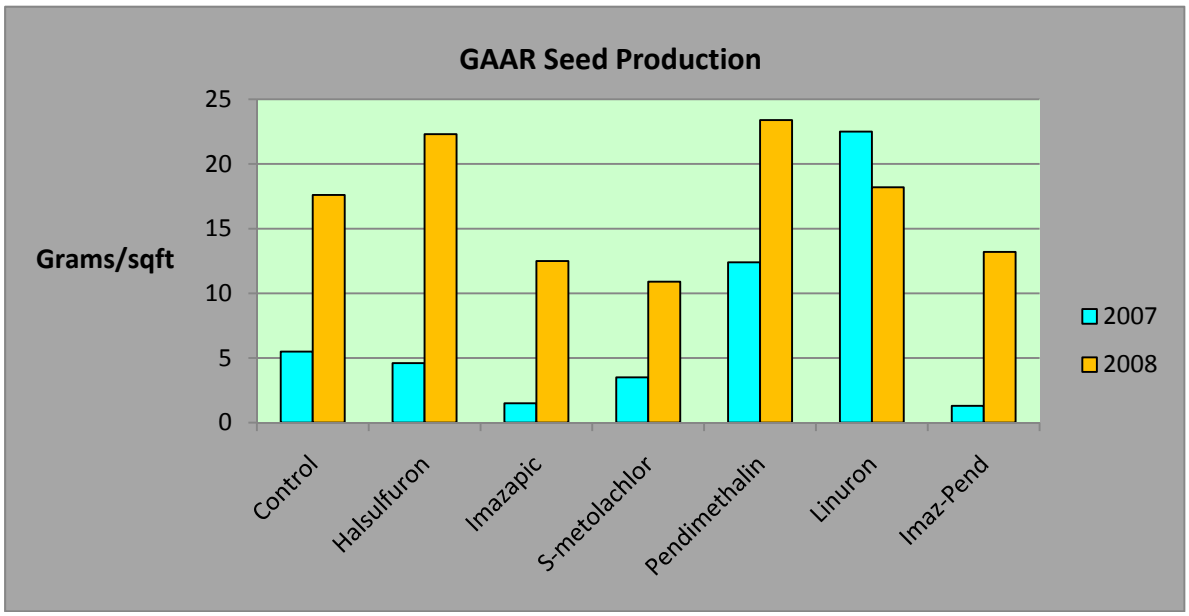


Figure 5. The 2007 and 2008 seed production of *Gaillardia aristata* as affected by herbicide treatment.

Liatris punctata LIPU dotted gayfeather.

There were no significant differences in dotted gayfeather (Table 5) or weedy grass (shown in Appendix Table 2) mean seedling densities among treatments. In 2008, broadleaf weed densities were lowest in plots treated with linuron, but not significantly different from those in five other treatments (Figure 6). Plots treated with halsulfuron and pendimethalin had significantly greater broadleaf weed densities than the other treatments. Plots treated with s-metolachlor had significantly lower seed production when compared to halsulfuron (Figure 7).

Table 5. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half mean plant densities and seed production for *Liatris punctata* in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment	LIPU	Broadleaf Weed	Seed Production
	plt/0.3 m²	*plt/0.3 m²*	*gr/0.3 m²*
Control	7.7 a*	13.5 ab*	4.8 ab*
Linuron	10.3 a	4.5 a	3.3 ab
S-metolachlor	8.2 a	9.7 ab	2.3 b
Halsulfuron	10.0 a	18.0 b	7.6 a
Imazapic	10.5 a	10.0 ab	3.9 ab
Pendimethalin	11.5 a	17.3 b	5.8 ab
Mix: Imazapic +pendimethalin	13.5 a	9.2 ab	3.9 ab
% CV	38.44	45.23	62.49

* LSD test--means followed by the same letter are not significantly different at p<0.05.

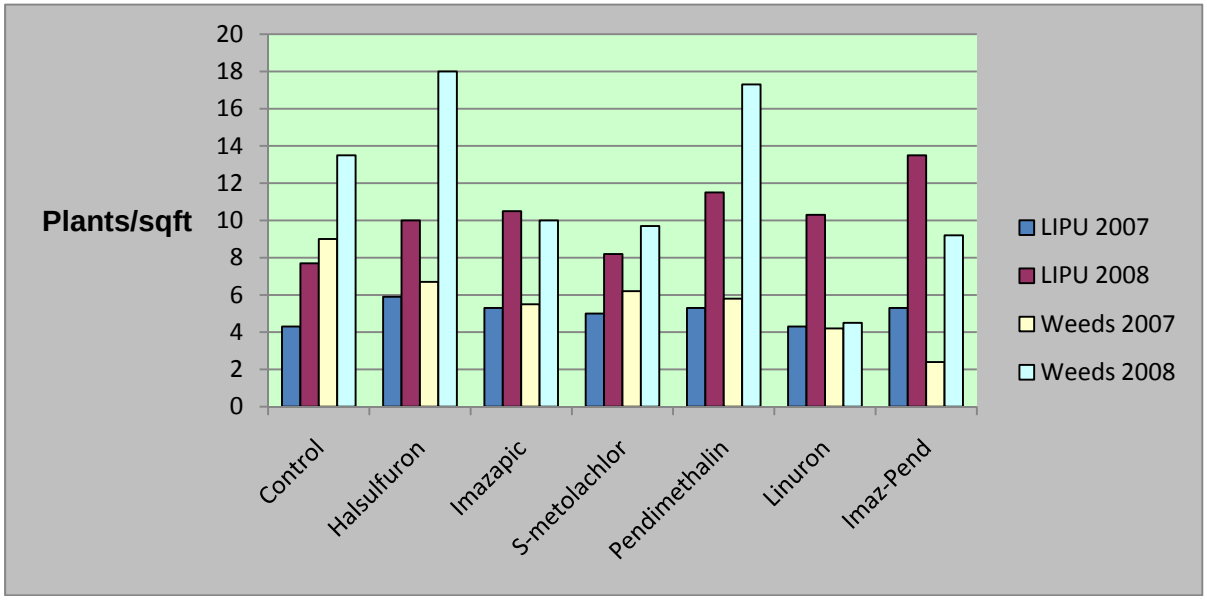


Figure 6. The 2007 and 2008 seedling densities of *Liatris punctata* and broadleaf weeds as affected by herbicide treatment.

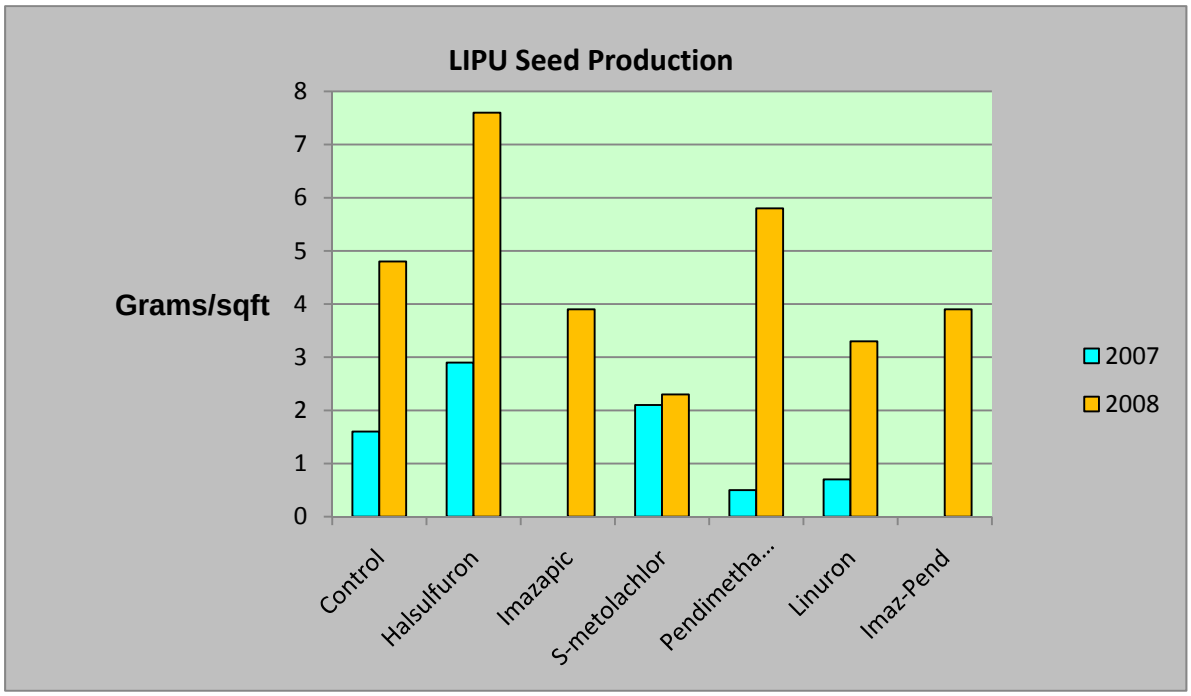


Figure 7. The 2007 and 2008 seed production of *Liatris punctata* as affected by herbicide treatment.

Penstemon eriantherus PEER fuzzytongue penstemon.

There were no significant differences in fuzzytongue penstemon weedy forbs (Table 6), or weedy grass (shown in Appendix Table 2) mean seedling densities, or seed production among treatments. Broadleaf weed densities were lowest in plots treated with s-metolachlor, but not significantly different from those in the other treatments. Seed production was higher in plots treated with linuron, but not significantly different than the other treatments.

Table 6. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half mean plant densities and seed production for *Penstemon eriantherus* in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment	PEER[†]	Broadleaf Weed[†]	Seed Production[‡]
	plt/0.3 m²	*plt/0.3 m²*	*gr/0.3 m²*
Control	1.7 a[†]	14.5 a[†]	1.3 a
Linuron	1.7 a	11.0 a	2.8 a
S-metolachlor	2.0 a	9.7 a	2.6 a
Halsulfuron	2.3 a	21.3 a	0.9 a
Imazapic	1.7 a	20.3 a	1.0 a
Pendimethalin	2.0 a	20.5 a	1.0 a
Mix: Imazapic +pendimethalin	0.3 a	21.8 a	0.3 a
% CV	142.6	25.33	148.97

[†] LSD test--means followed by the same letter are not significantly different at p<0.05.

Phacelia hastata PHHA silverleaf phacelia.

The highest seedling densities in silverleaf phacelia were in the control plot and plots treated with s-metolachlor (Table 7). Silverleaf phacelia seedling densities were significantly lower in plots treated with imazapic. There were no grassy weeds in plots treated with imazapic or in the mixture of imazapic and pendimethalin. The linuron-treated plots had significantly greater grassy weeds than in six other treatments. In 2008, broadleaf weed densities were lowest in plots treated with linuron, but not significantly lower than in the other six treatments (Figure 8). Seed production was less impacted by s-metolachlor than in the other treatments (Figure 9).

Table 7. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half mean plant densities and seed production for *Phacelia hastata* in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment	PHHA	Broadleaf Weed	Grass Weed	Seed Production
	plt/0.3 m^2	*plt/0.3 m^2*	*plt/0.3 m^2*	*gr/0.3 m^2*
Control	4.0 a*	6.3 a*	0.2 a*	1.7 a*
Linuron	3.7 ab	5.2 a	2.2 b	0.3 b
S-metolachlor	4.0 a	17.3 a	0.8 ab	0.9 ab
Halsulfuron	2.0 ab	10.7 a	0.5 ab	0.1 b
Imazapic	0.3 b	19.7 a	0.0 a	0.0 b
Pendimethalin	1.7 ab	20.0 a	0.2 a	0.1 b
Mix: Imazapic +pendimethalin	0.8 ab	9.7 a	0.0 a	0.0 b
% CV	86.31	89.68	197.24	140.34

* LSD test--means followed by the same letter are not significantly different at p<0.05.

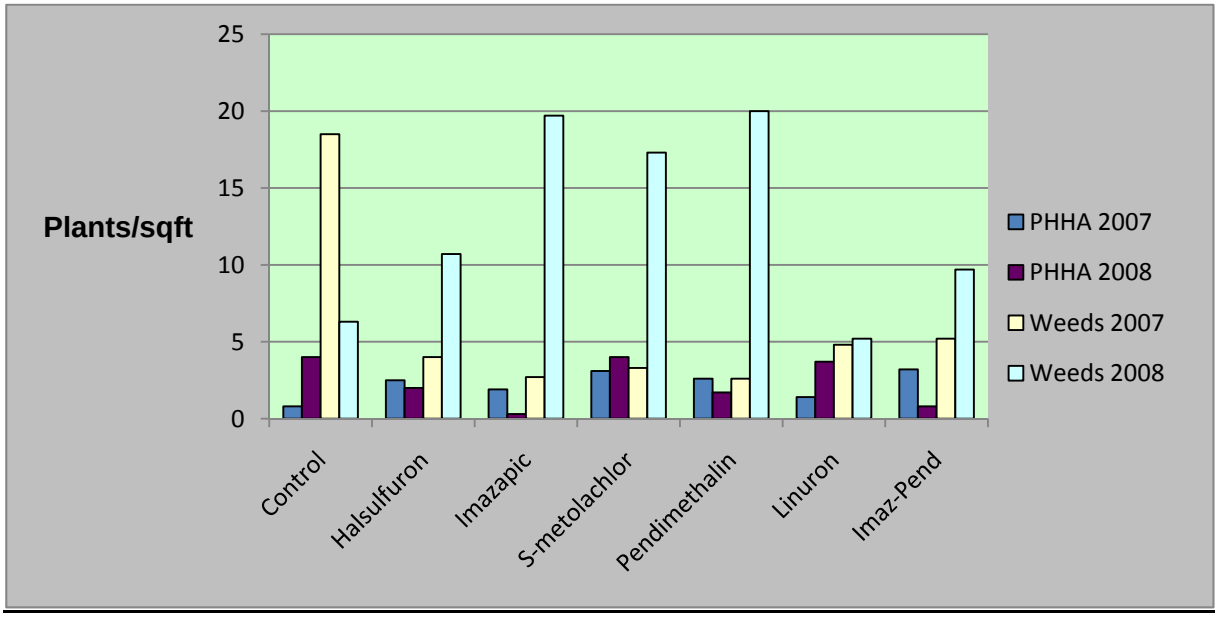


Figure 8. The 2007 and 2008 seedling densities of *Phacelia hastata* and broadleaf weeds as affected by herbicide treatment.

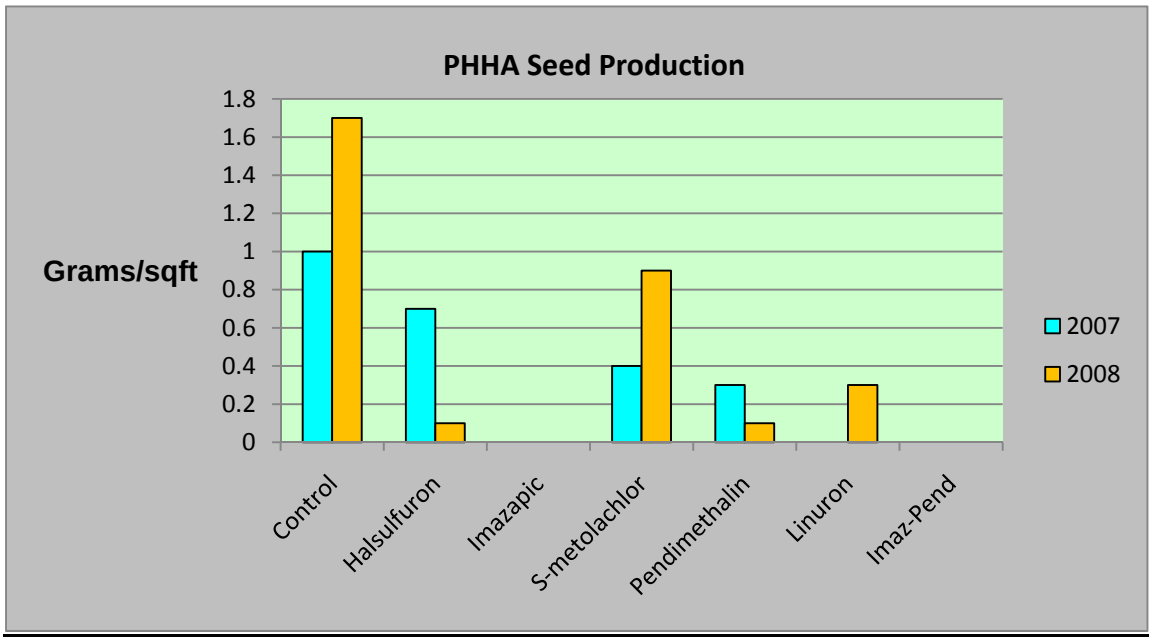


Figure 9. The 2007 and 2008 seed production of *Phacelia hastata* as affected by herbicide treatment.

