USDA NRCS
Natural Resources Conservation Service

Aberdeen Plant Materials Center

2014 Annual Technical Report

United States
Department of
Agriculture

Natural Resources
Conservation Service

Aberdeen, Idaho

March 2015

Contents

INTRODUCTION

The Plant Materials Center at Aberdeen is part of a national plant materials program operated by the United States Department of Agriculture, Natural Resources Conservation Service. The purpose of the Plant Materials Center is to develop and communicate new technology for the use and management of plants to solve natural resource concerns. We also assemble, evaluate and release plant materials for conservation use and develop new techniques for establishment of conservation plants. The Aberdeen Plant Materials Center was established in 1939 and currently maintains 14 cultivars and 4 pre-variety (Selected Class) releases. The Aberdeen Plant Materials Center serves portions of Nevada, Utah, Oregon, Wyoming and Idaho. This document is a compilation of progress reports for activities by the Aberdeen Plant Materials Center during FY 2014.

The following presentations were developed during FY 2014 and may be obtained by contacting the Aberdeen Plant Materials Center:

Title: Establishing plants for weed suppression
Presenter: D. Tilley
Location: Shoshone, Idaho
Description: Discussed selection and establishment of plant materials for reducing weed pressure. Wood River SCD weed workshop.
Date presented: 2/14/2014

Title: NRCS policy on T&E species
Presenter: D. Tilley
Location: Boise, Idaho
Description: Presented NRCS policy and PM resources to Idaho Rare Plant Committee.
Date presented: 2/27/2014

Title: Update of PMC activities for GBNPP
Presenter: D. TIlley
Location: Boise, Idaho
Description: Presented PMC work for Great Basin native plant project.
Date presented: 3/18/2014

Title: Developing seed mixes for sage-grouse habitat
Presenter: D. Tilley
Location: Aberdeen, Idaho (webinar)
Description: Webinar developed for SGI staff
Date presented: 4/16/2014

Title: Species selection and mix calculations for sage-grouse habitat
Presenter: D. Tilley, B. Brazee
Location: Twin Falls, Idaho
Description: Went over species appropriate for sage grouse habitat restoration and did classroom exercise developing seed mixes.
Date presented: 5/8/2014

Title: 5th grade soil health field day
Presenter: D. Tilley
Location: Aberdeen, Idaho
Description: 5th grade tour sponsored by SBSCD for 3 classes from Aberdeen Elementary. Taught soil health and conservation practices.
Date presented: 5/22/2014

Title: American Falls Soil Health Demonstration

Presenter: D. Tilley
Description: 5th grade tour sponsored by SBSCD for classes from American Falls Elementary. Taught soil health and conservation practices.
Date presented: 5/22/2014

Title: Plant Materials Committee meeting update
Presenter: D. Tilley
Location: Aberdeen, Idaho
Description: Update on PMC/PMS activities givien to ID PM committee.
Date presented: 6/10/2014

Title: Soil health and cover crop tour
Presenter: D. Tilley
Location: Aberdeen, Idaho
Description: Gave soil health presentation and toured cover crop related plantings.
Date presented: 6/12/2014

Title: Pollinator plantings
Presenter: D. Tilley
Location: Bellevue, Idaho
Description: Toured Silver Spring Ranch with OSU entemology class. Discussed site preparation and installation of pollinator plantings.
Date presented: 7/2/2014

Title: Soil health demonstration for Aberdeen District Library
Presenter: D. Tilley
Location: Aberdeen, Idaho
Description: Gave soil health presentation and demonstration to youth.
Date presented: 7/17/2014

Title: Plant materials for fire breaks
Presenter: D. Tilley
Location: Aberdeen, Idaho
Description: Toured plots of Russian wildrye and forage kochia. Visited Coffee Point off-center site.
Date presented: 9/3/2014

FOUNDATION SEED PRODUCTION AT ABERDEEN PLANT MATERIALS CENTER

A major responsibility of the Aberdeen Plant Materials Center is the production of Foundation quality seed of the plant releases from the Center. Foundation seed is made available to the University of Idaho Agricultural Experiment Station, Idaho Crop Improvement Association, Utah Crop Improvement Association, other plant materials centers and cooperating agencies. Seed is distributed as provided for by allocation and exchange or other written agreements. Foundation seed of recent releases may also be provided to soil conservation districts for registered or certified seed production under the District Seed Increase (DSI) program.

The following table illustrates seed shipments from the Aberdeen Plant Materials Center for Fiscal year 2006 through 2014:

Cultivar	2006	2007	2008	2009	2010	2011	2012	2013	2014	TOTAL POUNDS
					POUNDS PLS					
Anatone bluebunch wheatgrass	350	400	775	450	155	125	80	640	150	3125
Appar blue flax	955	150	150	200	120	175	150	200	175	2275
Bannock thickspike wheatgrass	900	240	150	0	0	100	850	1369	200	3809
Delar small burnet	490	100	1225	0	0	300	0	1200	200	3515
Ephraim crested wheatgrass	1300	300	500	605	0	0	300	350	0	3355
Goldar bluebunch wheatgrass	170	250	450	300	250	100	400	200	150	2270
Magnar basin wildrye	0	490	50	0	50	0	150	225	0	965
Maple Grove lewis flax	70	-	-	-	0	0	65	15	20	170
Nezpar Indian ricegrass	500	700	150	100	0	0	200	200	0	1850
P-27 Siberian wheatgrass [1/]	0	200	200	0	-	-	-	-	0	400
Clearwater selection penstemon	0	0	0	1	4	20	0	25	0	50
Richfield selection penstemon	25	6	4	11	9	5	10	5	0	75
Paiute orchardgrass	75	200	50	300	0	0	0	0	0	625
Recovery western wheatgrass	-	-	-	400	0	450	425	950	200	2425
Regar meadow brome	650	50	400	0	50	100	100	100	0	1450
Rush intermediate wheatgrass	300	500	0	0	0	0	50	725	400	1975
S.R.P. fourwing saltbush [2/]	0	0	0	0	0	0	0	-	0	0
Sodar streambank wheatgrass	775	250	400	50	0	0	300	800	600	3175
Tegmar dwarf intermediate wheatgrass	0	0	0	250	250	150	0	500	0	1150
Northern Cold Desert winterfat [2/]	5	4	0	0	2	0	0	-	0	11
Vavilov II Siberian wheatgrass	-	-	600	300	635	320	230	366	100	2551
TOTAL POUNDS	6565	3840	5104	2967	1525	1845	3310	7870	2195	35221

[1/] Release discontinued in 2009.
[2/] Release discontinued in 2012.

Aberdeen Plant Materials Center
2014 Field Annual Plan of Operation
Home Farm

Field	Acres	Crop	Operation
1	1.7	Display Nursery	Manage for display
2E	1.3	Tegmar Breeder (2014)	Install and Manage for certified seed production
2Ma	0.07	Douglas Dustymaiden (2 rows)	Manage for seed production
2Mb	0.07	Hoary Tansyaster (2011)	Fallow
3W		Cover Crop Demo/Radish boltting trial	Establish and evaluate
3M	0.9	Tansyaster (2014)	Establish and manage for certified seed production
4	1.4	Constructed wetland ponds	Control weeds
5	2.4	Anatone (2012)	Manage for certified seed production
6	2.4	Regar (2012)	Manage for certified seed production
7	3.2	Anatone (2009)	Manage for certified seed production
8	3.2	Appar (2012)	Manage for certified seed production
9	3.2	Vavilov II (2013)	Manage for certified seed production
10	3.2	Anatone (2013)	Manage for certified seed production
11A	0.08	Tansyaster (2012)	Manage for seed production
11B	1.4	Anatone (2014)	Manage for certified seed production
12A		Buckwheat (2013) (2)	Manage for certified seed production
12B		Buckwheat (2014) (1)	Manage for certified seed production
12C		Dusty Maiden (2013)(1)	Manage for certified seed production
12D		ARNG Globemallow (2011)	Manage for certified seed production
12E		Fallow	
12F		Fallow	
13A	0.6	NV Bluegrass IEP (2011)	Manage for evaluation
13B	0.2	Venus Penstemon (2003)	Maintain for pollinator habitat
13C	0.6	Anatone G0 (2013)	Maintain and harvest G1
14	1.2	Woody display nursery	Maintain display of wood conservation plants. Manage Durar/Cover cover.
14S	0.3	Richfield Penstemon (2013)	Manage for certified seed production
15	1.4	Field windbreak (2000)	Maintain Simon poplar windbreak
16	1.0	Anatone Zeolite (2014)	Non-replicated trial of zeolite/humate
17	0.5	Hybrid Poplars	Manage for long-term survival evaluation
18-19	0.9	Fourwing and winterfat (1999)	Maintain cover
20	1.5	Display Nursery (2012)	Manage for display