Ratibida columnifera RACO3 prairie coneflower.

There were no significant differences among treatments in seedling densities of prairie coneflower (Table 8). There were no grassy weeds in the control plot and in plots treated with linuron or pendimethalin. In 2008, the lowest number of broadleaf weeds was in plots treated with s-metolachlor and there were significantly greater broadleaf weeds in plots treated with pendimethalin, compared to six other treatments (Figure 10). Seed production was greatest in the control plot and in plots treated with halsulfuron and pendimethalin (Figure 11). Seed production was significantly lower in plots treated with imazapic and the mixture of imazapic and pendimethalin (Figure 11).

Table 8. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half mean plant densities and seed production for *Ratibida columnifera* in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment	RACO3	Broadleaf Weed	Grass Weed	Seed Production
	plt/0.3 m^2	*plt/0.3 m^2*	*plt/0.3 m^2*	*gr/0.3 m^2*
Control	3.7 a*	9.8 ab*	0.0 a*	28.1 a*
Linuron	4.3 a	5.5 b	0.0 a	20.5 ab
S-metolachlor	4.2 a	2.7 b	0.2 ab	19.2 ab
Halsulfuron	4.3 a	5.7 b	0.5 ab	23.5 a
Imazapic	5.3 a	3.8 b	0.0 a	2.6 b
Pendimethalin	2.8 a	40.3 a	1.2 b	24.9 a
Mix: Imazapic +pendimethalin	4.5 a	5.0 b	0.5 ab	4.2 b
% CV	40.85	181.89	181.89	61.47

* LSD test--means followed by the same letter are not significantly different at p<0.05.

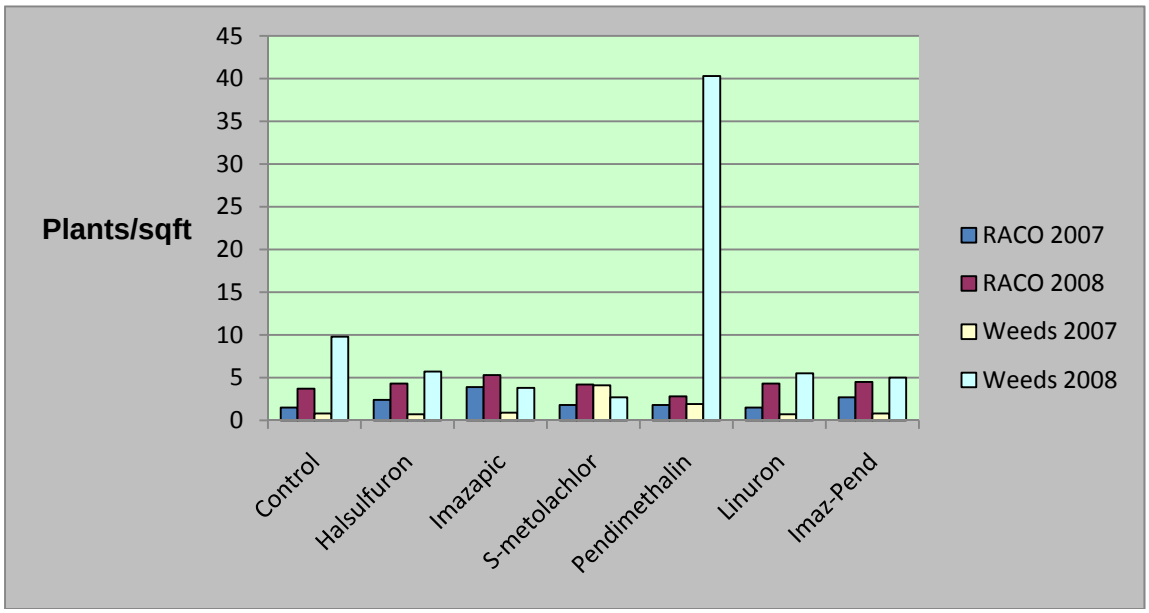


Figure 10. The 2007 and 2008 seedling densities of *Ratibida columnifera* and broadleaf weeds as affected by herbicide treatment.

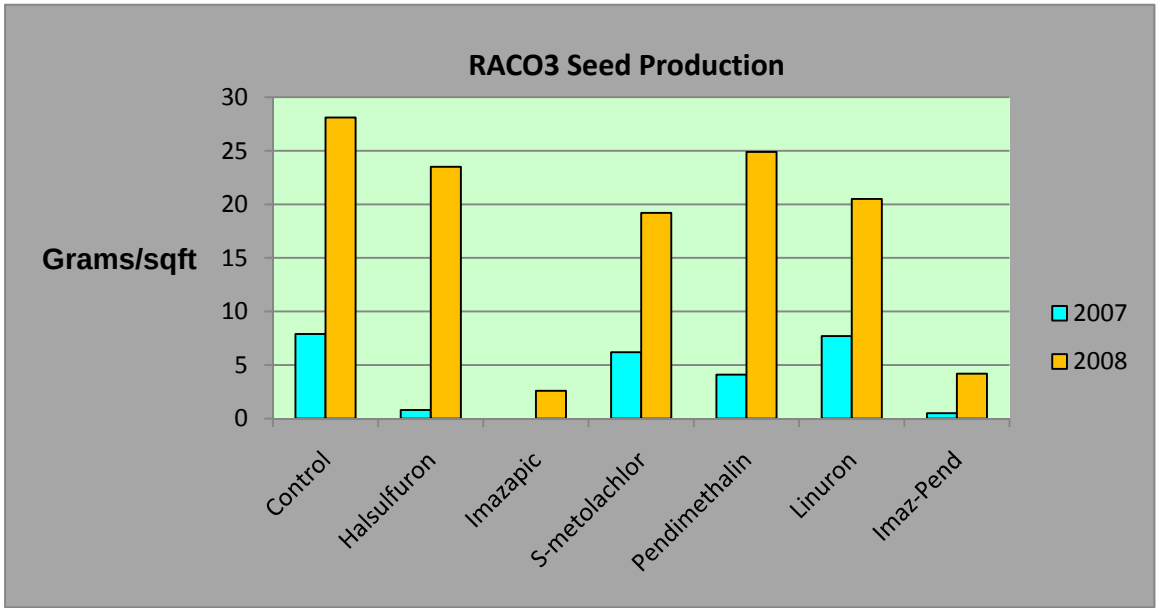


Figure 11. The 2007 and 2008 seed production of *Ratibida columnifera* as affected by herbicide treatment.

Summary: The herbicide treatments did not appear to affect plant establishment in three of the five species. Seedling density increased, when compared to the previous year, for: *Dalea candida* (42%), *Gaillardia aristata* (41%), *Liatris punctata* (50%), and *Ratibida columnifera* (44%). Seedling densities declined 73% in *Phacelia hastata* and were variable in *Penstemon eriantherus*. In almost all cases, there was an increase in broadleaf weed densities, with the exception of the s-metolachlor treatment in *Ratibida columnifera*, and it was variable in *Dalea candida*. Overall grass control was accepTable with one application of clethodim in most of the treated plots, with the exception of *Dalea candida,* where grass

density mostly increased. The imazapic and mixture of imazapic and pendimethalin treatments severely impacted seed production in *Gaillardia aristata, Liatris punctata*, *Phacelia hastata,* and *Ratibida columnifera*. All of the treatments negatively impacted seed production in *Dalea candida*, when compared to the previous year. Treatment response was variable in seed production of *Penstemon eriantherus*. It is generally considered for many species that seed yield should continue to improve into the third year of establishment, which was not the case in the study plots.

Conclusion: These results indicate that herbicide effectiveness in controlling broadleaf weeds in wildflower seed production fields is species-specific. Desirable species respond differently to different active ingredients. For the most part, wildflower densities were not significantly different among treatments, with the exception of silverleaf phacelia. This may be due to the short-lived nature of the species rather than to impacts associated with herbicide applications. As commercial demand continues to increase for seed of native wildflowers, it is important to recognize the need to continue herbicide research on a variety of additional species.

This study may provide growers and land managers a valuable management tool, or set the stage for future evaluations in the revegetation of disturbed lands and associated long-term sustainability of plant and animal life. In either case, there will be additional management tools for the production and successful establishment of native wildflowers for land rehabilitation and revegetation. The study was discontinued in 2008.

Appendix Table 1. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half plant densities and seed production.

Accession	Plot No.	Species' Density		Grass Weed Density		Forb Weed Density		Seed Wt.
		Row 2	Row 3	Row 2	Row 3	Row 2	Row 3	*grams*
ACMIO	112	-	-	-	-	-	-	-
GAAR	132	2	8	0	0	2	2	6.1
PHHA	162	1	0	1	0	6	7	0
RACO3	172	7	0	1	0	7	8	23.0
DACA7	122	1	2	10	15	10	11	6.7
PEER	152	0	0	0	0	10	5	4.1
LIPU	142	4	1	0	0	14	5	0.5
LIPU	141	12	10	1	0	2	4	1.8
PEER	151	2	6	0	0	8	10	0.1
DACA7	121	6	3	1	0	3	4	6.1
RACO3	171	1	4	0	0	1	1	20.3
PHHA	161	3	1	1	1	0	2	0.2
GAAR	131	4	7	1	2	3	3	20.5
ACMIO	111	-	-	-	-	-	-	-
ACMIO	110	-	-	-	-	-	-	-
GAAR	130	4	11	0	1	1	1	16.7
PHHA	160	2	1	0	1	7	6	0.2
RACO3	170	5	5	0	0	4	6	18.5
DACA7	120	5	7	0	2	45	30	6.5
PEER	150	0	0	0	0	14	9	0
LIPU	140	4	7	1	1	20	21	3.1
LIPU	143	12	11	1	1	12	8	4.3
PEER	153	5	9	1	0	19	26	1.2
DACA7	123	7	10	1	1	16	27	6.8
RACO3	173	5	7	0	0	2	2	24.7
PHHA	163	0	0	0	0	1	3	0
GAAR	133	5	12	0	0	7	0	27.7
ACMIO	113	-	-	-	-	-	-	-
ACMIO	115	-	-	-	-	-	-	-
GAAR	135	10	7	0	0	6	1	28.4
PHHA	165	0	3	0	0	30	35	0
RACO3	175	6	5	3	1	13	8	23.4
DACA7	125	5	12	1	0	18	6	8.8
PEER	155	4	3	0	2	6	27	2.2
LIPU	145	17	14	0	0	19	14	5.3

Appendix Table 1. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half plant densities and seed production (continued).

Accession	Plot No.	Species' Density		Grass Weed Density		Forb Weed Density		Seed Prod.
		Row 2	Row 3	Row 2	Row 3	Row 2	Row 3	*grams*
LIPU	144	7	10	1	8	8	10	0.8
PEER	154	0	0	1	0	8	25	0
DACA7	124	9	5	0	0	12	30	3.1
RACO3	174	8	6	0	0	1	6	0.5
PHHA	164	0	0	0	0	5	16	0
GAAR	134	12	6	0	2	4	2	9.0
ACMIO	114	-	-	-	-	-	-	-
ACMIO	116	-	-	-	-	-	-	-
GAAR	136	5	11	1	0	3	3	11.2
PHHA	166	0	0	0	0	10	6	0.1
RACO3	176	6	4	1	2	5	16	2.2
DACA7	126	7	4	0	0	16	6	4.8
PEER	156	0	0	1	1	11	15	0
LIPU	146	19	21	0	0	5	9	2.8
LIPU	246	9	11	0	0	7	10	2.0
PEER	256	0	0	0	0	29	24	0
DACA7	226	10	11	0	0	15	16	8.5
RACO3	276	4	6	0	0	2	6	4.1
PHHA	266	0	1	0	0	17	20	0
GAAR	236	7	9	0	0	30	25	8.2
ACMIO	216	-	-	-	-	-	-	-
ACMIO	215	-	-	-	-	-	-	-
GAAR	235	15	5	0	0	10	4	9.7
PHHA	265	1	1	0	0	3	5	0
RACO3	275	0	0	0	0	100	100	2.5
DACA7	225	10	7	0	0	7	4	8.8
PEER	255	0	1	0	0	18	18	0.1
LIPU	245	4	16	0	0	5	12	3.7
LIPU	241	6	15	10	2	2	2	1.4
PEER	251	1	1	2	1	6	5	0
DACA7	221	12	9	0	0	1	2	5.2
RACO3	271	6	5	0	0	10	20	14.9
PHHA	261	0	0	0	0	3	3	0
GAAR	231	16	6	0	0	3	4	13.5
ACMIO	211	-	-	-	-	-	-	-

Appendix Table 1. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half plant densities and seed production (continued).

Accession	Plot No.	Species' Density		Grass Weed Density		Forb Weed Density		Seed Prod.
		Row 2	Row 3	Row 2	Row 3	Row 2	Row 3	*grams*
ACMIO	213	-	-	-	-	-	-	-
GAAR	233	15	10	0	0	18	9	17.7
PHHA	263	0	0	0	0	12	25	0.1
RACO3	273	1	6	0	0	8	8	18.8
DACA7	223	3	5	0	0	17	20	16.7
PEER	253	0	0	2	2	10	9	0.1
LIPU	243	4	13	1	1	30	11	3.0
LIPU	244	10	17	1	1	19	7	7.7
PEER	254	5	2	0	2	16	15	0
DACA7	224	7	6	0	0	12	19	11.9
RACO3	274	6	3	0	0	6	10	7.6
PHHA	264	1	1	0	0	25	30	0
GAAR	234	9	6	0	0	6	1	12.8
ACMIO	214	-	-	-	-	-	-	-
ACMIO	212	-	-	-	-	-	-	-
GAAR	232	7	6	0	0	40	40	3.7
PHHA	262	5	0	0	0	35	45	0.3
RACO3	272	2	3	0	0	0	0	14.6
DACA7	222	9	9	0	0	8	40	6.6
PEER	252	9	1	0	0	1	10	1.9
LIPU	242	11	15	1	0	16	5	2.3
LIPU	240	10	16	0	2	8	9	5.7
PEER	250	2	4	0	0	15	8	3.1
DACA7	220	9	7	1	0	3	6	8.7
RACO3	270	3	4	0	0	24	20	12.3
PHHA	260	3	4	0	0	2	2	2.6
GAAR	230	4	4	0	0	6	15	19.3
ACMIO	210	-	-	-	-	-	-	-
ACMIO	311	-	-	-	-	-	-	-
GAAR	331	10	8	1	0	0	1	20.4
PHHA	361	13	5	5	6	6	17	0.7
RACO3	371	5	5	0	0	0	1	26.2
DACA7	321	11	12	0	0	5	20	5.4
PEER	351	0	0	1	0	13	24	8.4
LIPU	341	12	7	1	1	8	10	6.9

Appendix Table 1. Cultural Establishment Trial—Effects of Herbicides on Wildflowers. The 2008 north-half plant densities and seed production (continued).

Accession	Plot No.	Species' Density		Grass Weed Density		Forb Weed Density		Seed Prod.
		Row 2	Row 3	Row 2	Row 3	Row 2	Row 3	*grams*
LIPU	342	-	-	-	-	-	-	4.3
PEER	352	13	5	0	0	9	9	1.8
DACA7	322	7	8	0	0	8	32	6.7
RACO3	372	5	8	0	0	1	0	19.9
PHHA	362	13	5	4	0	6	5	2.5
GAAR	332	11	5	0	0	5	2	22.8
ACMIO	312	-	-	-	-	-	-	-
ACMIO	316	-	-	-	-	-	-	-
GAAR	336	15	9	0	1	3	5	20.0
PHHA	366	3	1	0	0	3	2	0
RACO3	376	2	5	0	0	0	1	6.4
DACA7	326	6	3	1	0	30	60	10.6
PEER	356	0	2	1	1	35	17	0.9
LIPU	346	13	8	0	1	9	15	6.8
LIPU	344	8	11	1	1	6	10	3.1
PEER	354	0	0	0	0	35	23	3.0
DACA7	324	1	0	1	2	60	60	3.5
RACO3	274	5	4	0	0	0	0	0.3
PHHA	364	0	0	0	0	2	40	0
GAAR	334	16	8	0	0	0	3	15.8
ACMIO	314	-	-	-	-	-	-	-
ACMIO	313	-	-	-	-	-	-	-
GAAR	333	9	8	0	0	1	2	21.4
PHHA	363	12	0	1	2	5	18	0.3
RACO3	373	4	3	2	1	1	13	27.1
DACA7	323	4	6	1	1	48	60	10.5
PEER	353	0	1	1	1	30	34	1.4
LIPU	343	13	7	0	0	16	31	15.6
LIPU	345	8	10	0	1	35	19	8.5
PEER	355	1	3	0	2	24	30	0.7
DACA7	325	7	6	0	0	30	30	10.0
RACO3	375	4	2	1	2	7	14	48.8
PHHA	365	2	3	1	0	12	35	0.4
GAAR	335	10	12	0	1	0	0	32.2
ACMIO	315	-	-	-	-	-	-	
ACMIO	310	-	-	-	-	-	-	-
GAAR	330	8	8	1	1	3	7	17.0
PHHA	360	6	8	0	0	16	5	2.3
RACO3	370	2	3	0	0	3	2	53.5
DACA7	320	8	3	0	1	25	40	11.8
PEER	350	2	2	0	1	20	21	0.8
LIPU	340	4	5	1	0	14	9	5.5

Appendix Table 2. Cultural and Establishment Trial—Effects of Six Herbicides on Wildflowers. The 2008 density and seed production of seeded species, and density of broadleaf and grassy weeds. Established in Field 1 at the Bridger PMC. Planted November 22, 2005.

Treatment		DACA7[‡]	GAAR[†]	LIPU[‡]	PEER[‡]	PHHA[†]	RACO3[†]
Control	Seeded	6.5	6.5	7.8	1.7	4.0	3.7
	Grass weed	0.7	0.5	0.8	0.2	0.2	0.0
	Broadleaf weed	3.6	3.5	13.5	14.5	6.3	9.8
	Seed Production	9.0	17.6	4.8	1.3	1.7	28.1
Linuron	Seeded	8.8	8.5	10.3	1.7	3.7	4.3
	Grass weed	0.2	0.7	2.5	0.7	2.2	0.0
	Broadleaf weed	4.5	4.6	4.7	11.0	5.2	5.5
	Seed Production	5.6	18.2	3.3	2.8	0.3	20.5
S-metolachlor	Seeded	6.0	6.5	8.2	2.0	4.0	4.2
	Grass weed	4.2	0.0	0.2	0.0	0.8	0.2
	Broadleaf weed	5.1	3.3	9.7	9.7	17.3	2.7
	Seed Production	6.7	10.9	2.3	2.6	0.9	19.2
Halsulfuron	Seeded	5.8	9.8	10.0	2.3	2.0	4.3
	Grass weed	0.7	0.0	0.7	1.2	0.5	0.5
	Broadleaf weed	3.3	4.9	18.0	21.3	10.7	5.7
	Seed Production	11.3	22.3	7.6	0.9	0.1	23.5
Imazapic	Seeded	4.7	9.5	10.5	1.2	0.3	5.3
	Grass weed	0.5	0.3	2.2	0.5	0.0	0.0
	Broadleaf weed	2.6	4.9	10.0	20.3	19.7	3.8
	Seed Production	6.7	12.5	3.9	1.0	0.0	2.6
Pendimethalin	Seeded	7.8	9.8	11.5	2.0	1.7	2.8
	Grass weed	0.3	0.2	0.2	0.7	0.2	1.2
	Broadleaf weed	4.1	5.0	17.3	20.5	20.0	40.3
	Seed Production	9.2	23.4	5.8	1.0	0.2	24.9
Imazapic + Pendimethalin	Seeded	6.8	9.3	13.5	0.3	0.8	4.5
	Grass weed	0.2	0.3	0.2	0.7	0.0	0.5
	Broadleaf weed	3.5	4.8	9.2	21.8	9.7	5.0
	Seed Production	8.0	13.2	3.5	0.3	0.0	4.2

[†] Evaluated September 30, seeded species, grass, and broadleaf weed densities/0.3 m^2.
[‡] Seed harvest began July 16 and ended October 27; seed production in g/0.3 m^2.

VI. COLLABORATIVE AND REIMBURSABLE PROJECTS

GLACIER NATIONAL PARK
FY 2009 ANNUAL SUMMARY REPORT

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.

ACCOMPLISHMENTS: In 2009, 150 seed lots representing 73 species were delivered to Glacier or used for Bridger Plant Materials Center seed increase. Total weight of seed delivered in 2009 was 24.1 kilograms (53.1 pounds). The 2009 seed distribution included 36 grasses (22 species), 62 forbs (28 species), and 52 woody plants (23 species). No containerized plants were delivered to Glacier Park in 2009. A total of 290 wildland seed collections, including 72 new accessions, were processed at the Bridger Plant Materials Center in 2009 and are reported in the 2009 Glacier Annual Technical Report.

Active and new seed production fields as of December 2009 appear in Table 1. Seed production was consistently low in 2009, and many aging and poorly established fields were removed. Field seed increase at the Center in 2009 is reported in the Glacier Park 2009 Annual Technical Report.

Table 1. Glacier Park seed production fields at the Bridger Plant Materials Center, December 2009.

Genus and Species	Accession Number	Site	Field	Date Field Planted	Field Size	2009 Harvest
					acre	*kg*
Carex pachystachya	9078645	LM	4	4/08/98	0.02	0.298
Eurybia conspicua	9087433	LM	4	6/21/05	0.05	0.305
Festuca idahoensis	9075848	SM	6	4/15/05	0.37	0.227
Geum macrophyllum	9087654	LM	4	6/9/06	0.07	0.693
Pseudoroegneria spicata	9076127	TM	4	6/21/05	0.14	0.090
Symphyotrichum laeve	9081447	LM	4	1998	0.04	NA
Symphyotrichum laeve	9081447	LM	4	6/3and23/04	0.09	NA
Festuca idahoensis	9058298	Camas	15N	4/14/2009	0.63	No-new
Elymus glaucus	9087348	LM	15N	4/14/2009	0.75	No-new
Elymus glaucus	9087348	LM	15N	4/14/2009	0.52	No-new

Container plants sown or held at the Bridger Plant Materials Center in 2009 for GNP appear in Table 2.

Table 2. Container plants sown or held in storage for Glacier Park, December 2009.

Species Name	Glacier Lot Number	Accession Number	Collection Location	Date Sown	Number of Units	Size Container
						cubic inches
Rubus parviflorus	06-044	9078329	Two Medicine	1-30-08	131 plants	10
Rubus parviflorus	06-038	9078268	Lake McDonald	8-10-09	85 plants	10
Rosa woodsii	multiple	9063260	Lake McDonald		262 plants	10
Mahonia repens	07-054	9063248	Saint Mary	2008	~2,000 plants	4
Mahonia repens	07-092	9054489	North Fork	8-10-09	1,000 pots	4
Mahonia repens	07-054	9063248	Saint Mary	8-10-09	600 pots	4
Mahonia repens	03-049	9087360	Goat Haunt	8-10-09	400 pots	4

TECHNOLOGY DEVELOPMENT AND ASSISTANCE: Staff from Glacier Park traveled to the Plant Materials Center on December 1 through 2, 2009, to coordinate activities for the 2009 through 2010 fiscal year. Plant Materials training for Park personnel is scheduled for the week of July 12, 2010, and will include the demonstration of a prototype electronic labeling system for wildland seed collection. This system is currently under development by the Natural Resources Conservation Service State Office staff in cooperation with the Plant Materials Center.

YELLOWSTONE NATIONAL PARK
2009 Summary Reports
prepared by

Natural Resources Conservation Service
Bridger Montana Plant Materials Center

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-FLIP disturbed areas.**

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

In 2009, 10 allocations of 138 seed lots from 47 species were distributed to YNP, YNP-contracted growers, or to the PMC totaling 186 pounds (84 kg). This included 56 grass lots (14 species) weighing 171 pounds (78 kg); 79 forb lots (31 species) weighing 15 pounds (7 kg); and three woody lots weighing 0.14 pound (0.06 kg). The distribution included 10 grass lots (five species) and one tree species to the BPMC for planting seed increase fields and container production.

Accomplishments: Yellowstone National Park has identified future road projects allowing collection and production efforts to begin at least 3 years in advance of each project.

Wildland seed collections are made by YNP and BPMC crews, dried, and either delivered to the Bridger PMC, or picked up by PMC personnel. In 2009, 67 collections were made from 29 species: 44 grasses (15 species) at 51 pounds (23 kg) and 23 forbs (14 species) at three pounds (1.3 kg). The wildland seed collections totaled 54 pounds (25 kg).

Records are maintained by the PMC of person-hours to collect each seed lot, from which the approximate cost of collecting native seed can be estimated. In 2009, YNP and BPMC personnel spent more than 329 person-hours in the activity of seed collection on 15 different sites. There were 283 hours (approximately 6.4 hours per collection) dedicated to collecting grass seed on 15 sites and 46 hours (approximately 2 hours per collection) for forbs on eight sites.

There were seven grass increase blocks planted at the PMC on 1.23 acres (0.5 ha) in 2009. Seed increase blocks of two grasses on 0.52 acres (0.2 ha) were removed due to natural decline in production, project completion, or poor establishment. Currently there are 1.87 acres (0.76 ha) planted with 10 accessions of eight grass species in seed increase blocks at the Bridger PMC.

During the past growing season, five grass species were harvested on 1.5 acres (0.6 ha). The total amount of seed produced was 78 pounds (35 kg), with the best grass stand yielding 174 lb/acre (195 kg/ha).

Purity analysis and tetrazolium viability tests are being conducted on PMC seed increase production for two grass accessions. All samples were cleaned to exceed purity standards set forth for foundation seed class as established by the Association of Official Seed Certifying Agencies. The samples are expected to average greater than 90% viability and purity.

The wildland collection and seed increase inventory contains 482 lots (89 species) totaling 1,509 pounds (684 kg). It is comprised of 250 grass lots (30 species) at 1,456 pounds (660 kg), 227 forb lots (55 species) at 53 pounds (24 kg) and five woody lots (four species) weighing 0.5 pound (0.3kg). There are approximately 1,600 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. Extensive assistance was provided in seed collection, study site selection, and planting of cereal grains to revegetate the Northern Boundary.

---

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 historically abandoned cropland in the Park. The plots will be evaluated on the effectiveness of different weed control methods, seeding techniques, and plant performance.

Accomplishments: The BPMC was instrumental in securing a mechanical seed harvest permit from the Bureau of Land Management to assist YNP with seed collection efforts at the Carbella Site over several years. The permit also sanctions a cooperative soil microbial study with Dr. Bill Hamilton of Washington and Lee University in Lexington, Virginia. The BPMC orchestrated scheduling and use of the Native Seedster™, a new, innovative seed-stripping machine. On July 23, it was transported from Billings, Montana, for a 1-day performance and efficiency test in wildland collecting of bluebunch wheatgrass at the Carbella site along the Yellowstone River, 15 miles north of the Park. In addition, YNP personnel spent more than 118 hours hand-collecting seed of four grasses at the same site.

On April 13, 2009, the BPMC planted a 0.51-acre bluebunch wheatgrass seed-increase field and a 0.38-acre field of needle and thread grass. The two areas were periodically irrigated, sprayed with herbicides to control weeds, and cultivated over the course of the growing season. Despite all the agronomic effort, seedling establishment was extremely variable. On August 21, two more seed-increase fields were planted and kept moist with constant irrigation until the seedlings emerged and grew to at least a three- to four-leaf stage and appeared large enough to withstand freezing temperatures.

The 2008 and 2009 wildland seed collections from the Carbella site were processed and inventoried at the BPMC. There are seven lots of four grasses with more than 35 pounds (16 kg) of seed

Technology Development: On May 7, 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. The 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.

On September 17, the PMC assisted with training YNP personnel in the calibration and operation of a newly-purchased Truax Rough Rider rangeland drill. The YNP crew successfully planted ‘Willow Creek’ winter wheat in a 22-acre fenced area near Stephens Creek, previously spring-seeded to barley. The cereal grains are being planted to improve organic matter, and herbicides are being applied to reduce the amount of weedy desert alyssum and eliminate a minor population of crested wheatgrass. The site will continue to be treated until the restoration test plots are established in the fall of 2011.

Study Title: Wyoming BLM Initial Evaluation Planting

Study Number: NA

Objective: 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 to be released for commercially-available sources of native plant seed for reclamation, restoration, and fire rehabilitation.

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 four-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 of each sample (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, the 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 (Figure 1). On April 22, 2009, five late-arriving entries were seeded at the end of the ninth row in plots 26 and 27, and in the first three plots of the tenth row.

In early spring 2009, the study area was periodically monitored for plant growth and development. Weed control measures were repeated over the course of the growing season. On August 25, 2009, the BPMC received a penstemon collection from BLM. It was assigned an accession number and the material was processed over a fanning mill to a high percentage of purity. On September 2, a study evaluation was conducted on plant density, and plant and/or seedhead height.

Results: For the purpose of this report, comparisons were made only among the entries of prairie thermopsis (Table 2). Seedling emergence was mostly uniform beginning in early April and plants established in 17 of 18 plots (94%). Density counts per plot were very low with an average of 11 plants, compared to a target of 225 plants. The 9087509 collection from Judith Basin County, Montana, achieved the greatest density at 25 plants per plot. Density plant counts per plot of the three BLM accessions, 9087869, 9087870, and 9087871, were five, eight, and 16, respectively. The best performer of the BLM collections was from Washakie County, Wyoming (Figure 2). Plant height of the 17 entries was more consistent than density and averaged 17 centimeters. Seed viability was not determined in the 16, non-BLM collections. Flowering did not occur in any of the entries. Results of the entire study will be available upon request in early 2010.

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.