2014 Field Annual Plan of Operation
Fish and Game Farm

Field	Acres	Crop	Operation
21W	0.7	Bozoisky Cover (2013)	Maintain for permanent cover
21W	0.3	Forage Kochia trial (2012)	Manage/evaluate according to study plan
21M	0.3	GT Idaho Fescue (2010)	Manage for seed production
21E	1.4	Pipe Yard (2004)	Maintain permanent yard for pipe storage
21N	1.3	Bozoisky cover (1985)	Maintain for permanent cover
22W	4.1	Alfalfa (2008)	Manage for hay production and wildlife
22E	1.3	Willow IEP (1984)	Maintain for wildlife cover
23W	2.4	Bozoisky Cover (2007)	Maintain for permanent cover
23M		Windbreak	Maintain and irrigate as needed
23E	2.2	Goldar (2011)	Manage for certified seed production
24W	1.1	Windbreaks	Maintain and irrigate as needed
24M	2.2	Maple Grove (2013)	Manage for certified seed production
24E	1.5	Goldar (2014)	Establish and manage for certified seed production
25W	1.5	Goldar (2014)	Establish and manage for certified seed production
25E	3.5	Goldar (2009)	Establish and manage for certified seed production
26W	1.0	Bozoisky Cover (2005)	Maintain for permanent cover
26E	2.7	Willow Cutting Nursery (1994)	Maintain as needed
27W	2.2	Bozoisky Cover (2005)	Maintain for permanent cover
27M	1.2	Bozoisky Cover (2007)	Maintain for permanent cover
27E	1.0	Corn (2014)	Establish and maintain for food plot
28W	0.2	Wheat (2014)	Establish and maintain for food plot
28M	0.2	Pollinator mix trial (2013)	Maintain and evaluate
28E	5.0	Pollinator Plot (2011)	Maintain and evaluate
29W	1.3	Willows (1994)	Manage for cuttings
29E	3.7	Alfalfa (2008)	Manage for hay production and wildlife
30W	0.7	Windbreak	Maintain and irrigate as needed
30E	4.8	Alfalfa (2010)	Manage for hay production and wildlife
31W	1.5	Alfalfa (2010)	Manage for hay production and wildlife
31E	4.0	Fallow	
32	6.2	Windbreak IEP (1982)	Maintain as needed

Any hay grown will not be cut prior to June 15 and not after September 1. Hay will be irrigated after last cut to first fall frost to achieve regrowth prior to winter dormancy.

Irrigated, permanent grass cover seedings will not be mowed prior to July 1 and not after August 1 and will be irrigated a minimum of 3 times. Non-irrigated grass cover seedings will not be mowed. Early mowing or mowing of non-irrigated grass cover requires notification to and inspection by Fish and Game.

Aberdeen Plant Materials Center
2014 Field Annual Plan of Operation
Pearl Farm

Field	Acres	Crop	Operation
P1W	2.5	Delar (2014)	Establish and manage for certified seed production
P1E	2.5	Bannock (2014)	Establish and manage for certified seed production
P2W	2.5	Bluebunch (2013) YNP	Manage for seed production
P2E	2.5	Sandberg (2013) YNP	Manage for seed production
P3	5.0	Alfalfa (2006)	Maintain for hay harvest; Roundup in fall
P4	2.0	Maple Grove	Manage for chem trials
P5W	2.5	Alfalfa (2007)	Manage for hay production and soil building
P5E	2.5	Alfalfa (2012)	Manage for hay production and soil building
P6	5.0	Alfalfa (2012)	Manage for hay production and soil building
P7W	2.5	Alfalfa (2014)	Manage for hay production and soil building
P7M	1.0	Idaho Fescue (2012) Grand Teton	Manage for seed production
P7E	1.5	Fallow	
P8	2.2	ARS test plots	Manage according to ARS guidelines

Maintain two-row windbreak (Rocky Mountain Juniper and Simon Poplar) established on south and west farm borders. Maintain Bozoisky cover.

Project Title: Aberdeen Plant Materials Center Report of Activities

Project Agreement No: 11-1A-11221632-004

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Highlights:

- Development of NRCS Plant Guides
- Progress towards release of Douglas' dustymaiden
- Progress towards release of hoary tansyaster
- Progress towards release of Wyeth buckwheat

Project Description:

Plant Guides

The Aberdeen PMC is gathering information on selected plant species to create NRCS plant guides. Plant guides offer the most recent information on plant establishment, management and seed and plant production information. General information for the species can also be found in the plant guide, including information on potential uses, ethnobotanical significance, adaptation, pests, and potential problems. In 2013 plant guides were completed or revised for Palmer's penstemon, thickleaf penstemon, Rydberg's penstemon, Columbia needlegrass, bigflower Agoseris, showy goldeneye and limestone hawksbeard. Plant guides are available at the PLANTS database, www.plants.usda.gov, and at the Aberdeen Plant Materials Center website, www.id.nrcs.usda.gov/programs/plant.html.

Douglas' Dustymaiden

Fifteen accessions of Douglas' dustymaiden (*Chaenactis douglasii*) were evaluated at Aberdeen PMC from 2009 to 2010. The accessions were evaluated for establishment, growth and seed production. Following evaluation, accession 9076577 was chosen for selected class release. Accession 9076577 was originally collected in Boise County, Idaho near Arrow Rock and Lucky Peak Reservoirs, approximately 0.5 miles west of the dam on Forest Road 268. The site is a mountain big sagebrush/bitterbrush community in coarse granitic soils at 3150 ft elevation. Accession 9076577 ranked at or near the top in percent establishment, plant vigor, height, flower production and seed yield.

Seed increase plots have been established at the PMC for early generation Certified seed production. In the fall of 2013 we planted a total of 0.18 acres of weed barrier fabric to G-0 seed. Release documentation is being developed and official release will occur once the PMC has produced a sufficient amount of early generation seed.

Hoary tansyaster

Nine accessions of hoary tansyaster (*Machaeranthera canescens*) were evaluated from 2009 through 2011 for establishment, plant growth and seed production. Accession 9076670 had the best establishment and stands for 2009 and 2010, and had the best rated vigor in 2010. This accession also had the tallest plants in the study. The population for 9076670 is located near the St. Anthony Sand Dunes in Fremont County, Idaho at 5,000 ft elevation. The site has sandy soils and supports a bitterbrush, Indian ricegrass, rabbitbrush, and scurfpea plant community. The location receives on average between 10 and 15 inches of mean annual precipitation.

Several strips of weed barrier fabric have been planted to hoary tansyaster for initial seed bulking. An additional 0.6 acres of hoary tansyaster was drill seeded in spring 2012 to investigate agronomics without using weed barrier fabric.

We have made comparisons of using a small-plot combine in a single combine harvest with multiple vacuum harvests from a jet harvester. The single combining method takes less time in the field; however this method yields correspondingly less seed, and requires significantly more time to clean the seed compared to vacuum harvesting. The 2010 drill seeded 0.6 acres was harvested twice in 2013 using a Flailvac harvester. The field was harvested on September 3 and 23. First harvest yielded 4.5 lb clean seed and second harvest yielded 2.8 lbs for a combined total of 7.3 lbs (equivalent to 12.2 lbs/ac).