In addition to testing the performance of prairie thermopsis, there are an additional 34 native herbaceous species currently established in the IEP (Figure 2). The study area allows for expansion and the BPMC looks forward to seeding 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 and Species	Date Collected	County Origin	Collector	Amount	Seeds	Viability	IEP 2008
					kg	*lb*	*% TZ*	*Yes/No*
9087869	*Thermopsis rhombifolia*	8/04/08	Carbon	Drizin, J. and P. Nguyen	0.432	24,900	95	Y
9087870	*T. rhombifolia*	8/11/08	Carbon	Drizin, J. and P. Nguyen	0.256	22,100	95	Y
9087871	*T. rhombifolia*	7/16/08	Washakie	Warren, Y.	0.015	21,200	-	Y
9087909	*Pseudoroegneria spicata*	7/21/08	Carbon	Drizin, J. and P. Nguyen	0.028	168,600	95	N
9087915	*Purshia tridentata*	8/15/08	Carbon	Drizin, J. and P. Nguyen	0.132	21,200	37	N
9088005	*Penstemon*	7/31/09	Sweetwater	Biasotti, V.	0.020	-	-	N
6 collections	4 species	6 days	3 counties	4 collectors	0.883	-	-	-

Table 2. The 2009 performance of prairie thermopsis *Thermopsis rhombifolia* in the Initial Evaluation Planting at the Plant Materials Center in Bridger, Montana; seeded in Field 2 on November 17, 2008.

Accession[†]	Date Collected	County Origin	Density[‡]	Height
			no. of plants	*cm*
9078644	6/20/97	McCone, Montana	13	21
9082253	7/22/02	Carbon, Montana	17	15
9082291	7/06/03	Lewis and Clark, Montana	0	0
9082292	7/04/03	Petroleum, Montana	21	17
9087509	7/25/03	Judith Basin, Montana	25	16
9087535	8/17/05	Carbon, Wyoming	16	25
9087841	7/02/07	Hot Springs, Wyoming	15	13
9087842	7/10/07	Fallon, Montana	18	13
9087843	7/05/07	Fallon, Montana	11	20
9087844	7/03/07	Weston, Wyoming	1	20
9087845	7/10/07	Fergus, Montana	5	21
9087846	7/12/07	Fergus, Montana	6	13
9087847	7/25/07	Carter, Montana	1	12
9087848	7/18/07	Campbell, Wyoming	3	16
9087849	7/14/07	Campbell, Wyoming	3	15
9087869	8/04/08	Carbon, Wyoming	5	13
9087870	8/11/08	Carbon, Wyoming	8	17
9087871	7/16/08	Washakie, Wyoming	16	19

[†] **Wyoming BLM.**

[‡] **Plants per 4.6 meter (15 foot) plot.**

Figure 1. November 2008 seeding of the Initial Evaluation Planting.

Figure 2. Bottom right, BLM prairie thermopsis Washakie County, Wyoming.

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

Plant Materials Specialist Report

Field Plantings

In Montana there were 44 active herbaceous plantings and 21 active woody plantings in 2009. In Wyoming there were 19 active herbaceous plantings and 15 active woody plantings in 2009. The 2009 field planting registers for Montana and Wyoming follow. Thirty eight and 20 herbaceous evaluations were reported from Montana and Wyoming, respectively in 2009. For woody plantings in 2009, two evaluations were reported from Wyoming and six were reported from Montana. In Montana, one herbaceous and no woody planting was installed in 2009 and in Wyoming one herbaceous and one woody planting were installed. Evaluation results were recorded in Excel databases.

REGISTER OF MONTANA HERBACEOUS ESTABLISHED FIELD PLANTINGS - 2009

BAKER,MT	96052	LEIBEE,JACK	HAYLAND	CLOSED 2006
BIG HORN	10401	GREENWOOD FARM	PASTUREandHAYLAND	ACTIVE 2010
BIG SANDY,MT	96075	RAY,JAMES	WILDLIFE	CLOSED 2006
BIG TIMBER,MT	97042	BLAKE,SANDY	XERISCAPE DEMO	CLOSED 2008
BILLINGS,MT	00049	BUREAU OF LAND MANAG	WILDLIFE COVER	CLOSED 2006
BILLINGS,MT	02008	POPELKA,ED	WILDLIFE HABITAT	ACTIVE 2006
BILLINGS,MT	97095	BUREAU OF LAND MANAG	RESTORATION	ACTIVE 2006
BILLINGS,MT	09031	BUREAU OF LAND MANAG	WILDLIFE HABITAT	ACTIVE 2009
BOZEMAN,MT	03074	WILLIAMS,W/D.CARACCI	NATIVE RANGE	ACTIVE 2008
BROADUS,MT	00118	SMITH,GENE	LATE FALL/WINTER PAS	ACTIVE 2009
BROADUS,MT	90027	MANGEN,JOHN	EROSION CONTROL	CLOSED 2006
BROADUS,MT	98121	MANGEN RANCH	HAYLAND/PASTURELAND	ACTIVE 2006
CHINOOK,MT	03138	RATY,KEITH	HAYLAND	ACTIVE 2008
CHOTEAU, MT	04054	BASTA, RAY	WINTER WILDLIFE COVE	ACTIVE 2006
CIRCLE,MT	00050	MEISSNER,JERRY	TALL WILDLIFE COVER	CLOSED 2009
CIRCLE,MT	99053	C.R. SEEDS	TALL WILDLIFE COVER	ACTIVE 2008
COLUMBUS,MT	02085	COLES,DAVID	DEMONSTRATION	ACTIVE 2006
CONRAD,MT	04093	VANDYKE,DUANE	PASTURE	ACTIVE 2006
CONRAD,MT	99045	JOHNSON,PAUL	FIELD PLANTING	ACTIVE 2008
EKALAKA,MT	94080	WATERLAND,LUTHER	SEED INCREASE	CLOSED 2006
EKALAKA,MT	98056	BREWER,TOM	PASTURE	CLOSED 2006
EUREKA,MT	98066	GIBSON,SPENCER	WILDLIFE	ACTIVE 2007
FORSYTH,MT	00034	LENZ,AL	IRRIGATED PASTURE TR	ACTIVE 2009
FORSYTH,MT	01062	FERGUSON,DICK	VARIETAL EVAL	ACTIVE 2006
FORSYTH, MT	06036	ICOPINI FAMILY TRUST	DEMONSTRATION PLANTI	ACTIVE 2008
FORSYTH, MT	06037	ICOPINI FAMILY TRUST	DEMONSTRATION PLANTI	ACTIVE 2008
FORSYTH, MT	06071	WEIGHT, CRAIG	IRRIGATED PASTURE	ACTIVE 2008
FORSYTH,MT	93094	PAYER,JACK	PASTURE DEMO	ACTIVE 2006
FORSYTH,MT	94059	HOFER,PAUL and RACHEL	PASTURE and HAYLAND	ACTIVE 2006
FORSYTH,MT	94123	PAYER,JACK	SALINE SEEP DEMO	ACTIVE 2006
FORT BELKNAP,MT	04080	FT.BELKNAP RESERVATI	CULTURALLY SIGNIFICA	ACTIVE 2006
GLENDIVE,MT	96058	DELP,ROBERT	HAYLAND	CLOSED 2006
HARDIN, MT	10401	GREENWOOD FARM	HAYLANDandGRAZING	ACTIVE 2010
JOLIET,MT	86098	SKORUPA,BILL	SEED PRODUCTION	ACTIVE 2006
JORDAN,MT	96041	WITT,DAVE	FIELD PLANTING	CLOSED 2006
JORDAN,MT	97028	GIBBS,PAT	PASTUREandHAYLAND	ACTIVE 2006
JORDAN,MT	97056	JERREL,RAY	PASTURE	ACTIVE 2006
JORDAN,MT	99044	HENSLEIGH,JERRY	EXTENDED GRAZING	ACTIVE 2008
LEWISTOWN,MT	95076	PAGE,STEVE	PASTURE	CLOSED 2006
LEWISTOWN,MT	95100	DONALDSON,HOWARD	HAYLAND	CLOSED 2006
LIVINGSTON,MT	97055	PINKERTON RANCH(1)	PASTURE	ACTIVE 2006
MALTA,MT	00115	KINDLE,BRYAN	IRRIGATED PASTURE	ACTIVE 2009
MILES CITY,MT	96049	DRGA,FRED	SEED PRODUCTION	ACTIVE 2006
MILES CITY,MT	97053	GEORGE,ROBERT	HAYLAND	ACTIVE 2006
PLENTYWOOD,MT	03140	FRENCH,DEAN	SALINE PASTURE	ACTIVE 2008
PLENTYWOOD,MT	03141	HILYARD,RICK	HAY	ACTIVE 2008
SHERIDAN,MT	01058	SAUERBIER RANCH	CRITICAL AREA SEEDIN	ACTIVE 2010
SIDNEY,MT	04038	SIDNEY AIRPORT	GRASS RUNWAY	ACTIVE 2006
SIDNEY, MT	06038	SIDNEY PARKS AND REC	DEMONSTRATION	ACTIVE 2008
STANFORD,MT	03075	DOVER,DAVID	SPRING PASTURE	ACTIVE 2008
STANFORD,MT	97040	HOLZER,DICK	PASTURE	ACTIVE 2006
STANFORD,MT	97054	KOLAR,VINCE	PASTURE	ACTIVE 2006
STANFORD,MT	98071	HECOCK,DALE	HAYLAND	ACTIVE 2007
WHITE SULPHUR SPR,MT	03113	GRANDE,JOHN	PASTURE	ACTIVE 2008
WHITEHALL,MT	98097	FITZGERALD,CORY	WINTER PASTURE	ACTIVE 2007
WIBAUX, MT	04053	BEGGEN, RALPH	PASTURE	ACTIVE 2006

REGISTER OF MONTANA WOODY ESTABLISHED FIELD PLANTINGS — 2009

BAKER,MT	01074	FISCHER,CHIPandANN	WILDLIFE/SCREEN/AEST	ACTIVE 2009
BAKER,MT	91042	STAR X RANCH	WINDBREAK and WILDLIFE	CLOSED 2006
BAKER,MT	94047	GOOKIN,MARVIN and SHAR	FARMSTEAD WINDBREAK	ACTIVE 2008
BAKER,MT	95037	PHEBUS,DRURY	WILDLIFE HABITAT	CLOSED 2006
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	ACTIVE 2008
CIRCLE,MT	04068	MCCONE CONSERV. DIST	WINDBREAK	ACTIVE 2006
COLUMBUS,MT	95045	DOWNS,DAN	FARMSTEAD	CLOSED 2006
FORSYTH,MT	96050	BENNETT,BRYON	SHELTERBELT	ACTIVE 2006
GLASGOW,MT	94051	ANDERSON,ARNOLD	FARMSTEAD WINDBREAK	ACTIVE 2008
HAVRE, MT	06057	NYSTROM, CONRAD	WINDBREAK/SHELTERBEL	ACTIVE 2008
JOLIET,MT	93060	EVERTZ,GREG	FARMSTEAD SHELTERBEL	ACTIVE 2007
LIVINGSTON,MT	95063	PETERSON,MAHLON	WINDBREAK	ACTIVE 2009
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 2006
TOWNSEND,MT	95067	COX,CLIFF	FARMSTEAD WINDBREAK	ACTIVE 2009

REGISTER OF WYOMING HERBACEOUS ESTABLISHED FIELD PLANTINGS - 2009

BAGGS,WY	92036	CNC CATTLE CO.	EVAL-EARLY SEASON GR	CLOSED 2006
BAGGS,WY	88118	MUDDY CREEK	STREAMBANK STABILIZA	CLOSED 2006
BAGGS,WY	88188	MUDDY CREEK	STREAMBANK	CLOSED 2006
BAGGS,WY	90124	SNYDER OIL CORP.	RECLAMATION	ACTIVE 2006
BAGGS,WY	95073	MARSELLA,BILL	PASTURE	CLOSED 2006
BAGGS,WY	04092	TOLLE,ELDON	FALL/WINTER PASTURE	ACTIVE 2006
BUFFALO, WY	06008	LOHSE, TOM	SAGE GROUSE HABITAT	ACTIVE 2008
BUFFALO, WY	06035	LOHSE, TOM	SAGE GROUSE HABITAT	ACTIVE 2008
COKEVILLE,WY	97114	COOK,KAAandKENNETH	PASTURE/HAYLAND	ACTIVE 2006
FORT WASHAKIE,WY	05050	WIND RIVER ELEMENTRY	EDUCATION/DEMONSTRAT	ACTIVE 2009
FORT WASHAKIE,WY	09021	FRED TAMMANY	EDUCATION/DEMONSTRAT	ACTIVE 2009
GILETTE,WY	04026	SMITH,LYNN	FALL/WINTER PASTURE	closed 2006
GILETTE,WY	08001	FOUNDATION COAL	CRITICAL AREA	ACTIVE 2009
JACKSON,WY	96102	WY DEPT OF TRANSPORT	RANGELAND	CLOSED 2006
JACKSON,WY	02062	WDOT	HIGHWAY REVEGITATION	ACTIVE 2008
LOVELL,WY	03086	WYOMING GAME AND FIS	DENSE NESTING COVER	CLOSED 2008
LUSK, WY	04052	EITEL, EDWARD	FIELD TRIAL	ACTIVE 2006
LYMAN, WY	06039	UNITA COUNTY CONS. D	HIGH ELEVATION PASTU	ACTIVE 2008
LYMAN,WY	95098	WADSWORTH,GLEN	RANGE SEEDING	CLOSED 2006
LYMAN,WY	95099	WADSWORTH,GLEN	IRRIGATED PASTURE	CLOSED 2006
PINEDALE,WY	02070	BARNES,CALVIN	HAY	ACTIVE 2008
SARATOGA,WY	99144	KRAFT,JERRY	FIELD PLANTING	ACTIVE 2008
SHERIDAN,WY	02024	PADLOCK RANCH	RECLAMATION	ACTIVE 2007
SHERIDAN,WY	02042	PADLOCK RANCH	RECLAMATION	ACTIVE 2007
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 2008
WHEATLAND,WY	03087	KENNEDY,KEN AND DAN	CRP RENOVATION-WILDL	CLOSED 2006
WHEATLAND,WY	00100	SWAN/MCQUISTEN	CRP	ACTIVE 2010

REGISTER OF WYOMING WOODY ESTABLISHED FIELD PLANTINGS — 2009

BAGGS,WY	95134	LOCOCRK#1,LOWER	STREAMBANK STABILIZA	CLOSED 2006
BAGGS,WY	95133	LOCOCRK#2,UPPER	STREAMBANK STABILIZA	CLOSED 2006
BAGGS,WY	95130	MUDCRK#1,SULPHURS	STREAMBANK STABILIZA	CLOSED 2006
BAGGS,WY	95131	MUDCRK#2,CANGRO	STREAMBANK STABILIZA	CLOSED 2006
BAGGS,WY	95132	MUDCRK#3,MUDFLA	STREAMBANK STABILIZA	CLOSED 2006
BUFFALO, WY	06058	CROSS H RANCH	WINDBREAK	ACTIVE 2008
DOUGLAS,WY	92044	ROTARY CLUB	URBAN BEAUTIFICATION	ACTIVE 2006
FORT WASHAKI,WY	90055	GADDIE,DON	WINDBREAK	CLOSED 2006
GILLETTE,WY	92073	DISNEY,DARLA	FARMSTEAD WINDBREAK	closed 2006
GILLETTE,WY	92059	OLEINIK,JOE	FARMSTEAD WINDBREAK	closed 2006
KAYCEE,WY	09102	WALTERS, BILLandERIN	WINDBREAK	ACTIVE 2009
LYMAN,WY	91055	EVANSTON MIDDLE SCHO	OUTDOOR CLASSROOM	CLOSED 2006
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 2008
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
SUNDANCE,WY	91115	GRAY,RICH	WINDBREAK	CLOSED 2006
SUNDANCE,WY	91116	GRAY,RICH	WINDBREAK	CLOSED 2006
TORRINGTON,WY	95066	KELLER,RICHARD	FARMSTEAD WINDBREAK	ACTIVE 2009
TORRINGTON,WY	92031	SAUL,RICHARD	WINDBREAK	ACTIVE 2006
WHEATLAND,WY	94074	COLE,SCOTTandMARIAN	WILDLIFE HABITAT	ACTIVE 2008
WHEATLAND,WY	91117	LOYD,CLINT	WINDBREAK	CLOSED 2006
WHEATLAND,WY	91118	LOYD,CLINT	WINDBREAK	CLOSED 2006
WHEATLAND,WY	91119	LOYD,CLINT	WINDBREAK	CLOSED 2006
WHEATLAND,WY	91120	LOYD,CLINT	WINDBREAK	CLOSED 2006
WORLAND,WY	97037	DOVER,DAN	WILDLIFE HABITAT	ACTIVE 2006

Study Title: Reestablishing perennial grasses to cheatgrass infested rangelands

Study Number: MTPMS-T-0601-IN

Objective: To determine herbicide management of cheatgrass and grass species for rangeland restoration.

Project Description:

Methods and Materials: Herbicide treatments will be used to temporarily reduce cheatgrass (and spotted knapweed where present) competition. Perennial grass species will be drill seeded to improve forage potential and provide competition to prevent re-establishment of invasive species. Herbicide treatment: 1) glyphosate (12 oz/acre of a 48.7% product solution), 2) imazapic (8 oz/acre), 3) glyphosate+imazapic (Journey® 5 oz + 6 oz/acre = 16 oz/acre), and 4) a no herbicide control. Add picloram (Tordon® 16 oz/acre) where there is spotted knapweed. Seeding treatments: 1) native mix consisting of slender, bluebunch, thickspike, and Snake River wheatgrasses sandbergs bluegrass, and basinwildrye, 2) crested wheatgrass, 3) smooth brome, 4) pubescent wheatgrass, and 5) Russian wild rye. There are two sites for the study, one with a fall application (2006), and one with a fall and spring (2007) application. Herbicides (whole-plots) will be applied using an ATV mounted sprayer to actively growing cheatgrass in Sepetember (fall) or April (Spring). Grasses (sub-plots) will be drill seeded in November (fall) or April (spring) at rates recommended in Plant Materials Technical Note MT46.

Results: Herbicides provided one growing season of suppression of annual grasses. Plateau and Journey were equally effective in controlling annual grasses at about 70 percent. Glyphosate applied in the fall provided about 50 percent control. Glyphosate applied in the spring controlled annual grasses by about 80 percent, slightly better than Plateau or Journey applied in the spring. Seeded grasses failed to establish at site two. There were on average seven pubescent wheatgrass plants per square foot, three Russian wildrye plants per square foot one plant per square foot of crested wheatgrass and native grasses and orchardgrass and smooth brome failed to establish at site one.

Summary of Data: Pubescent wheatgrass and native grasses established best where glyphosate was applied and crested wheatgrass and Russian wildrye had better establishment where plateau was applied.

Conclusions: Herbicides that suppress populations of annual invasive grasses will improve desired grass establishment, and the choice of herbicide active ingredient may be species dependent.

Study Title: Well-pad reclamation field trials.

Study Number: WYPMS-T-0901-CA

Objectives:

1) does cover crop improve diverse establishment and survival?

2) are diverse establishment and survival better using broadcast or drill seeding?

3) Are diverse establishment and survival better with irrigation during spring of establishment?

4) Do any combinations of treatments improve diverse establishment and survival? – the diversity BLM are interested is forbs for sage grouse and other wildlife.

Project Description: Randomized split-split plot design with three well pads as blocks at two sites. Whole plots are cover crop treatment, sub-plots are seeding method, and sup-sup-plots are irrigation treatments.

Methods and Materials: The trials will be on 3 common range sites for this area; sandy, clayey and saline lowland. There will be three treatments, the first will evaluate the method of seeding with some plots broadcast seeded and some drilled. The second will focus on germination and will use irrigation in the spring versus non irrigation. The third is to aid in establishment and will use a cover crop to protect seedlings and aid in weed control. In the plots that have no cover crop Slender wheatgrass will be included in the mix so we can evaluate how much protection this may give to the other seedlings during and after germination. There will be one seed mix that is standard with the same percents of species in the mixture. Added to the standard mixture there will be two species, one grass and one shrub, which are site specific. The trial will last a total of 10 years. The first season all sites will be evaluated at least weekly the following spring after planting to determine emergence. At the end of the first season an overall visual evaluation of establishment will be done by species and invasive species. After the second season density and cover by species will be measured. The third, fifth and tenth years the plots will be clipped and a density count by species will be done.

Site Preparation

To maintain biological attributes, topsoil should not be stored longer than one year. Sites that are unsuitable for vegetation establishment should be covered with a minimum of 6 inches of topsoil if possible. Topsoil should be spread evenly over the subsoil. Sites reshaped with heavy equipment may have a smooth hard surface and soil compaction making it difficult to prepare a good seedbed. Disking, ripping or other treatment may be necessary to prepare the site for seeding. During site preparation, all debris that could potentially interfere with the normal seeding operation should be removed.

Prepare a firm, clean, weed-free seedbed prior to seeding. A seedbed is considered firm when the boot heel imprint of an average person leaves a maximum impression in the soil of no more than ½ inch. On sites where equipment cannot be operated, the seedbed will be prepared by hand. Broadcast seeding should be on freshly roughened soil surfaces. The horizontal indentations left by tracked equipment may provide a suitable broadcast or drill planting site on steep slopes.

Cover Crop

Temporary cover crops can be used for up to two years where cover is needed. If reclamation activities or reseeding is delayed on a site that has been disturbed, or will be re-disturbed in the near future, temporary cover crops can be used to protect the site and/or topsoil against erosion or stabilize the site for eventual permanent vegetation establishment. In the latter situation, the cover crop must be clipped or chemically terminated prior to seed set to control volunteer competition to new seedlings.

All plots with a cover crop shall use the same cover crop at the same rate to eliminate that variable from the trial. We are recommending barley because of availability, ease of establishment and will winter kill any volunteer seedlings. Seeding rate will be 36lbs/acre or ¾ bushel/acre and seeding date will be between March 1st and May 15th. Target date for the cover crop will be April 15th.

Seeding

Drilling
Drills will have agitators and other equipment needed to assure uniform seeding. Rice hulls and other dilutants will be used when determined necessary by the planner. Drilling will be on the contour or across slope where practical. Seed should be placed at a depth of ¼ inch. Drilling will be done in two stages, the grass will be drilled one way and then the forbs and shrubs across the grass drilling.

Broadcasting
When broadcast seeding, a freshly roughened surface will accommodate seed catchment. The seed will be covered by use of hand raking or by dragging harrows, chains or other suitable equipment over the surface or mulched to cover the seed where practical. The drilled planting rates for this critical area planting will be double the normal rate. If seeding is to be completed by broadcasting or hydro-seeding, the seeding rates must be double the critical area planting rate (2 x 2 = 4x). If planting will be harrowed and packed after broadcasting, standard seeding rates may be used.

All sites shall be drilled/broadcast in the fall after October 15th to eliminate that variable from the trial.

Irrigation
From weather station data the highest effective precipitation in the Riverton and Boysen Dam areas comes in April (on avg. 1.26 Boysen and 1.01 Riverton), May (on avg. 1.81 Boysen and 1.78 Riverton) and June (on avg. 1.15 and 1.18). The highest of these is in May. On the irrigated plots a sprinkler system will be used. Irrigation will be done twice during the season to aid in germination. The first irrigation will be the first week of May, applying no more than a ½ inch. The second will be the last week of May or the first week of June, again applying no more than a ½ inch. Using this schedule we will be giving the seeds adequate moisture for germination at the critical times that we would normally receive moisture.

Results: None to date

Tabular Data: None to date

Summary of Data: None to date

Conclusions: In 2009 the sites were selected and the cover crop was seeded.

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.

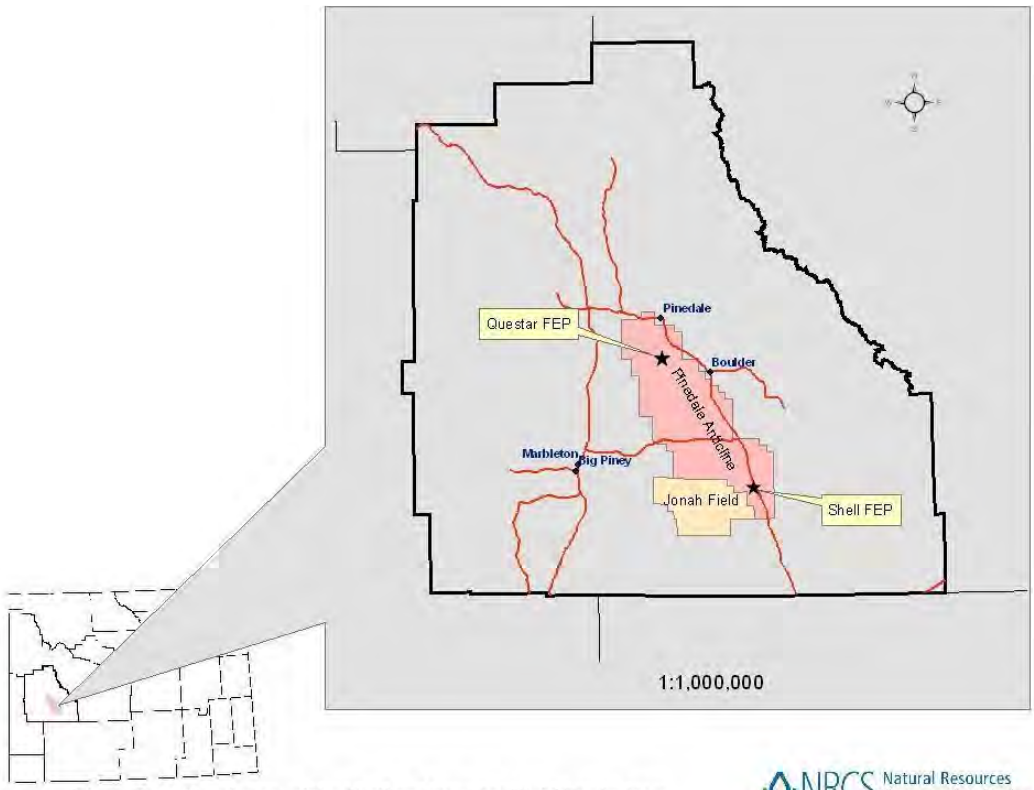


Fig. 1. Locational map of the Shell and Questar Field Evaluation Plantings in Sublette County, near Pinedale, Wyoming.

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).

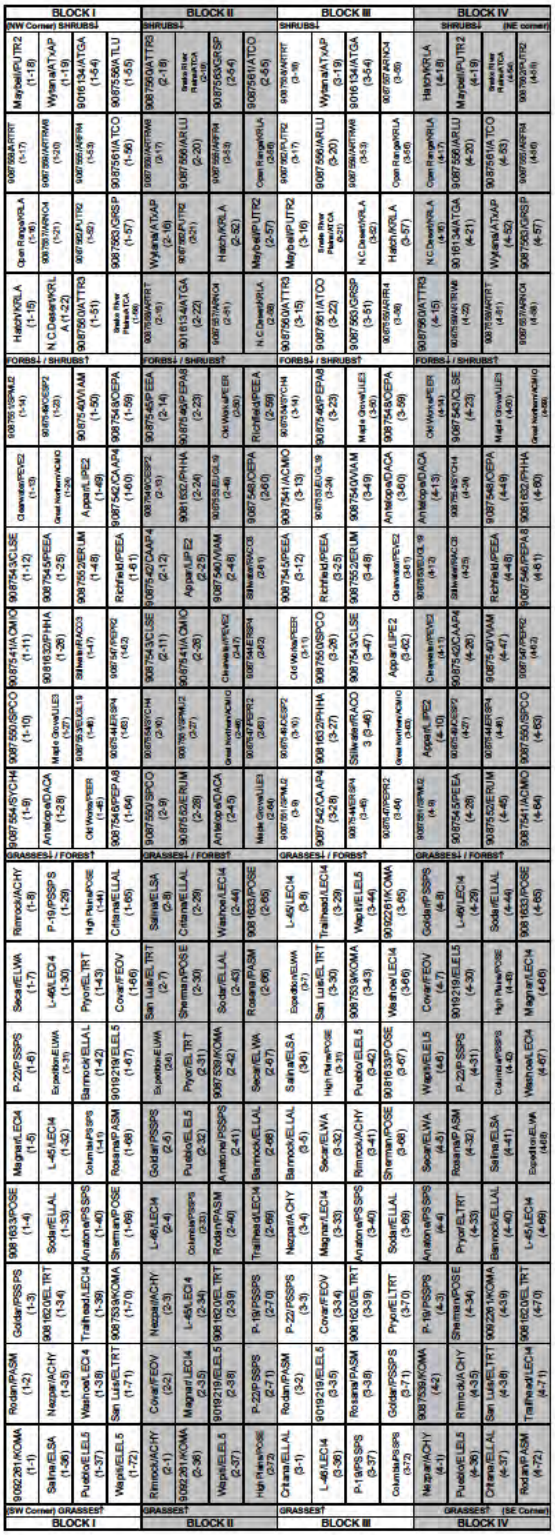


Figure 2. The Shell FEP replicated plot design. Seeded October 19, 2005, near Pinedale, Wyoming.

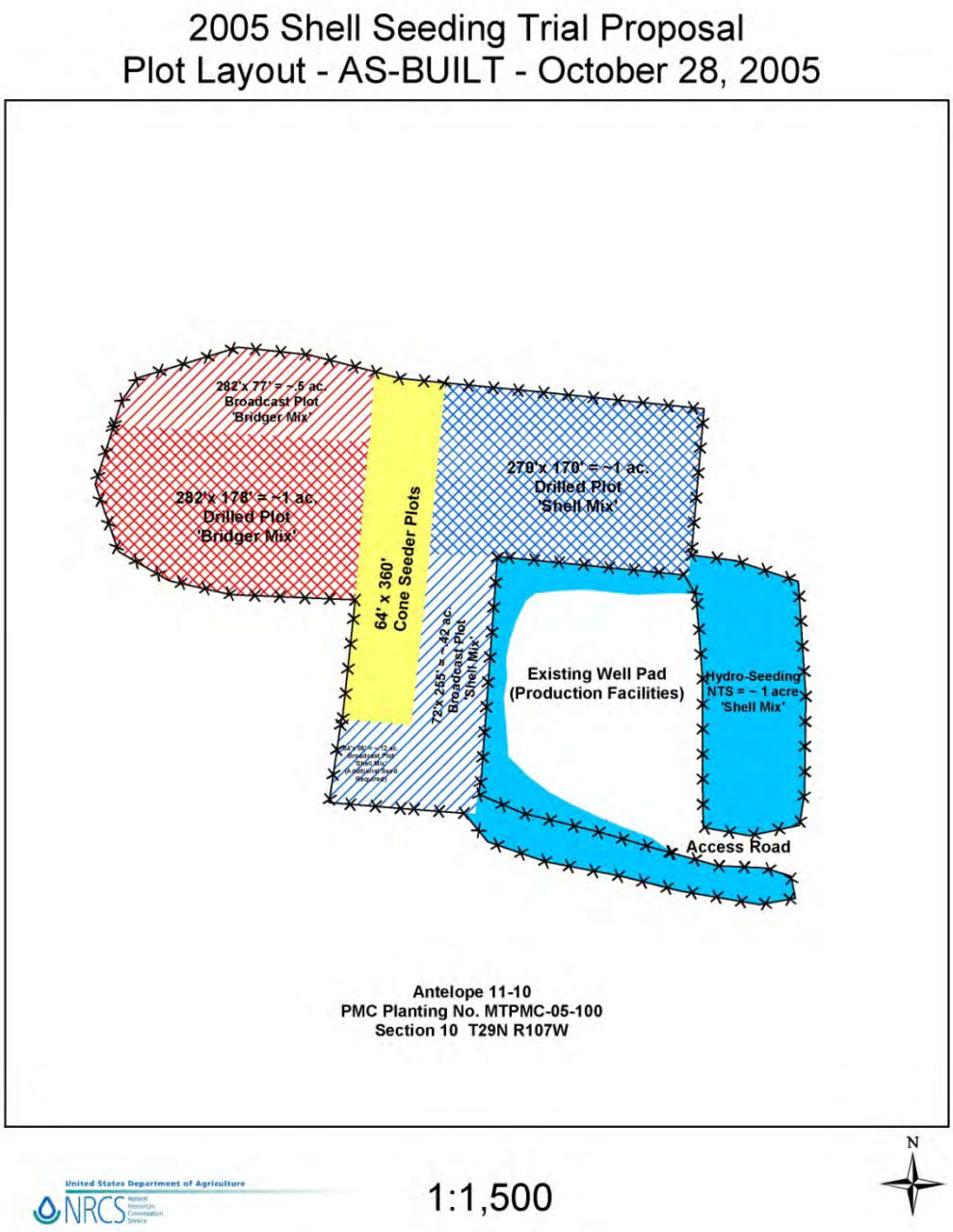


Figure 3. Shell FEP plot layout. Seeded October 19, 2005, near Pinedale, Wyoming.