Release documentation is being developed and official release will occur once the PMC has produced a sufficient amount of early generation seed.

Wyeth or whorled buckwheat

Thirty-nine accessions of Wyeth and sulphurflower buckwheat (*Eriogonum heracleoides* and *E. umbellatum*) were compared in a common garden study from 2007 through 2011. Accession 9076546 Wyeth buckwheat showed good establishment, seed production and longevity compared with the other accessions.

In fall 2011, two, 500 ft rows of weed barrier fabric were planted to accession 9076546. Accession 9076546 was originally collected in Caribou County, Idaho northeast of Soda Springs in an 18 to 20 inch precipitation area occurring with mountain big sagebrush, three-tip sagebrush, bluebunch wheatgrass and basin wildrye. Germination in the weed barrier fabric in 2012 was poor, likely due to drier and warmer than normal winter and early spring conditions. Plants were propagated in the greenhouse in winter/spring 2013 and transplanted to the fabric in summer 2013.

In the summer of 2013, 520 ft of weed barrier fabric was planted to approximately 700 greenhouse grown transplants. Establishment was excellent with good survival.. First seed harvest should occur in 2014. Release documentation is being developed and official release will occur once the PMC has produced a sufficient amount of early generation seed.

Publications:

Ogle, D., Peterson, S., St. John, L. 2013. Plant Guide for Palmer's penstemon (*Penstemon palmeri*). USDA-Natural Resources Conservation Service, Plant Materials Center. Aberdeen, Idaho 83210. Revised October, 2013.

Ogle, D., Peterson, S., St. John, L. 2013. Plant Guide for thickleaf penstemon (*Penstemon pachyphyllus)*. USDA-Natural Resources Conservation Service, Plant Materials Center. Aberdeen, Idaho 83210.

Ogle, D., Peterson, S., St. John, L. 2013. Plant Guide for Rydberg's penstemon (*Penstemon rydbergii)*. USDA-Natural Resources Conservation Service, Plant Materials Center. Aberdeen, Idaho 83210.

St. John, L. Tilley, D. 2012. Plant Guide for limestone hawksbeard (*Crepis intermedia*). USDA-Natural Resources Conservation Service, Aberdeen Plant Materials Center. Aberdeen, Idaho 83210.

Tilley, D. and L. St. John, L. 2013. Plant guide for Columbia needlegrass (*Achnatherum nelsonii*) USDA-Natural Resources Conservation Service, Plant Materials Center, Aberdeen, Idaho 83210.

Tilley, D. 2013. Plant Guide for bigflower agoseris (*Agoseris grandiflora*). USDA-Natural Resources Conservation Service, Aberdeen Plant Materials Center. Aberdeen, Idaho 83210.

Tilley, D. 2012. Plant Guide for showy goldeneye (*Heliomeris multiflora*). USDA-Natural Resources Conservation Service, Aberdeen, ID Plant Materials Center. 83210-0296.

Products:

1. Plant Guides are available for Palmer's penstemon, thickleaf penstemon, Rydberg's penstemon, Columbia needlegrass, bigflower Agoseris, showy goldeneye and limestone hawksbeard.

2. Early generation Certified seed of hoary tansyaster, Douglas' dustymaiden and Wyeth buckwheat is being produced and will be available through Utah Crop Improvement and University of Idaho Foundation Seed Program when release is approved.

GRAND TETON NATIONAL PARK

FY2013 Annual Report
Prepared by

NATURAL RESOURCES CONSERVATION SERVICE
PLANT MATERIALS CENTER
ABERDEEN, IDAHO

INTRODUCTION - The Aberdeen Plant Materials Center (PMC) entered into an interagency agreement with Grand Teton National Park (GTNP) in 2006 to produce seed of four native grasses for use in revegetation of disturbed areas following road construction. Seed fields of slender wheatgrass (*Elymus trachycaulus*), Sandberg bluegrass (*Poa secunda*), blue wildrye (*Elymus glaucus*) and mountain brome (*Bromus marginatus*) were planted in 2006, and seed was harvested in 2007 and 2008. Fields of Idaho fescue (*Festuca idahonensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*) were planted in May, 2008. Seed from these fields were harvested in 2009 and 2010. The bluebunch wheatgrass field was removed in late 2010 because of poor seed yield. In 2010, a second field of mountain brome was planted for seed harvests in 2011 and 2012. The mountain brome field was removed after harvest in 2012. The Idaho fescue field was also harvested in 2011-2013 and is scheduled for its last harvest in 2014. A new Idaho fescue field (1 ac) was established in 2012 for seed production in 2013 - 2014.

ACCOMPLISHMENTS – Seed fields are sprinkler irrigated to supplement natural precipitation to approximate 18 to 20 inches of total annual moisture. Weeds were controlled during the growing season. The following table lists the species grown and seed still on hand at the end of 2013, field acreage, current seed inventory, seed shipments in 2013 and seed test date.

Species	Harvest year	Field size (ac)	Inventory (PLS pounds)	Lbs. shipped 2013	Seed Test date
Idaho fescue	2013	0.3	76		1/23/14
Idaho fescue	2013	1.0	71		1/23/14
Mtn. brome	2012	2.5	1001	800	2/1/13
Idaho fescue	2012	0.3	0	60	2/5/13
Mtn. brome	2011	2.5	0	66	9/19/11
Idaho fescue	2011	0.3	0	83	2/22/12
Slender wht.g.	2009	1.0	0	499	5/17/10
Slender wht.g.	2008	1.0	0	498	4/14/09
Blue wildrye	2008	2.7	0	389	4/22/09
Blue wildrye	2007	2.7	608	0	3/10/08

DIGITAL PHOTOS

Grand Teton National Park new Idaho fescue seed increase field at Aberdeen PMC. April, 2013.

Grand Teton National Park Idaho fescue seed harvest at Aberdeen PMC. July 2013.

YELLOWSTONE NATIONAL PARK – GRASS SEED PRODUCTION

FY2013 Annual Report
Prepared by

NATURAL RESOURCES CONSERVATION SERVICE
PLANT MATERIALS CENTER
ABERDEEN, IDAHO

INTRODUCTION - In 2008, the Natural Resources Conservation Service (NRCS), Plant Materials Center (PMC), Aberdeen, Idaho entered into an interagency agreement with the National Park Service (NPS), Yellowstone National Park (YNP) to produce seed of Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and needleandthread (*Hesperostipa comata* ssp. *comata*) for use on restoration sites at YNP. The needleandthread was harvested as hay mulch and baled for transport in 2010 - 2012. Seed was harvested from the Sandberg bluegrass field in 2010 - 2013 and bluebunch wheatgrass field in 2011 - 2013. New seed fields of bluebunch wheatgrass and Sandberg bluegrass were established in 2013 and will produce seed in 2014 and 2015.

ACCOMPLISHMENTS – New, 2.5 acre seed fields were planted in May, 2013. Sandberg bluegrass was planted in field P2E and the bluebunch wheatgrass was planted in field P2W, both at the PMC Pearl Farm. Soils at the PMC Pearl Farm are Kimama silt loam with pH of 7.4 to 8.4. Average annual precipitation is 9.39 inches and seed fields are sprinkler irrigated to supplement natural precipitation to approximate 18 to 20 inches total annual precipitation. Establishment of the new seed production fields were rated fair to good. The fields established in 2009 were harvested for the last time in 2013 and returned to fallow. The following table lists the species grown for YNP, field acreage, current seed inventory and seed shipped during 2013.

Species	Harvest year	Field size (ac)	Inventory PLS pounds	Lbs. shipped 2013	Seed Test date
Sandberg b.g.	2013	1.0	74	0	3/10/14
Sandberg b.g.	2012	1.0	17	35	2/25/13
Sandberg b.g.	2011	1.0	0	95	2/22/12
Sandberg b.g.	2010	1.0	0	58	3/28/11
Bluebunch wht. g	2013	1.0	76	0	3/25/14
Bluebunch wht. g	2012	1.0	0	110	2/5/13
Bluebunch wht.g.	2011	1.0	29	49	2/29/12

DIGITAL PHOTOS

YNP Sandberg bluegrass seed harvest drying on floor at Aberdeen PMC, 2013.