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 and 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.

Evaluations: On July 28 and 29, 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 second row were counted in 1-foot increments on the tape at 4, 9, and 14 feet. In the third 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-, and hydro-seeded mixture treatments, plants were counted in 20, 9.62 ft^2 plots (total 192.4 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. All seeded species in a plot were counted that fell outside the sample area. Analysis of variance and mean separations were performed using Statistix 2008.

The analysis of variance of the 2009 data showed biomass production was different among grass accessions ($p \leq 0.05$) as reported in Table 3. The five entries of basin wildrye, 'Trailhead', Washoe, 'Continental', L-46, and 'Magnar', and 'Critana' thickspike wheatgrass, produced significantly more biomass than the other entries. Trailhead basin wildrye produced nearly eight times more biomass than in 2008. Plant density was greatest in three rhizomatous species, Critana thickspike wheatgrass, 'Sodar' streambank wheatgrass, and 'Rodan' western wheatgrass. Plant density was relatively good in the previously mentioned basin wildryes, in P-19, P-24, and Anatone bluebunch wheatgrass, and in 9019219 bottlebrush squirreltail. Considering a target of approximately 20 plants per-row-foot, the plant densities of the top six species ranged from about 1% to 13% of a full stand (USDA, 2007). There was an overall decline for most of the entries in the number of plants per square foot. The height of the grasses also differed among accessions with the basin wildrye entries the tallest. However, the grasses with the better establishment were not always the tallest, due to inherent differences in growth form. Differences among accessions in relative stand establishment ratings and vigor ratings were more in line with density counts than height measurements.

The analysis of variance of the 2009 data showed a substantial decline from 2008 in more than 59% of the forb entries. The best performing forbs ($p \leq 0.05$), as reported in Table 4, were native yarrow, two flax entries, Rocky Mountain beeplant, gray aster, sulfurflower buckwheat, and Palmer penstemon. Eight of the test species (33%) were counted in the plots but were outside the actual sample area. Plant establishment was very low compared to the actual seeding rate, with an average stand of 0.2 plant per square foot. The average stand and vigor ratings were poor and moderate, respectively. Height increased dramatically to an average of 14 inches compared to an average of 2 inches in 2008. American vetch, wavyleaf Indian paintbrush, aspen fleabane, and pinkladies were not observed in the plots.

The analysis of variance of the 2009 shrub data showed significantly better performance ($p \leq 0.05$) in 'Wytana' fourwing saltbush, Snake River Plains fourwing saltbush, and 9063134 Gardiner's saltbush (Table 4**)**. Six of the test species were counted in the plots but were outside the sample area. Shadscale saltbush was not observed in the plots. Plant establishment was very low compared to the actual seeding rate, with an average of 0.2 plant per square foot. The average vigor and stand ratings were moderately poor and fair, respectively. Height increased dramatically to an average of 15 inches compared to an average of 4 inches in 2008.

Table 3. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 mean replicated plot performance of 32 grasses; evaluation conducted July 28 and 29. Seeded October 19, 2005.

Accession/Common Name	Production	Production	Density	Stand†	Vigor†	Height
	kg/ha	*lb/ac*	*plts/ft²*			*inches*
Grass						
Trailhead basin wildrye	1,062.82 a*	947.93	1.42	4	5	37.0
Washoe basin wildrye	993.87 a	886.44	1.92	4	6	37.0
Critana thickspike wheatgrass	993.54 a	886.14	2.62	4	3	23.8
L-46 basin wildrye 9087568	846.22 ab	754.74	1.79	4	6	40.0
Continental basin wildrye	785.68 abc	700.75	2.17	4	5	40.5
Magnar basin wildrye	741.28 abcd	661.15	1.09	5	7	31.0
P-24 bluebunch wheatgrass	524.68 bcde	467.97	2.00	4	4	26.0
Sodar thickspike wheatgrass	471.54 bcdef	420.57	2.42	5	4	21.3
9019219 bottlebrush squirreltail	436.23 cdefg	389.07	1.13	5	3	12.3
Bannock thickspike wheatgrass	371.65 defgh	331.48	1.33	5	4	28.0
P-19 bluebunch wheatgrass	324.56 efgh	289.48	1.17	6	4	29.5
Anatone bluebunch wheatgrass	302.03 efgh	269.38	1.13	6	4	22.5
Rodan western wheatgrass	276.47 efgh	246.58	2.46	7	5	20.3
Pryor slender wheatgrass	265.03 efgh	236.38	0.50	7	3	28.5
San Luis slender wheatgrass	243.17 efgh	216.88	0.88	6	3	28.3
Salina wildrye	228.04 efgh	203.39	0.50	7	6	17.3
Secar Snake River wheatgrass	224.67 efgh	200.39	0.46	7	4	30.3
Rosana western wheatgrass	213.91 efgh	190.79	1.04	7	7	18.8
P-22 bluebunch wheatgrass	202.81 efgh	180.89	0.80	7	5	24.3
Goldar bluebunch wheatgrass	142.27 efgh	126.89	0.84	7	5	21.8
Copperhead slender wheatgrass	124.11 efgh	110.69	0.71	8	4	26.5
Rimrock Indian ricegrass	108.30 fgh	96.59	0.21	8	4	19.3
Sherman big bluegrass	102.92 fgh	91.79	0.38	8	6	21.5
E-45 Snake River wheatgrass 9087567	87.45 fgh	77.99	0.25	8	8	24.0
Opportunity Nevada bluegrass	84.08 fgh	74.99	0.17	9	5	18.3
9087539 prairie Junegrass	62.22 gh	55.50	0.04	9	6	13.5
Pueblo bottlebrush squirreltail	58.52 gh	52.20	0.00	9	5	14.0
High Plains Sandberg bluegrass	55.16 gh	49.20	0.25	8	6	16.5
Nezpar Indian ricegrass	49.78 gh	44.40	0.16	9	6	16.0
Covar sheep fescue	33.63 h	30.00	0.04	9	5	21.3
9092261 prairie Junegrass	30.27 h	27.00	0.13	9	4	12.3
Wapiti bottlebrush squirreltail	7.06 h	6.30	0.29	8	6	16.3

† Rated 1-9 with 1 best.

Table 4. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 mean replicated plot performance of 24 forbs and 16 shrubs; conducted July 28 and 29. Seeded October 19, 2005.

Accession/Common Name	Density	Stand†	Vigor†	Height
	plts/ft²			*inches*
Forbs				
9087541 western yarrow	0.46 a*	8	3	15.5 cd*
Appar prairie flax	0.33 ab	6	5	16.3 cd
Maple Grove Lewis flax	0.33 ab	8	5	10.0 def
9087543 Rocky Mountain beeplant	0.21 ab	9	8	7.5 efg
9087552 sulfurflower buckwheat	0.25 ab	8	8	2.3 fg
9087553 gray aster	0.13 ab	8	3	11.3 cde
9087546 Palmer's penstemon	0.17 ab	6	2	50.8 a
Old Works fuzzytongue penstemon	0.08 b	9	8	4.8 efg
9081632 silverleaf phacelia	0.08 b	9	8	0.1 g
Richfield Eaton's penstemon	0.09 b	8	4	28.0 b
9087554 Pacific aster	0.09 b	9	7	3.3 fg
Stillwater prairie coneflower	0.08 b	9	5	18.5 c
9087551 Munro's globemallow	0.00	9	7	12.5
Great Northern western yarrow	0.00	9	3	10.5
9087545 Eaton's penstemon	0.00	9	7	9.0
9087547 littleflower penstemon	0.00	9	4	3.3
Clearwater Venus penstemon	0.00	9	8	3.3
Antelope white prairie clover	0.00	9	8	1.0
9087550 scarlet globemallow	0.00	9	9	0.8
9087548 pale evening-primrose	0.00	9	9	0.5
9087540 American vetch	0.00	0	0	0.0
9087542 wavyleaf Indian paintbrush	0.00	0	0	0.0
9087544 aspen fleabane	0.00	0	0	0.0
9087549 pinkladies	0.00	0	0	0.0
Shrubs				
Wytana fourwing saltbush	0.50 a	4	3	19.5 ab
Snake River Plains fourwing saltbush	0.38 ab	5	2	23.5 a
9016134 Gardner's saltbush	0.25 abc	8	6	11.8 cde
Hatch winterfat	0.17 bc	9	5	16.8 bc
Open Range winterfat	0.17 bc	8	4	15.3 bcd
9087556 white sagebrush	0.08 bc	9	7	16.8 bc
9087557 black sagebrush	0.04 c	9	7	9.5 de
Northern Cold Desert winterfat	0.04 c	9	6	13.5 bcde
9087562 antelope bitterbrush	0.04 c	9	6	7.5 e
9087555 prairie sagewort	0.00	9	3	12.0
9087558 basin big sagebrush	0.00	9	4	18.8
9087559 Wyoming big sagebrush	0.00	9	4	10.8
9087560 basin saltbush	0.00	9	9	1.3
9087561 shadscale saltbush	0.00	0	0	0.0
9087563 spiny hopsage	0.00	8	5	14.3
Maybell antelope bitterbrush	0.00	9	7	3.0

† Rated 1-9 with 1 best.

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 (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 (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 substantial increase in the number of grass plants/ft^2 in the 1-acre treatment with the Bridger Mix in 2009 compared to 2008, at 1.7 and 0.4, respectively (Table 5). The increase was attributed to the rhizomatous spread of Critana thickspike wheatgrass and Rosana western wheatgrass. Wytana fourwing saltbush was the only other species measured at 0.4 plants/ft^2. Of the species in the mix, 47% were present in the sampled area. The species, in order of most to least frequency, were Rosana western wheatgrass (70%), Critana thickspike wheatgrass (55%), Pryor slender wheatgrass (45%), Trailhead basin wildrye (40%), Rimrock Indian ricegrass (25%), Wytana fourwing saltbush (20%), and High Plains Sandberg bluegrass (10%). Overall vigor was moderate and the average plant height was nearly four times greater than in 2008, at 16 inches. Seven of the eight remaining species were present outside the sample area, with only scarlet globemallow not present on-site.

Shell Mix: In the 1-acre treatment with the Shell Mix, 50% of species in the mix was present in the sample area (Table 6**).** The number of plants/ft^2 was up 28% from the previous year, with the biggest gain in the population of Sandberg bluegrass. The species, in order of most to least frequency, were Wyoming big sagebrush (85%), Sandberg bluegrass (50%), Rimrock Indian ricegrass and fourwing saltbush (30%), and winterfat (0.5%). Overall plant vigor was very good and average plant height was considerably taller at 13 inches. Fringed sage was present outside the sampled area, and the remaining 40% of the species in the mix not present included Rydberg's penstemon, native yarrow, scarlet globemallow, and silvery lupine.

There was much higher plant density in the Bridger mixture treatment, 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 both treatments.

Broadcast-Seeded.
Bridger Mix: There was a substantial increase in the number of grass plants/ft^2 in the 0.5-acre treatment with the Bridger Mix in 2009 compared to 2008, at 1.4 and 0.6, respectively (Table 7). The increase was attributed to the rhizomatous spread of Critana thickspike wheatgrass and Rosana western wheatgrass. Of the species in the mix, 93% were present in the sample area. The species, in order of most to least frequency, were Critana thickspike wheatgrass (85%), Rosana western wheatgrass (80%), High Plains Sandberg bluegrass (75%), Wytana fourwing saltbush (45%), Pryor slender wheatgrass (40%), Rimrock Indian ricegrass and Wyoming big sagebrush (35%), Trailhead basin wildrye (30%), Maple Grove prairie flax (20%), Stillwater prairie coneflower and Open Range winterfat (10%), and silverleaf phacelia, Great Northern western yarrow, and fringed sage (0.5%). Overall vigor was moderate, and plant height was up from an average in 2008 of 3 inches, to averages ranging from 5 to 23 inches. Scarlet globemallow was not present on-site.

Shell Mix: In the 0.5-acre treatment with the Shell Mix, 60% of the species were present in the sample area (Table 8). In 2009, there was a slight decline compared to 2008, in the number of plants/ft^2 at 1.7 and 2.2, respectively. The species, in order of most to least frequency, were Sandberg bluegrass (90%), Wyoming big sagebrush (80%), winterfat and fourwing saltbush (30%), fringed sage (20%), and Rimrock Indian ricegrass (0.5%). Overall vigor was good, and plant height was approximately 11 inches. The remaining 40% of the species in the mix not present included silvery lupine, Rydberg's penstemon, native yarrow, and scarlet globemallow.

The broadcast-seeded plots of both mixes were very similar in plant densities. Plant densities in both mixes of the broadcast-seeded treatments and plant densities in the Bridger mix drill-seeded treatment were more than three times greater than that of plant densities in the Shell mix drill-seeded treatment. The original composition of the Bridger mix in the broadcast-seeded treatment increased to nearly 90% grass. The Shell mix broadcast plot, seeded 80% non-grass, is now composed of 63% 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 (Table 9). 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.

Table 5. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 species performance of the Bridger seed mixture in the Truax drill treatment.

Accession	Symbol	Stand	Stand	Vigor[†] Rating	Height
		plants/acre	*plants/ft^2*	*(1-9)*	*in.*
High Plains Sandberg bluegrass	POSE	436	0.01	6	14
Rimrock Indian ricegrass	ACHY	2,178	0.05	5	11
Pryor slender wheatgrass	ELTRT	5,663	0.13	2	22
Rosana western wheatgrass	PASM	38,768	0.89	4	12
Critana thickspike wheatgrass	ELLAL	26,572	0.61	3	13
Trailhead basin wildrye	LECI4	3,049	0.07	3	26
Great Northern western yarrow	ACMIO	0	0	7	12
Stillwater prairie coneflower	RACO3	0	0	5	17
Maple Grove prairie flax	LILE3	0	0	5	14
silverleaf phacelia	PHHA	0	0	6	3
scarlet globemallow	SPCO	0	0	0	0
Open Range winterfat	KRLA2	0	0	6	14
Wytana fourwing saltbush	ATxAP	1,307	0.03	2	9
fringed sagewort	ARFR4	0	0.00	6	14
Wyoming big sagebrush	ARTRW8	0	0.00	4	16
	Total:	77,973	1.76		

[†] Rated 1 to 9 with 1 best.

Seeding rate 39 pure live seeds/ft^2 (10 PLS lb/acre).

Table 6. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 species performance of the Shell seed mixture in the Truax drill treatment.

Accession	Symbol	Stand	Stand	Vigor† Rating	Height
		plants/acre	*plants/ft²*	*(1-9)*	*in.*
Sandberg bluegrass	POSE	7,841	0.18	4	9
Rimrock Indian ricegrass	ACHY	2,178	0.05	5	9
common yarrow	ACMIO	0	0	0	0
Rydberg's penstemon	PERY	0	0	0	0
silvery lupine	LUAR3	0	0	0	0
scarlet globemallow	SPCO	0	0	0	0
fringed sagewort	ARFR4	0	0	4	0
fourwing saltbush	ATCA	1,742	0.04	3	11
winterfat	KRLA2	436	0.01	10	20
Wyoming big sagebrush	ARTRW8	7,841	0.18	2	15
	Total:	20,038	0.46		

† Rated 1-9 with 1 best.
Seeding rate 69 pure live seeds/ft^2 (5 PLS lb/acre).

Table 7**.** Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 species performance of the Bridger seed mixture in the broadcast treatment.

Accession	Symbol	Stand	Stand	Vigor† Rating	Height
		plants/acre	*plants/ft²*	*(1-9)*	*in.*
High Plains Sandberg bluegrass	POSE	6,098	0.14	5	11
Rimrock Indian ricegrass	ACHY	1,742	0.04	6	12
Pryor slender wheatgrass	ELTRT	4,356	0.10	3	23
Rosana western wheatgrass	PASM	1,307	0.30	5	11
Critana thickspike wheatgrass	ELLAL	34,848	0.80	4	14
Trailhead basin wildrye	LECI4	2,614	0.06	5	17
Great Northern western yarrow	ACMIO	871	0.02	4	15
Stillwater prairie coneflower	RACO3	436	0.01	3	16
Maple Grove prairie flax	LILE3	1,307	0.03	3	13
silverleaf phacelia	PHHA	436	0.01	3	5
scarlet globemallow	SPCO	0	0.00	0	0
Open Range winterfat	KRLA2	871	0.02	5	13
Wytana fourwing saltbush	ATxAP	2,614	0.06	3	12
fringed sagewort	ARFR4	436	0.01	3	14
Wyoming big sagebrush	ARTRW8	1,742	0.04	4	11
	Total:	59,678	1.64		

‡ Rated 1-9 with 1 best.
Seeding rate 78 pure live seeds/ft^2 (20 PLS lb/acre).

Table 8. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 species performance of the Shell seed mixture in the broadcast seeding treatment.

Accession	Symbol	Stand	Stand	Vigor† Rating	Height
		plants/acre	*plants/ft²*	*(1-9)*	*in.*
Sandberg bluegrass	POSE	46,609	1.07	3	9
Rimrock Indian ricegrass	ACHY	436	0.01	4	8
common yarrow	ACMIO	0	0.00	4	0
Rydberg's penstemon	PERY	0	0.00	0	0
silvery lupine	LUAR3	0	0.00	0	0
scarlet globemallow	SPCO	0	0.00	0	0
fringed sagewort	ARFR4	1,307	0.03	3	14
fourwing saltbush	ATCA	1,742	0.04	3	10
winterfat	KRLA2	2,178	0.05	3	7
Wyoming big sagebrush	ARTRW8	22,651	0.52	2	13
	Total:	74,923	1.72		

† Rated 1-9 with 1 best.
Seeding rate 138 pure live seeds/ft^2 (10 PLS lb/acre).

Table 9. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 species performance of the Shell seed mixture in the hydro-seeding treatment.

Accession	Symbol	Stand	Stand	Vigor† Rating	Height
		plants/acre	*plants/ft²*	*(1-9)*	*in.*
Sandberg bluegrass	POSE	6,098	0.14	6	6
Rimrock Indian ricegrass	ACHY	19,166	0.44	7	6
common yarrow	ACMIO	0	0	0	0
Rydberg's penstemon	PERY	0	0	0	0
silvery lupine	LUAR3	0	0	0	0
scarlet globemallow	SPCO	0	0	0	0
fringed sagewort	ARFR4	1,307	0.03	6	7
fourwing saltbush	ATCA	436	0.01	6	6
winterfat	KRLA2	1,307	0.03	6	7
Wyoming big sagebrush	ARTRW8	1,307	0.03	5	12
	Total:	29,621	0.68		

† Rated 1-9 with 1 best.
Seeding rate 138 pure live seeds/ft^2 (10 PLS lb/acre).

Summary: The replicated plots on the Shell site indicate plant materials, currently developed, that are easily established 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, *C. serrulata*, *Achillea. millefolium*, *Linum* species, *Penstemon eatonii*, *Penstemon eriantherus*, *Penstemon palmeri,* and *Phacelia hastata* showed the greatest promise for providing diversity of this functional group important to wildlife habitat. Similarly, shrub establishment was disappointing with only four of 16 species important to wildlife established after four growing seasons. They were *Atriplex aptera*, *Atriplex canescens*, two accessions of *Krascheninnikovia lanata*, and *Artemisia tridentata* ssp. *tridentata.* Although establishment was below estimates of a full stand, these same 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. The plot is dominated by shrub cover 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.

At the end of the evaluation period, results of the trial will be 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 and Water Conservation Districts; industry; NRCS Field Offices in Wyoming, Colorado, Montana, Idaho, and Utah; BLM Field Offices; and Wyoming Game and 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.

Literature Cited

Holzworth, L.K. 2007. Personal communication. Bozeman, Montana.

Monsen, S.B., R. Stevens, N. Shaw, comps. 2004. Restoring western ranges and wildlands. Gen. Tech Rep. RMRS-GTR-136-vol-1. Fort Collins, Colorado: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Pages 1-294, plus index.

Pierson, F.B., W.H. Blackburn, and S.S. Van Vactor. 2007. Hydrological impacts of mechanical seeding treatments on sagebrush rangelands. Rangeland Ecol. Manage. 60(6):666-674.

PRACWA--Pinedale Resource Area Cooperative Working Agreement. 2005. Natural Resources Conservation Service, Bureau of Land Management, Wyoming Game and Fish Department, Petroleum Association of Wyoming. Pinedale, Wyoming.

Statistix for Windows. 2008. Statistix 8 User Guide for the Plant Materials Program. Analytical Software. Tallahassee, Florida.

USDA, NRCS. 2008. Soda Lake Field Evaluation Planting, Final Summary 1986-2002. *In* The Bridger Plant Materials Center Draft Technical Report 2006-2007, Bridger, Montana.

USDA, NRCS. 2009. PLANTS Database (http://plants.usda.gov, 4 January 2009). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28 and 29, 2009. Planted on October 19, 2005.

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Grasses							
Nezpar	ACHY	1	0.30	9	5	20	
Nezpar	ACHY	2	0.00	9	7	13	6 plants
Nezpar	ACHY	3	0.33	9	8	14	
Nezpar	ACHY	4	0.00	9	4	17	9 plants
Rimrock	ACHY	1	0.00	9	5	20	9 plants total
Rimrock	ACHY	2	0.17	8	4	17	16 plants
Rimrock	ACHY	3	0.50	8	4	18	10 plants
Rimrock	ACHY	4	0.17	8	4	22	12 plants
9019219	ELEL5	1	1.00	6	5	9	
9019219	ELEL5	2	1.67	5	2	15	
9019219	ELEL5	3	1.33	4	3	13	
9019219	ELEL5	4	0.50	5	3	12	
Pueblo	ELEL5	1	0.00	9	3	18	3 plants
Pueblo	ELEL5	2	0.00	9	9	7	2 plants
Pueblo	ELEL5	3	0.00	9	5	15	4 plants
Pueblo	ELEL5	4	0.00	8	4	16	11 plants
Wapiti	ELEL5	1	0.67	8	6	10	
Wapiti	ELEL5	2	0.00	0	0	27	1 big plant
Wapiti	ELEL5	3	0.50	8	5	15	4 plants
Wapiti	ELEL5	4	0.00	9	5	13	4 plants
Bannock	ELLAL	1	1.50	4	3	28	
Bannock	ELLAL	2	1.33	5	5	27	
Bannock	ELLAL	3	1.67	5	4	27	
Bannock	ELLAL	4	0.83	7	4	30	
Sodar	ELLAL	1	3.33	3	2	19	
Sodar	ELLAL	2	2.00	6	3	18	
Sodar	ELLAL	3	1.17	7	6	24	
Sodar	ELLAL	4	3.17	4	3	24	
Critana	ELLAL	1	0.83	6	3	23	
Critana	ELLAL	2	2.33	4	4	29	
Critana	ELLAL	3	5.00	3	3	22	
Critana	ELLAL	4	2.33	3	3	21	
Salina	ELSA	1	0.17	7	5	30	1 row
Salina	ELSA	2	0.00	0	0	0	failure
Salina	ELSA	3	1.33	7	6	23	
Salina	ELSA	4	0.50	7	8	16	left side better
Copperhead	ELTRT	1	1.00	8	3	28	
Copperhead	ELTRT	2	1.17	7	3	28	
Copperhead	ELTRT	3	0.00	9	4	20	
Copperhead	ELTRT	4	0.67	6	4	30	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Grasses (Cont.)							
San Luis	ELTRT	1	1.83	5	2	26	
San Luis	ELTRT	2	0.67	7	3	33	
San Luis	ELTRT	3	0.00	9	4	25	5 plants
San Luis	ELTRT	4	1.00	3	3	29	
Pryor	ELTRT	1	0.67	7	2	31	
Pryor	ELTRT	2	0.50	7	2	34	
Pryor	ELTRT	3	0.50	7	4	24	
Pryor	ELTRT	4	0.33	6	3	25	
Expedition	ELWA	1	0.17	7	6	30	
Expedition	ELWA	2	0.17	9	7	24	4 plants
Expedition	ELWA	3	0.17	8	8	23	
Expedition	ELWA	4	0.50	9	9	19	
Secar	ELWA	1	1.00	6	4	35	
Secar	ELWA	2	0.50	7	2	26	
Secar	ELWA	3	0.33	6	3	33	
Secar	ELWA	4	0.00	9	7	27	8 plants
Covar	FEOV	1	0.00	9	5	22	4 plants
Covar	FEOV	2	0.00	9	5	19	3 plants
Covar	FEOV	3	0.00	9	6	18	6 plants
Covar	FEOV	4	0.17	9	4	26	13 plants
9092261	KOMA	1	0.00	0	0	0	failure
9092261	KOMA	2	0.00	0	0	0	failure
9092261	KOMA	3	0.33	9	4	24	12 plants
9092261	KOMA	4	0.17	8	4	25	
9087539	KOMA	1	0.00	8	5	15	20 plants (grazed)
9087539	KOMA	2	0.00	9	7	13	3 plants (grazed)
9087539	KOMA	3	0.17	9	5	16	
9087539	KOMA	4	0.00	9	8	10	9 plants
Continental	LECI4	1	3.00	2	7	20	
Continental	LECI4	2	1.50	4	2	48	
Continental	LECI4	3	3.50	3	5	47	
Continental	LECI4	4	0.67	5	7	47	
L-46	LECI4	1	2.00	3	2	50	
L-46	LECI4	2	1.33	4	6	15	
L-46	LECI4	3	2.17	3	7	43	
L-46	LECI4	4	1.67	4	7	52	
Magnar	LECI4	1	2.17	2	5	28	ht 45 outside edge effect
Magnar	LECI4	2	0.67	4	6	26	
Magnar	LECI4	3	0.17	9	9	16	8 plants
Magnar	LECI4	4	1.33	4	6	54	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Grasses (Cont.)							
Trailhead	LECI4	1	2.83	2	3	29	still growing
Trailhead	LECI4	2	0.33	8	7	14	
Trailhead	LECI4	3	1.67	3	6	51	
Trailhead	LECI4	4	0.83	4	3	54	
Washoe	LECI4	1	1.67	4	5	40	
Washoe	LECI4	2	2.00	4	3	25	
Washoe	LECI4	3	2.67	3	5	51	
Washoe	LECI4	4	1.33	6	9	32	
Rodan	PASM	1	0.17	9	3	19	
Rodan	PASM	2	1.33	7	8	16	
Rodan	PASM	3	7.67	4	4	21	
Rodan	PASM	4	0.67	6	5	25	
Rosana	PASM	1	1.67	3	5	21	
Rosana	PASM	2	0.83	8	7	24	
Rosana	PASM	3	0.33	8	5	21	outside rows look better
Rosana	PASM	4	1.33	8	9	9	
High Plains	POSE	1	0.17	8	5	13	
High Plains	POSE	2	0.83	7	4	19	
High Plains	POSE	3	0.00	8	6	21	outside rows look better
High Plains	POSE	4	0.00	8	8	13	12 plants (clipping damage)
Sherman	POSE	1	0.67	8	5	24	
Sherman	POSE	2	0.00	9	9	8	2 plants
Sherman	POSE	3	0.33	9	5	27	2 plants (clipping damage)
Sherman	POSE	4	0.50	6	4	27	
Opportunity	POSE	1	0.00	0	0	17	3 plants total
Opportunity	POSE	2	0.17	9	3	13	
Opportunity	POSE	3	0.33	8	5	22	grazed
Opportunity	POSE	4	0.17	9	8	21	4 plants
Anatone	PSSPS	1	1.83	5	5	22	
Anatone	PSSPS	2	0.83	4	3	26	
Anatone	PSSPS	3	0.67	8	5	21	
Anatone	PSSPS	4	1.17	5	4	21	
Columbia	PSSPS	1	2.67	3	3	27	
Columbia	PSSPS	2	1.33	5	6	26	
Columbia	PSSPS	3	1.67	3	3	26	
Columbia	PSSPS	4	2.33	5	3	25	
Goldar	PSSPS	1	0.17	9	5	25	
Goldar	PSSPS	2	1.17	6	4	22	
Goldar	PSSPS	3	1.00	7	6	20	ELTRT in plot
Goldar	PSSPS	4	1.00	6	5	20	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Grasses (Cont.)							
P-19	PSSPS	1	1.50	6	4	36	
P-19	PSSPS	2	1.00	5	3	28	
P-19	PSSPS	3	1.17	6	4	27	
P-19	PSSPS	4	1.00	7	5	27	
P-22	PSSPS	1	1.17	7	5	26	ht 28 outside edge effect
P-22	PSSPS	2	1.17	5	3	24	
P-22	PSSPS	3	0.17	7	5	24	
P-22	PSSPS	4	0.67	8	6	23	
Shrubs							
9087555	ARFR4	1	0.00	9	2	13	1 plant
9087555	ARFR4	2	0.00	9	3	16	2 plants
9087555	ARFR4	3	0.00	9	4	19	3 plants
9087555	ARFR4	4	0.00	0	0	0	failure
9087556	ARLU	1	0.00	9	9	9	2 plants
9087556	ARLU	2	0.00	9	3	20	2 plants
9087556	ARLU	3	0.33	9	7	16	5 plants
9087556	ARLU	4	0.00	8	7	22	1 plant
9087557	ARN04	1	0.00	9	8	12	4 plants
9087557	ARN04	2	0.00	0	0	0	failure
9087557	ARN04	3	0.17	9	8	12	2 plants
9087557	ARN04	4	0.00	8	5	14	2 plants
9087558	ARTRT	1	0.00	9	2	25	4 plants
9087558	ARTRT	2	0.00	9	5	15	5 plants
9087558	ARTRT	3	0.00	8	5	18	11 plants
9087558	ARTRT	4	0.00	8	5	17	4 plants
9087559	ARTRW8	1	0.00	9	2	16	3 plants total
9087559	ARTRW8	2	0.00	9	5	13	4 plants
9087559	ARTRW8	3	0.00	9	6	14	1 plant
9087559	ARTRW8	4	0.00	0	0	0	failure
SnakeRiverPlains	ATCA	1	0.33	5	1	24	10 plants
SnakeRiverPlains	ATCA	2	0.00	6	3	24	18 plants
SnakeRiverPlains	ATCA	3	0.50	5	3	25	15 plants
SnakeRiverPlains	ATCA	4	0.67	4	2	21	28 plants
9087561	ATCO	1	0.00	0	0	0	failure
9087561	ATCO	2	0.00	0	0	0	failure
9087561	ATCO	3	0.00	0	0	0	failure
9087561	ATCO	4	0.00	0	0	0	failure
9016134	ATGA	1	0.67	8	5	15	12 plants
9016134	ATGA	2	0.00	8	8	7	8 plants
9016134	ATGA	3	0.17	8	7	12	10 plants
9016134	ATGA	4	0.17	8	5	13	2 plants