Harvesting YNP bluebunch wheatgrass at Aberdeen PMC, 2013.

New YNP Sandberg bluegrass field at Aberdeen PMC September, 2013.

New YNP bluebunch wheatgrass field at Aberdeen PMC September, 2013.

2011 Pollinator Planting, 2014 Progress Report
Fish and Game Farm, Field 28
Derek J. Tilley, PMC Agronomist
Natural Resources Conservation Service
Plant Materials Center
Aberdeen, Idaho

Introduction

The Conservation Reserve program of the 2008 USDA Farm Bill promotes the establishment of pollinator friendly habitat. The desired goal in these pollinator plantings is to establish a variety pollinator species with some flowering in each of the three flowering periods – early, mid and late growing season. The mixture can also include native grasses not to exceed 25% of the total mixture.

Establishment of grasses and grass-dominant plantings including forbs and shrubs are common and largely successful; however, pollinator plantings consisting predominantly of forbs pose problems not typically encountered with grass plantings. Forbs, especially native forbs, are in many cases not competitive against weed species. Forb plantings also severely limit the herbicides available for controlling broadleaf weeds.

Healthy rangeland in the Intermountain West consists of approximately 5 to 25% shrub cover, 40 to 60% grasses and 5 to 20% forbs. There is concern that the 25% grass composition requirement may not provide the necessary competitive ability needed to persist in weed prone sites. More information is needed to understand pollinator planting dynamics and management.

Materials and Methods

In 2011, the PMC established 5 acres of pollinator habitat for display and to research management requirements involved in pollinator friendly plantings. The planting was established in field 28 of the PMC Fish and Game farm 5 miles northeast of Aberdeen. Soil at the planting site is a Declo silt loam with pH of 7.4 to 8.4. Average annual precipitation is 9.39 inches.

In 2010, the year prior to planting, the field was planted to field corn and managed for wildlife habitat. The stubble was mowed spring 2011. The field was irrigated in early spring to get weed seeds to germinate. The field was then sprayed with 64 oz Glyphosate/ac on May 11 prior to planting on May 18. The western 2.5 acres of the field were planted to a mixture consisting of 25% grasses (mix 1), while the eastern 2.5 acres were planted to a mixture of 50% grasses (mix 2).The field was irrigated through the growing seasons of 2011, 2012 and 2013 to approximate 14 to 16 inches of annual precipitation, the suitable range for the species in the seed mixture. The planting was not irrigated in 2014. In 2011, the establishment year, the fields were mowed three times after planting to prevent weeds from going to seed. In 2012, 2013 and 2014 noxious weeds

(broadleaf pepperweed, musk thistle, burdock, Canada thistle, and field bindweed) were spot-treated with 64 oz Glyphosate/ac.

The two pollinator mixes were developed to compare forb establishment and persistence with varying grass composition. The mixes were designed to provide blossoms for foraging insects in all three flowering periods (table 1). Each mixture has the same species components, but they have different proportions of forbs and grasses. The first mix follows NRCS guidelines and contains a 25% grass component and 75% forbs (Tables 2). The second mix is designed to more closely approximate natural healthy rangeland conditions. This mix contains the same species components, but the grasses are doubled to comprise 50% of the total mix, and the forb amounts are halved. The mixtures contain only 7 pollinator species. This reflects the limited number of available forb species suitable for use in arid to semi-arid environments, especially those with late summer bloom periods.

Table 1. Pollinator planting mixture components

			Bloom Color and Time			
Scientific Name	Common Name	Variety	spring	summer	late summer	Origin
Pseudoroegneria spicata	Bluebunch wheatgrass	Anatone				Native
Leymus cinereus	Basin wildrye	Magnar				Native
Poa ampla	Big bluegrass	Sherman				Native
Achillea millifolium	Western yarrow	Great Northern				Native
Linum perenne	Blue flax	Appar				Introduced
Medicago sativa ssp. *falcata*	Falcate alfalfa	Don				Introduced
Sanguisorba minor	Small burnet	Delar				Introduced
Onobrychis vicaeifolia	Sainfoin	Common				Introduced
Helianthus annuus	Sunflower	Common				Native
Machaerranthera canescens	Hoary tansyaster	Common				Native

The mixes were separated according to seeding depth, one mix for drilling seed at 1/4 to 1/2 inch and a broadcast mix for shallow (0 to 1/8 inch) seeding. Because the planting was done using a Truax Rough Rider range drill with alternate row seeding capabilities, the standard seeding rates (Ogle and others, 2011b) were also cut in half. By doing an alternate row seeding, the number of rows planted is effectively halved and seeding rates are therefore adjusted. Seeding rates and drill calibrations are shown in the appendix. All seed was mixed with rice hulls as an inert carrier to facilitate flow through seeding equipment using specifications found in St. John and others (2005).

Table 2. Seed mixture percentages

#	Variety	Common Name	25% grass	50% grass
			% of mix	% of mix
1	Anatone	Bluebunch wheatgrass	5	10
2	Magnar	Basin wildrye	5	10
3	Sherman	Big bluegrass	15	30
4	Great Northern	Western yarrow	5	2.5
5	Appar	Blue flax	10	7.5
6	Don	Falcate alfalfa	10	5
7	Delar	Small burnet	15	7.5
8	Eski	Sainfoin	20	10
9	Common	Sunflower	10	5
10	Common	Tansyaster	5	2.5

Evaluations took place on July 12, 2011, June 15, 2012, June 17, 2013 and May 13, 2014. A 200 ft transect was laid diagonally in each field beginning 100 ft from the southwest corner. Plant densities of target species were measured using a frequency grid based on that described by Vogel and Masters (2001). The grid measured approximately 40 x 41 inches, having four ten inch columns (to incorporate 1 drill row per column) and five rows, totaling 20 cells. Counts were made of the cells that contained at least one plant. Evaluations were made at 20 foot intervals making a total of 10 frames evaluated per seed mixture. The total cells were added for each species to determine average plants/ft². It is important to note that because cells with plants were counted and not number of plants per cell, the best possible score is 200 hits per ten frames which converts to 1.85 plants/ft^2. Actual plant density may be higher than the numbers indicated below.

It was difficult to find target species in the masses of weeds at the time of the first season evaluation. The native grasses were particularly difficult to find and were not counted in the evaluation. In 2012 and 2013 target grass species were more easily identified and were included in the evaluation.

Results

2011

In 2011, the 25% grass seed mix produced approximately 2 times more total forbs than the 50% grass mixture (Table 3). However, overall weed densities were similar for both planting mixes. These differences are to be expected early in the first growing season as the seeded plants are generally not big enough to cause direct competition for resources. Few

Figure 1. A solid stand of witchgrass. The planting was mowed 3 times to reduce the risk of weeds setting seed. Photo take July 20, 2011.

target grasses were observed, as young grass leaves are easily missed in the thick weeds.

Despite previous farming practices and weed control efforts, there was an abundance of annual weeds present in both fields. The most prevalent weed species in 2011 included witchgrass (*Panicum capilare*), shepherd's purse (*Capsella bursa-pastoris*), field bindweed (*Convolvulus arvensis*), volunteer wheat (*Triticum aestivum*), lamb's quarters (*Chenopodium album*), prickly lettuce (*Lactuca serriola*), red-root pigweed (*Amaranthus retroflexus*), prostrate pigweed (*A. blitoides*), nightshade, (*Solanum* sp.) and tumble mustard (*Sisymbrium altissimum*). Mowing provided fair control of annual broadleaf weeds, but witchgrass continued to dominate the fields throughout the season (Figure 1). In late summer, sunflowers covered the field with a thick understory of witchgrass (Figure 2).