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Shrubs (Cont.)							
9087560	ATTR3	1	0.00	0	0	0	failure
9087560	ATTR3	2	0.00	0	0	0	failure
9087560	ATTR3	3	0.00	9	9	5	1 plant
9087560	ATTR3	4	0.00	0	0	0	failure
Wytana	ATxAP	1	0.83	4	2	17	
Wytana	ATxAP	2	0.00	3	3	23	20 plants
Wytana	ATxAP	3	0.67	5	4	18	25 plants
Wytana	ATxAP	4	0.50	5	2	20	14 plants
9087563	GRSP	1	0.00	8	3	17	8 plants
9087563	GRSP	2	0.00	7	8	8	14 plants
9087563	GRSP	3	0.00	9	5	13	8 plants
9087563	GRSP	4	0.00	6	5	19	7 plants
Hatch	KRLA	1	0.00	9	4	16	4 plants
Hatch	KRLA	2	0.00	9	8	24	4 plants
Hatch	KRLA	3	0.00	9	5	9	1 plant
Hatch	KRLA	4	0.67	7	4	18	13 plants
Open Range	KRLA	1	0.17	8	4	19	15 plants
Open Range	KRLA	2	0.00	9	4	13	5 plants
Open Range	KRLA	3	0.17	9	4	16	4 plants
Open Range	KRLA	4	0.33	7	4	13	8 plants
N.C.Desert	KRLA2	1	0.00	8	4	19	7 plants
N.C.Desert	KRLA2	2	0.00	9	8	15	4 plants
N.C.Desert	KRLA2	3	0.17	9	6	10	
N.C.Desert	KRLA2	4	0.00	8	5	10	3 plants
9087562	PUTR2	1	0.00	9	8	5	1 plant
9087562	PUTR2	2	0.00	9	5	10	1 plant
9087562	PUTR2	3	0.17	8	6	9	11 plants
9087562	PUTR2	4	0.00	8	6	6	4 plants
Maybell	PUTR2	1	0.00	0	0	0	failure
Maybell	PUTR2	2	0.00	0	0	0	failure
Maybell	PUTR2	3	0.00	9	7	6	2 plants
Maybell	PUTR2	4	0.00	8	6	6	1 plant
Forbs							
9087541	ACMIO	1	1.17	6	1	20	big plants
9087541	ACMIO	2	0.00	0	0	0	failure
9087541	ACMIO	3	0.67	9	4	17	7 plants (all flowering)
9087541	ACMIO	4	0.00	8	3	25	16 plants
GreatNorthern	ACMIO	1	0.00	0	0	0	failure
GreatNorthern	ACMIO	2	0.00	9	3	23	5 plants
GreatNorthern	ACMIO	3	0.00	8	2	19	7 plants
GreatNorthern	ACMIO	4	0.00	0	0	0	failure

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Forbs (Cont.)							
9087542	CAAP4	1	0.00	0	0	0	failure
9087542	CAAP4	2	0.00	0	0	0	failure
9087542	CAAP4	3	0.00	0	0	0	failure
9087542	CAAP4	4	0.00	0	0	0	failure
9087543	CLSE	1	0.50	9	8	5	
9087543	CLSE	2	0.00	9	8	5	7 plants
9087543	CLSE	3	0.33	9	9	12	13 plants
9087543	CLSE	4	0.00	8	8	8	10 plants
Antelope	DACA	1	0.00	0	0	0	failure
Antelope	DACA	2	0.00	0	0	0	failure
Antelope	DACA	3	0.00	0	0	0	failure
Antelope	DACA	4	0.00	9	8	4	1 plant
9087544	ERSP4	1	0.00	0	0	0	failure
9087544	ERSP4	2	0.00	0	0	0	failure
9087544	ERSP4	3	0.00	0	0	0	failure
9087544	ERSP4	4	0.00	0	0	0	failure
9087552	ERUM	1	0.00	9	8	2	3 plants
9087552	ERUM	2	0.00	9	9	2	10 plants
9087552	ERUM	3	0.17	9	9	2	2 plants
9087552	ERUM	4	0.83	6	5	3	23 plants
9087553	EUGL19	1	0.17	7	2	18	12 plants
9087553	EUGL19	2	0.00	9	3	15	4 plants
9087553	EUGL19	3	0.33	9	5	12	6 plants
9087553	EUGL19	4	0.00	0	0	0	failure
Maple Grove	LILE3	1	0.50	8	5	18	
Maple Grove	LILE3	2	0.00	0	0	0	failure
Maple Grove	LILE3	3	0.00	0	0	0	failure
Maple Grove	LILE3	4	0.50	8	4	22	8 plants
Appar	LIPE2	1	0.33	9	9	13	
Appar	LIPE2	2	0.00	9	8	13	2 plants
Appar	LIPE2	3	0.67	4	1	18	61 plants
Appar	LIPE2	4	0.33	3	3	21	33 plants
9087548	OEPA	1	0.00	0	0	0	failure
9087548	OEPA	2	0.00	9	9	2	1 plant
9087548	OEPA	3	0.00	0	0	0	failure
9087548	OEPA	4	0.00	0	0	0	failure
9087549	OESP2	1	0.00	0	0	0	failure
9087549	OESP2	2	0.00	0	0	0	failure
9087549	OESP2	3	0.00	0	0	0	failure
9087549	OESP2	4	0.00	0	0	0	failure

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Forbs (Cont.)							
9087545	PEEA	1	0.00	9	9	7	3 plants (grazed)
9087545	PEEA	2	0.00	0	0	0	failure
9087545	PEEA	3	0.00	9	9	3	11 plants
9087545	PEEA	4	0.00	8	3	26	8 plants
Richfield	PEEA	1	0.00	9	3	30	7 plants
Richfield	PEEA	2	0.00	8	4	27	14 plants
Richfield	PEEA	3	0.17	9	4	23	7 plants (grazed)
Richfield	PEEA	4	0.17	5	3	32	18 plants
Old Works	PEER	1	0.00	9	8	5	9 plants (all grazed)
Old Works	PEER	2	0.00	9	8	2	5 plants
Old Works	PEER	3	0.33	9	9	6	17 plants (seedlings?)
Old Works	PEER	4	0.00	8	6	6	8 plants
9087546	PEPA8	1	0.00	7	1	54	19 plants
9087546	PEPA8	2	0.00	7	1	47	17 plants
9087546	PEPA8	3	0.33	5	3	47	22 plants?
9087546	PEPA8	4	0.33	5	2	55	15 plants
9087547	PEPR2	1	0.00	0	0	0	failure
9087547	PEPR2	2	0.00	0	0	0	failure
9087547	PEPR2	3	0.00	9	4	13	
9087547	PEPR2	4	0.00	0	0	0	failure
Clearwater	PEVE2	1	0.00	9	7	6	2 plants
Clearwater	PEVE2	2	0.00	0	0	0	failure
Clearwater	PEVE2	3	0.00	9	8	7	5 plants
Clearwater	PEVE2	4	0.00	0	0	0	failure
9081632	PHHA	1	0.00	0	0	0	failure
9081632	PHHA	2	0.00	0	0	0	failure
9081632	PHHA	3	0.33	9	8	0.5	8 plants (very little)
9081632	PHHA	4	0.00	0	0	0	failure
Stillwater	RACO3	1	0.00	8	2	18	8 plants
Stillwater	RACO3	2	0.00	9	8	18	4 plants
Stillwater	RACO3	3	0.33	9	3	17	9 plants
Stillwater	RACO3	4	0.00	9	5	21	2 plants
9087550	SPCO	1	0.00	0	0	0	failure
9087550	SPCO	2	0.00	0	0	0	failure
9087550	SPCO	3	0.00	9	9	3	7 plants
9087550	SPCO	4	0.00	0	0	0	failure
9087551	SPMU2	1	0.00	9	5	14	1 plant (grazed)
9087551	SPMU2	2	0.00	0	0	0	failure
9087551	SPMU2	3	0.00	9	9	21	1 plant
9087551	SPMU2	4	0.00	9	7	15	

† Rated 1-9 with 1 best.

Appendix Table 1. Field Evaluation Planting—Shell-Pinedale, Wyoming. The 2009 replicated plot performance, evaluation conducted July 28, 2009. Planted on October 19, 2005 (continued).

Accession	Symbol	Rep	Density	Stand†	Vigor†	Height	Comments
			plts/ft.			*inches*	
Forbs (Cont.)							
9087554	SYCH4	1	0.17	9	5	1	all plants eaten
9087554	SYCH4	2	0.00	9	7	6	9 plants (heavily grazed)
9087554	SYCH4	3	0.00	9	8	3	
9087554	SYCH4	4	0.17	9	7	3	14 plants
9087540	VIAM	1	0.00	0	0	0	failure
9087540	VIAM	2	0.00	0	0	0	failure
9087540	VIAM	3	0.00	0	0	0	failure
9087540	VIAM	4	0.00	0	0	0	failure

† Rated 1-9 with 1 best.

VIII. GRADUATE PROJECTS

POLLINATORS OF SLENDER WHITE PRAIRIECLOVER

by

April Marie Pearce

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Entomology

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2008

©COPYRIGHT

by

April Marie Pearce

2008

All Rights Reserved

APPROVAL

of this thesis submitted by

April Marie Pearce

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the Division of Graduate Education.

Dr. Kevin M. O'Neill

Approved for the Department Land Resources and Environmental Sciences

Dr. Jon M. Wraith

Approved for the Division of Graduate Education

Dr. Carl A. Fox

ABSTRACT

Slender white prairieclover (*Dalea candida*) is a perennial angiosperm, grown at the Bridger plant materials center (BPMC) for reclamation purposes. Interest in the pollinators and pests of this plant developed at BPMC following the death of a 5year old stand. The objectives of these experiments were to (1) determine the diversity and identify the potential pollinators on a *D. candida* and other cultivated and non-cultivated angiosperm species using sweep samples and pan traps; (2) determination of pollen load size and composition of individual insects collected on angiosperm plant species; (3) use of different size exclusion cages to determine the general sizes of insects most important for pollination of *D. candida* at BPMC; and (4) determine the composition of the community of cavity-nesting Hymenoptera at BPMC by using nest traps. The overall density of BPMC was much higher than expected in a monoculture agriculture area, with a total of 102 Hymenoptera taxa collected. Hill's #2 index was used to determine the diversity of different angiosperm plants and revealed that *D. candida* had the highest diversity. Analysis of pollen via the proportion of "pure" vs. mixed loads (PBP) and mean proportion of conspecific pollen (PCP) revealed conflicting results between the two measures, but there does not seem to be some floral constancy occurring, especially in *D. candida*. Kruskal-Wallis tests of differences in exclusion cage treatments revealed that there are differences in pollination efficacy and the size subset allowed to reach the flowers. Emergence from trap nests revealed differences in the trap nesting community at BPMC and actual pollinator collections in the field.

Additional information may be obtained by contacting the following individuals:

Dr. Kevin O'Neill 994-2333
Montana State University
Land Resources and Environmental Sciences
P.O. Box 173120
Bozeman, Montana 59717-3120
406-994.2333
koneill@montana.edu
http://etd.lib.montana.edu/etd/view/item.php?id=758

ESTABLISHMENT AND SEED PRODUCTION OF NATIVE FORBS USED IN RESTORATION

by

Jessica Linsay Wiese

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Environmental Biology

MONTANA STATE UNIVERSITY
Bozeman, Montana

August 2009

ABSTRACT

The importance of incorporating native wildflowers into seed mixtures for disturbed land revegetation projects is widely known and accepted. However, wildflower seed producers need to gain scientific, technical, and practical knowledge for the successful production of native seeds. In particular, assessing weed management approaches represents a necessary step to facilitate the successful establishment and seed production of native wildflowers in production settings. To fill this knowledge gap, we examined the impact of pre and post-emergence herbicides alone and in combination with hand weeding on 5 wildflower species [slender white prairie clover (*Dalea candida*), blanketflower (*Gaillardia aristat*), fuzzy tongue penstemon (*Penstemon eriantherus* var. *eriantherus*), silverleaf phacelia (*Phacelia hastat*), and prairie coneflower (*Ratibida columnifera*) under greenhouse and field conditions. Herbicides evaluated included Treflan (trifluralin) 189 l/ha, Lorox (linuron) 1.121 kg/ha., Permit (halsulfuron) 91 g/ha., Plateau (imazapic) 560 g/ha, and Prowl (pendimethalin) 4.2 l/ha. The objectives of this study were to 1.) Determine wildflower seedling tolerance to post-emergence herbicides, 2) Evaluate the effect of pre-and post-emergence herbicides on native wildflower seedling establishment, weed control, and wildflower seed production.

Objective 1 was carried out in a greenhouse setting. A randomized block design was used and repeated twice. A Monte Carlo simulation was used to assess herbicide damage and a randomized block design analysis of variance (ANOVA) was used to assess herbicide impact on fresh and dry biomass. Results indicated that the *D. candida* and *R. columnifera* were minimally affected by herbicide treatments, while *G. aristata* and *P. hastata* were frequently affected, the first by linuron and halosulfuron and the last by halosulfuron and imazapic.

Objective 2 was conducted at two sites (the Post Research Farm near Bozeman, MT and at the Bridger Plant Materials Center in Bridger, MT) to assess hand weeding and pre and postemergence herbicide effects on native wildflowers. A randomized block design was used to assess wildflower establishment, percentage cover, yield, and seed germinability and viability, along with weed community composition and cover as function of weed management approach. Data were analyzed with a randomized block design analysis of variance (ANOVA) to test for significant differences in wildflowers seedling emergence, percent cover of wildflowers, and seed yield. Results indicated site to site variation was important and that wildflower species responded uniquely to weed management. This indicates that caution should be used when applying herbicides to the tested species. Specifically, emergence of *P.eriantherus, D. candida* and *P.hastata* were negatively affected by trifluralin, indicating caution should be used if this herbicide is used on wildflowers. While incorporating herbicides as a component of weed management systems is a common, effective method to control weeds, caution should be used in wildflower seed production, as wildflower species were not tolerant to the same herbicides.

Additional information may be obtained by contacting the following individuals:

Jessie Wiese
406-599-1784
jessie_wiese@hotmail.com

http://etd.lib.montana.edu/etd/view/item.php?id=959