2012

Densities of all seeded species stayed the same or increased from 2011 to 2012. The plants were likely more numerous from volunteering, and were also larger and easier to find. Overall densities of target species were not different between the 25% and 50% grass plots in 2012. In 2012 total target species densities were 4 times greater in the 25% grass mix and 9 times greater in the 50% grass mix compared to 2011, with much of the increase being accounted for by the establishment and observation of grasses in 2012. Grass densities were 2 times higher in the 50% grass mix than the 25% grass mix as expected. There were approximately 2 times more alfalfa and sainfoin plants observed in the 25% grass plots than in the 50% grass plots. Sunflower and blue flax densities were essentially equal between the two treatments in 2012 as volunteers from seed shed the previous year (especially from sunflower) eliminated the original proportions. Yarrow densities were 7 times greater in the 25% grass plots than the 50% grass plots. Hoary tansyaster was observed in the planting but not encountered in the evaluated transects.

Figure 2. Despite mowing, sunflowers persisted and produced flowers in the first growing season. Photo taken September 12, 2011.

Total weed density was 40% lower in 2012 than 2011; however weed densities were not significantly different between the 25 and 50% grass treatments. The most abundant weed species encountered in 2012 was spear saltbush (*Atriplex patula*). This species may have mistaken for lamb's quarters in 2011. Other weed species encountered in 2012 included Canada thistle (*Cirsium arvense*), dandelion (*Taraxacum officinale*), kochia (*Bassia scoparia*), sowthistle (*Sonchus* sp.), cheatgrass (*Bromus tectorum*), yellow salsify (*Tragopogon dubius*), and biennial cinquefoil (*Potentilla biennis*). Other species seen in the planting but not in the evaluated

transects included hound's tongue (*Cynoglossum officinale*), bull thistle (*Cirsium vulgare*), musk thistle (*Carduus nutans*), and catnip (*Nepeta cataria*).

2013

The planting composition changed dramatically from 2012 to 2013. Grass and forb target species densities declined in the both plantings. In the 25% grass mixture, grass densities decreased from 0.15 plants/ft² to 0.04 plants/ft². Similarly, in the 50% grass planting, densities decreased from 0.30 to 0.14 plants/ft². Forb densities decreased in the 25% grass seeding from 2.49 to 1.01 plants/ft², a 60% reduction, and from 2.83 plants/ft² to 1.28 plants/ft² in the 50% grass seeding, a decrease of 55%. Many species including falcate alfalfa, small burnet and sainfoin decreased between 33 and 50% from the previous year. Annual sunflower declined as much as 60% from 2012, which explains the majority of the decrease in total target species density for the year.

Most weed species had similar densities compared to 2012 with the exception of prickly lettuce which increased approximately 300%. Prickly lettuce densities increased from 0.5 plants/ft² to 1.75 plants/ft² in the 25% grass planting and 0.45 plants/ft² to 1.45 plants/ft² in the 50% grass planting.

2014

In 2014 spring precipitation caused a flush of new seedlings, most notably of Appar blue flax. Approximately 2 times more forbs were recorded in the 25% grass mix compared to the 50% grass mix. Similarly grass densities in the 50% grass mix were double those of the 25% grass mix. Additionally, a significant reduction of weeds was observed in the 50% grass mix compared to the 25% grass mix, indicating that the increased grass percentage is at least somewhat effective at competing against non-target species. Prickly lettuce densities stayed at approximately the same level as last year. This continues to be a problem late in the season when the lettuce overtops many of the flowering target species.

Figure 3. Falcate alfalfa, small burnet, blue flax and basin wildrye can be seen. June 20, 2014.

Discussion

Acceptable establishment densities for NRCS plantings range from 1 to 2 plants/ft² (Ogle et al., 2011a). In 2011, the evaluated plant densities fell short of this standard; however this is likely due to the grasses not being included in the evaluation. In 2012 both treatments averaged more than 2 plants/ft². In 2013 plant densities of target species had decreased to nearly 1 plant/ft².

In the first growing season we saw little pollinator value in the two fields planted as most perennial forbs are not expected to blossom during the first growing season. Additionally, annual weeds forced multiple mowing treatments which removed the majority of flowers available for foraging insects. Annual sunflower persisted and blossomed despite the mowing; however, and provided food for foraging bumblebees in late summer and early fall. In 2012 there was no mowing and the perennial forbs were allowed to flower. Abundant pollinator activity was witnessed at the time of evaluation. Very little tansyaster was seen at the evaluation time; however more was observed later in the season, but was largely overshadowed by sunflower. Sunflower plants were small in June, with the majority of plants showing 2 to 4 true leaves, approximately 3 inches tall. In September the sunflower had formed a dense stand with plants averaging 3 to 8 feet tall.

During the second year the planting appeared to be an excellent pollinator resource. Native and European bees were observed foraging on all of the target forb species. The planting also provided excellent cover and forage for wildlife. Deer were observed in the planting and grazing was observed on sainfoin, small burnet, and prickly lettuce. Birds were also abundant in the planting.

Figure 4. Native bee (bottom left) and bee fly (right) visiting yarrow flowers in June, 2013.

In 2013 and 2014 target forbs and grasses were less prevalent than in 2012. Numerous blooms were still available however, and pollinator visitation was observed for all target forbs (figure 4). In the second half of the season the planting site was densely crowded with prickly lettuce which overtopped most of the target species (figure 5).

Weed species present a serious impediment to successful long-term pollinator plantings. Weedy species like prickly lettuce can overtop target forbs potentially making them less visible from the air and reducing pollinator visits. Weeds also compete for resources with target species reducing desired forb densities over time.

Noxious weeds are also a concern. Idaho state noxious weeds observed within the pollinator planting include musk thistle, Canada thistle, field bindweed, broadleaf pepperweed, and hound's tongue. Spot treatments of herbicides may be necessary to control and prevent the spread of noxious weeds. Farming practices and field history indicate that many of these species were not present prior to the planting and may have been introduced with non-certified seed. Use of certified seed is highly recommended to ensure seed quality.

Figure 5. Prickly lettuce dominates the pollinator planting in mid-summer, 2013.

Very few options exist for controlling broadleaf weeds in forb plantings. Hand rogueing and spot spraying are only feasible for small, concentrated infestations. Conversion of forb/pollinator plantings to weed dominated ground seems likely.

Future evaluations are scheduled to take place in 2015 to monitor plant persistence and long term trends in species densities. However, if noxious weeds continue to be a problem, the planting will be terminated.

Table 3. Pollinator planting plant densities (plants/ft²) from July 2011 through June 2013.

Target species	2011 25% Grass	2011 50% Grass	2012 25% Grass	2012 50% Grass	2013 25% Grass	2013 50% Grass	2014 25% Grass	2014 50% Grass
	----------Plants/ft²----------							
Bluebunch wheatgrass			0.06	0.11		0.02	0.01	0.05
Basin wildrye.			0.06	0.13	0.03	0.08	0.05	0.07
Big bluegrass			0.03	0.06	0.01	0.04		0.05
Total grasses	0.00	0.00	0.15	0.30	0.04	0.14	0.06	0.17
Western yarrow	0.02	0.02	0.07	0.01	0	0.02	0.02	0.02
Blue flax	0.07	0.03	0.07	0.15	0.09	0.17	0.49	0.46
Falcate alfalfa	0.07	0.02	0.28	0.20	0.16	0.15	0.29	0.09
Small burnet	0.19	0.07	0.17	0.16	0.07	0.04	0.04	0.01
Sainfoin	0.08	0.09	0.29	0.15	0.09	0.06	0.27	0.05
Sunflower	0.16	0.05	1.61	1.86	0.60	0.70	0.72	0.39
Tansyaster								
Total forbs	0.59	0.28	2.49	2.53	1.01	1.14	1.83	1.02
Total target species	0.59	0.28	2.61	2.83	1.05	1.28	1.89	1.19
Weed species								
Witchgrass	1.86	1.78			0.03	0.04		
Shepherd's purse	0.36	0.23	0.06	0.07	0.04	0.03		
Field bindweed		0.01				0.01	0.03	
Wheat	0.04	0.14						
Lamb's quarters	0.19	0.07						
Prickly lettuce	0.04	0.01	0.5	0.45	1.75	1.45	1.81	1.51
Redroot pigweed	0.25	0.16				0.04		
Prostrate pigweed	0.02							
Nightshade	0.01			0.01				
Tumble mustard		0.01		0.01				
Spear saltbush			1.0	0.88	0.05	0.02	0.31	0.23
Canada thistle			0.01		0.02	0.01	0.17	
Dandelion			0.04	0.02	0.01	0.05	0.08	0.05
Kochia			0.10		0.03	0.01	0.03	
Sow thistle			0.04	0.02				
Cheatgrass			0.01					
Salsify			0.01	0.01				
Cinquefoil				0.01				
Total weed species	2.77	2.41	1.76	1.48	1.93	1.66	2.43	1.79

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Appendix. Drill Calibrations

Mix 1 drill

Variety	Common Name	% of mix	Pure stand rate* lb PLS/acre	% PLS	lb/bu**	lb PLS/ac PLS*% of mix	bulk seed (lb/ac) PLS/%PLS*100	volume (% of bu) bulk seed/lb/bu*100
Anatone	bluebunch wg	5	4.00	84.60	21.70	0.20	0.24	1.09
Magnar	basin wildrye	5	4.00	92.70	18.50	0.20	0.22	1.17
Delar	small burnet	15	10.00	94.00	23.10	1.50	1.60	6.91
sainfoin	Sainfoin	20	17.00	90.00	28.60	3.40	3.78	13.21
sunflower	sunflower	10	11.50	90.00	23.00	1.15	1.28	5.56

Mix 1 broadcast

Variety	Common Name	% of mix	Pure stand rate* lb PLS/acre	% PLS	lb/bu**	lb PLS/ac PLS*% of mix	bulk seed (lb/ac) PLS/%PLS*100	volume (% of bu) bulk seed/lb/bu*100
						0.00	0.00	0.00
						0.00	0.00	0.00
Sherman	big bluegrass	15	1.00	90.00	17.90	0.15	0.17	0.93
Great Northern	yarrow	5	0.25	90.00	20.60	0.01	0.01	0.07
Appar	blue flax	15	2.00	97.00	46.10	0.30	0.31	0.67
Don	yellow alfalfa	10	2.50	90.00	60.00	0.25	0.28	0.46
tansyaster		5	1.00	35.00	12.00	0.05	0.14	1.19

* 1/2 of rate in Ogle and others, 2011b

** St. John and others, 2005

Mix 2 drill

Variety	Common Name	% of mix	Pure stand rate* lb PLS/acre	% PLS	lb/bu**	lb PLS/ac PLS*% of mix	bulk seed (lb/ac) PLS/%PLS*100	volume (% of bu) bulk seed/lb/bu*100
Anatone	bluebunch wg	10	4.00	84.60	21.70	0.40	0.47	2.18
Magnar	basin wildrye	10	4.00	92.70	18.50	0.40	0.43	2.33
Delar	small burnet	7.5	10.00	94.00	23.10	0.75	0.80	3.45
eski	Sainfoin	10	17.00	90.00	28.60	1.70	1.89	6.60
sunflower	sunflower	5	11.50	90.00	23.00	0.58	0.64	2.78

Mix 2
broadcast

Variety	Common Name	% of mix	Pure stand rate* lb PLS/acre	% PLS	lb/bu**	lb PLS/ac PLS*% of mix	bulk seed (lb/ac) PLS/%PLS*100	volume (% of bu) bulk seed/lb/bu*100
Sherman	big bluegrass	30	1.00	90.00	17.90	0.30	0.33	1.86
great northern	yarrow	2.5	0.25	90.00	37.00	0.01	0.01	0.02
Appar	blue flax	7.5	2.00	97.00	46.10	0.15	0.15	0.34
Don	yellow alfalfa	5	2.50	90.00	60.00	0.13	0.14	0.23
tansyaster	common	2.5	1.00	35.00	12.00	0.03	0.07	0.60

* 1/2 of rate in Ogle and others, 2011b

** St. John and others, 2005

COMMERCIAL WILDFLOWER SEED MIX EVALUATION, 2014 PROGRESS REPORT

Derek J. Tilley, PMC Manager

INTRODUCTION

Commercially produced wildflower seed mixes are commonly available and broadly used for attracting pollinators and adding beauty to small gardens and landscapes. These mixtures are popular with landowners because they are pre-mixed and eliminate the guess work of designing custom mixtures. They also eliminate the need to search for and purchase individual species from multiple vendors to create a seed mix.

Most commercial seed mixtures are created to cover a wide range of adaptation and may include plants adapted to extremely low precipitation areas (<9" mean annual precipitation) and plants adapted to wetter environments (>18" mean annual precipitation). This range provides some insurance that at least some of the species in the mixture are adapted to a specific site and may thrive. The problem however is that a significant portion of the species in the mixture is less likely to be adapted to the planting site and thus represent an unnecessary expense.

The species in the mixtures are selected for their attractiveness to bees, butterflies and other pollinators and are purportedly composed of species well adapted to specific regions or environments. Despite these advantages, suitability of many of the species in the mixes to pollinator plantings for CRP or other NRCS programs is largely unknown. Many species are from North America outside of the Intermountain West; still others are of Eurasian or African origin. Additionally, some commercial mixes may contain plant species that can become invasive, or the mix may not contain appropriate species to provide pollinator forage throughout the year, or may contain plant species that are attractive to humans but provide little value to the target pollinators. Establishment, persistence, and suitability of many of these species to pollinator plantings are poorly understood in this context. These issues need to be examined before NRCS can recommend commercially designed seed mixes for conservation practices.

MATERIALS AND METHODS

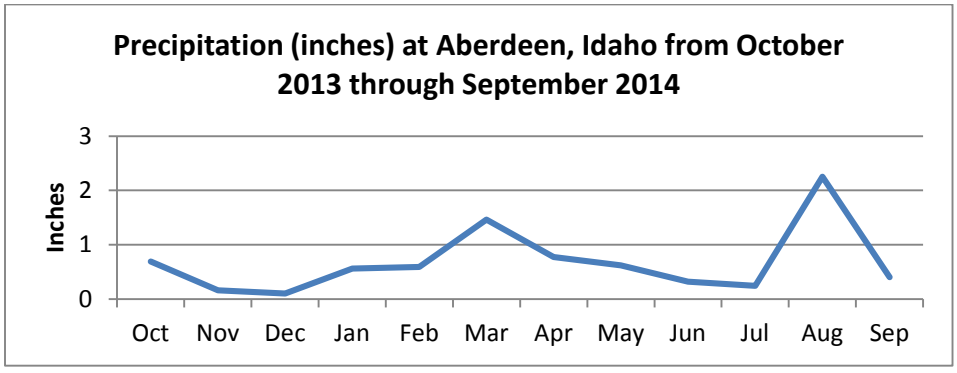
This trial was conducted on the Aberdeen Plant Materials Center Fish and Game Farm located 5 miles northeast of Aberdeen, Idaho. Soil at the site is a Declo silt loam with pH of 7.4 to 8.4. Average annual precipitation is 9.39 inches. The field had previously been planted to a crop of small grains left standing for wildlife food and cover.

We planted six commercially available wildflower seed mixes designed for use in western North America into non-replicated 90 x 20 ft plots. The mixtures selected were chosen based on their dissimilarity with other mixes in the trial to include the widest possible variety of species (see appendix). Each mix contained between 15 and 25 species. Prices of the mixtures ranged from

$23/lb to $60/lb plus shipping. Mention of a specific mixture or company is not an endorsement by the NRCS.

In mid-May, 2013 the field was mowed to knock down the standing small grain cover and was treated with 64 oz glyphosate per acre to control volunteer grains and emerging annual weeds. On May 23, 2013 the trial was planted using a 3 ft Truax® broadcast seeder pulled by an ATV followed with a packer roller. Recommended seeding rates for the various mixes range from 6 to 20 lbs/acre depending on the desired density of the stand. Each plot in this trial was seeded at a target rate of 10 lbs/ac to obtain a uniform density between the plots. The trial was irrigated approximately 8 hours (2 inches) every ten days during the establishment phase in 2013. Irrigation was discontinued on August 1. On July 10, 2013 the site was sprayed with 1 pt/ac sethoxydim to control annual grasses.

To see how the various species performed under limited water conditions, no supplemental irrigation was applied during the 2014 growing season. Precipitation totals were below average for most of the 2014 water year. Summer rains (2.25 inches in August) brought the total for the year to 8.16 inches.



Plots were evaluated to determine which species were well adapted to conditions in the PMC service area including the Intermountain and Rocky Mountain Regions and contributed to pollinator foraging. Plant density was evaluated on August 8, 2013 using a 1 m² frame placed in the center of the plots 5 paces and 10 paces into the plot. Plots were also visited periodically in 2013 and 2014 to observe blooming and insect visitation.

The trial will be evaluated again in 2015 and 2016 to observe changes in species composition and to identify any potential management problems that may be associated with using commercial pollinator seed mixes.

RESULTS AND DISCUSSION

Initial Density

Plant density was recorded early in the season on August 8, 2013 when plants could be easily counted (Table 1). Some species documented flowering in the later evaluations were not present at the early density evaluation. These were either located outside of the evaluated frames, or could have germinated later in the season or were unidentifiable at early life stages. Many

perennials listed here did not flower the first season and some of the perennial species require a winter stratification period and were not expected to germinate until spring 2014.

Early plant densities were largely composed of annual species that had no stratification requirement. Seed mixtures with a large component of annuals seemed in most cases better equipped to compete against weed species.

Table 1. Initial density (plants per meter^2) of target and weed species from each commercial seed mix evaluated August 8, 2013.

	AM Dry Area	AM Xeriscape	AM Native	Outside Pride	Applewood	Eden Bros.
Target species	----------plants/m²----------					
Cornflower	1.5			2.5	1.5	3.5
Plains coreopsis	1.0			0.5	1.5	2.0
Wild cosmos	0.5					
Baby snapdragon	0.5					
CA poppy	2.5	4.5		3.0	4.0	
Corn poppy	1.0			4.5	4.0	1.0
Siberian wallflower	0.5			0.5		
Sweet alyssum	1.0				3.5	
Indian blanket	1.0	0.5	2.5		1.5	
Birdsfoot trefoil	0.5					
Tidytips		2.5				
Bird's eye		1.5				
Greenthread		0.5				
Blue flax		0.5				0.5
Arroyo lupine		0.5				
Farewell to spring			2.0	0.5	0.5	
Candy tuft				3.0		
Total target	10.0	10.5	4.5	14.5	16.5	7.0
Weed species						
Volunteer millet	0.5	0.5	1.0		1.0	1.0
Green foxtail	3.5	4.0	2.0		3.5	9.0
Lambsquarters	0.5					0.5
Witchgrass	1.5	4.5	7.0	3.5	1.5	
Barnyardgrass	0.5		2.5	1.0	5.0	4.0
Shepherd's purse		1.0	0.5	1.0		0.5
Prickly lettuce			0.5			
Total weed	6.5	10.0	13.5	5.5	11.0	15.0

American Meadows Dry Area

American meadows Dry Area mix contains 25, primarily introduced species. Of the 25, 14 are annual, 2 biennial and 9 perennial. Eighteen of the 25 included species are not native to the Intermountain or Rocky Mountain west. Nineteen species bloomed during the first growing season beginning in early August and continuing through the end of September. Fourteen of the 18 species that bloomed during 2013 were annuals (Table 2). This mix showed the greatest floral and color diversity during the first growing season.

Several species in the Dry Area mix showed excellent vigor and flower persistence. Most of the species present began blooming in August and continued to bloom through late September. Many of the species were highly favored by European honey bees including California poppy, corn poppy, cornflower, wild cosmos and plains coreopsis. Despite being not native to the region, these species were also observed being visited readily by native bees and butterflies.

Table 2. American Meadows Dry Area Mix flowering color and duration, 2013. Colored bars indicate flower color. Green indicates no flowers in bloom.

		8-Aug	19-Aug	4-Sep	10-Sep	20-Sep	27-Sep
California poppy	Ann.						
Corn poppy	Ann.						
Cornflower	Ann.						
Sweet alyssum	Ann.						
Plains coreopsis	Ann.						
Wild cosmos	Ann.						
Blackeyed susan	Per.						
Indian blanket	Ann.						
African daisy	Ann.						
Baby snapdragon	Ann.						
Evening primrose	Bi.						
Catchfly	Ann.						
Prairie coneflower	Per.						
Siberian wallflower	Ann.						
Shasta daisy	Rhiz per.						
Sulphur cosmos	Ann.						
Gloriosa daisy	Per.						
Garland chrysanthemum	Ann.						
Yarrow	Per.						
Sweet William	Bi.						
Blanketflower	Per.						
Baby’s breath	Ann.						
Blue flax	Per.						
Bird’sfoot trefoil	Per.						
Rocky Mountain penstemon	Per.						

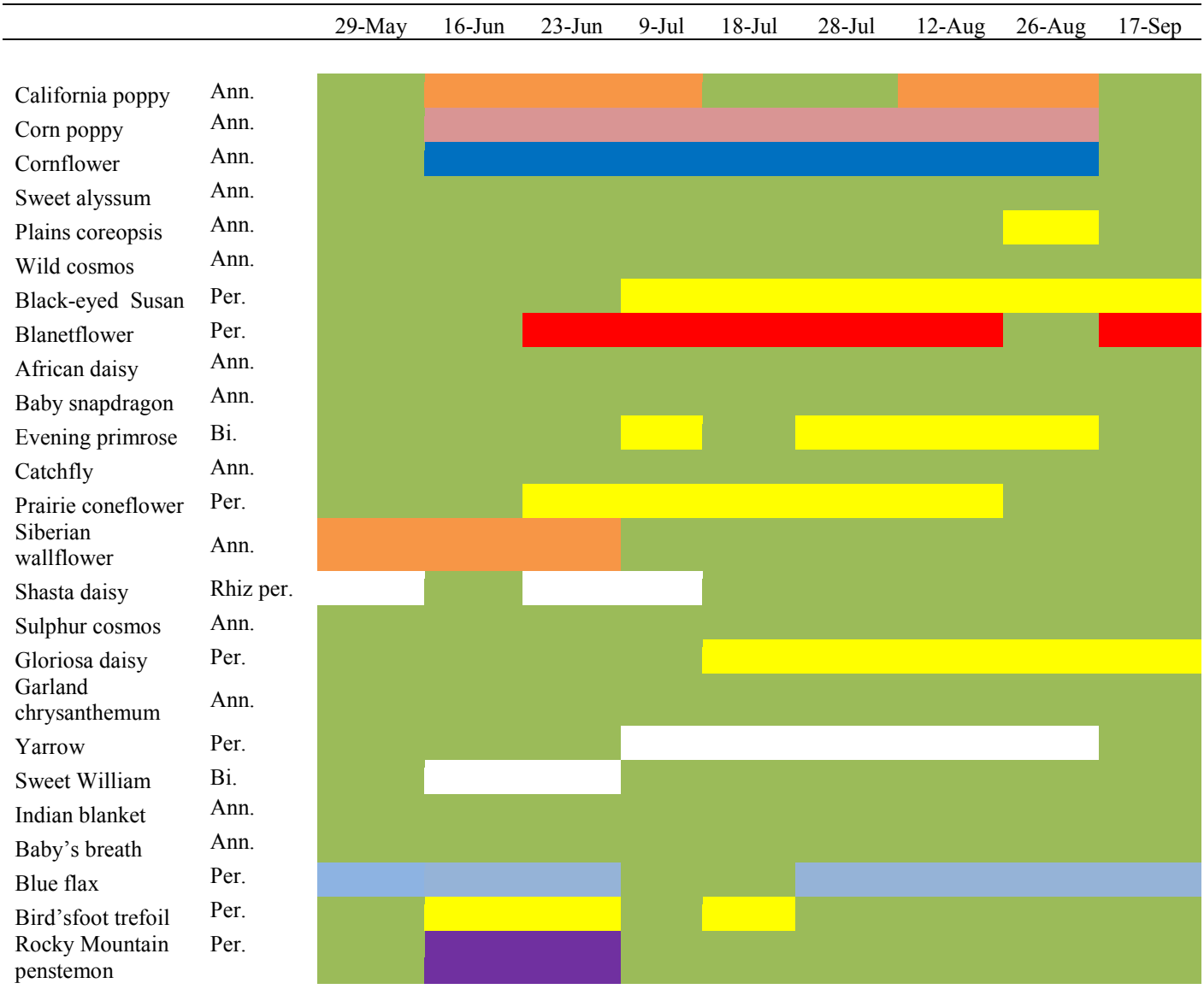
American Meadows Dry Area

July 22, 2013

August 29, 2013

Sixteen species in the American Meadows Dry Area mix flowered in 2014. In all, 5 annuals, 2 biennials and 9 perennials flowered during the second season indicating a shift from annuals to longer lived species. Black-eyed Susan, blanket flower, prairie coneflower, yarrow and blue flax all had long flowering durations. Cornflower and California poppy, both introduced annuals also provided significantly to the floral display. This mix again provided the greatest diversity of the evaluated mixes.

Table 3. American Meadows Dry Area Mix flowering color and duration 2014. Colored bars indicate flower color. Green indicates no flowers in bloom.



American Meadows Western Xeriscape

American Meadows Western Xeriscape mix contains 24 species, mostly native to the PMC service area with some plants being introduced from California. This mix is the closest to what might be recommended for pollinator plantings by the PMC. It contains 12 annuals 10 perennials and 2 biennials.

Nine species in the Xeriscape mix flowered during the first growing season (Table 4). This mixture contained a large percentage of tidytips and California poppy and provided a very yellow dominant appearance. Blanketflower was also present in good numbers. All flowering in the first season was done by annuals and the perennial blanketflower. Tidytips and blanketflower appeared highly attractive to small native bees. California bluebell, greenthread, arroyo lupine and blazingstar were present, but not in large numbers; most were represented by one or two plants.

Table 4. American meadows Western Xeriscape Mix flowering color and duration 2013. Colored bars indicate bloom color. Green indicates no flowers in bloom.

	Longevity	8-Aug	19-Aug	4-Sep	10-Sep	20-Sep	27-Sep
California poppy	Annual						
Tidytips	Annual						
Blanketflower	Perennial						
Bird's eye	Annual						
California bluebell	Annual						
Greenthread	Annual						
Arroyo lupine	Annual						
Prairie aster	Biennial						
Blazingstar	Annual						
Desert marigold	Ann., Bi.						
Deerhorn clarkia	Annual						
Common wooly sunflower	Perennial						
Blue flax	Perennial						
Five spot	Annual						
Pale evening primrose	Biennial						
Palmer penstemon	Perennial						
Rocky Mountain penstemon	Perennial						
Prairie coneflower	Perennial						
Gooseberryleaf globemallow	Perennial						
Baby blue-eyes	Annual						
Soapwort	Perennial						
Creeping thyme	Perennial						
Strawberry clover	Perennial						
Johnny jump-up	Annual						

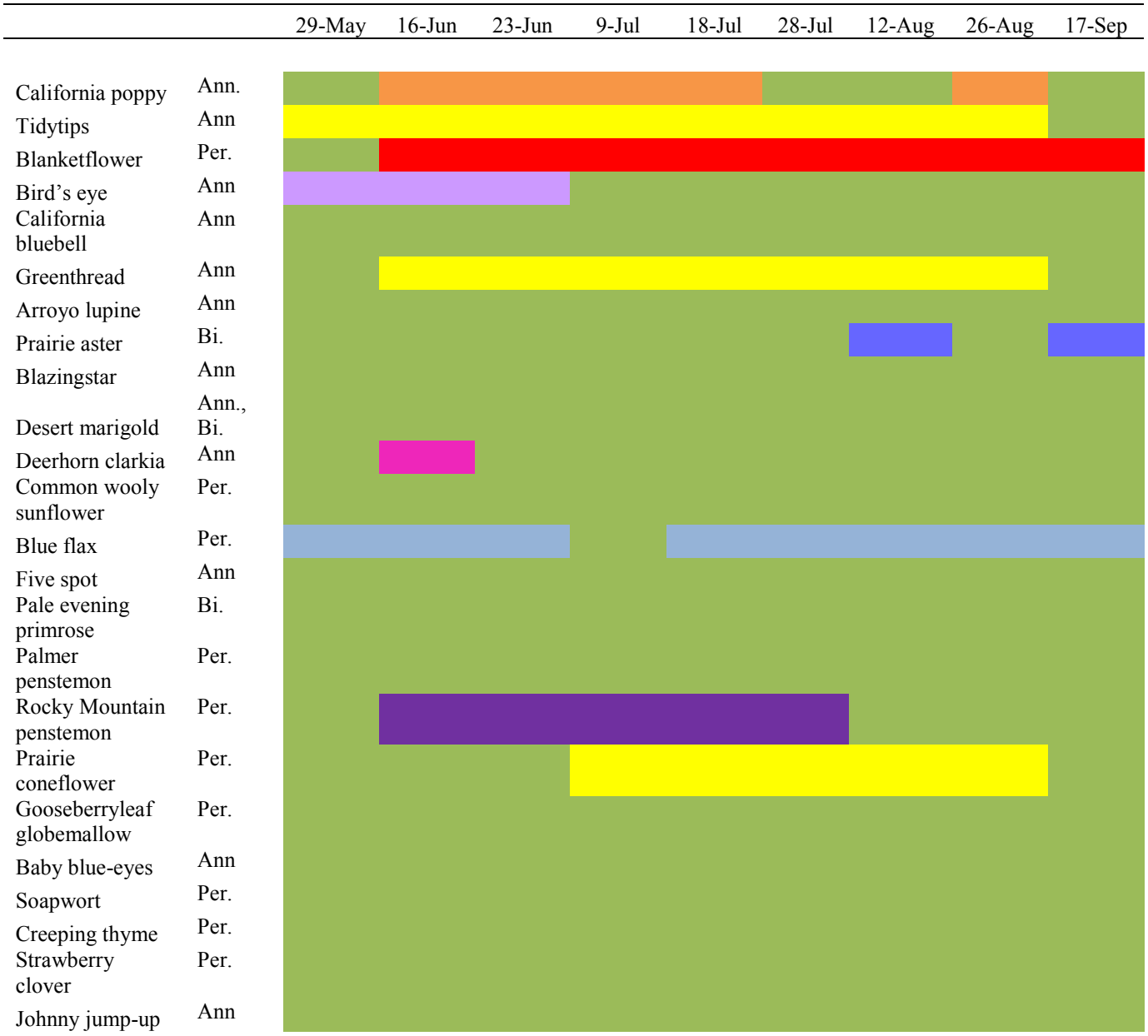
American Meadows Western Xeriscape

July 22, 2013

August 29, 2013

American Meadows Western Xeriscape mix had somewhat less floral diversity than the Dry Area mix. Ten species flowered in 2014 including 5 annuals, one biennial and 4 perennials. Two annual California natives, tidytips and California poppy showed well. Green thread, which is native to the east slope of the Rocky Mountains and into the Plains States, also provided a strong floral display. Blue flax, blanket flower and Rocky Mountain penstemon are native to the region. Prairie aster added to the late season color in August and September.

Table 5. American Meadows Western Xeriscape Mix flowering color and duration 2014. Colored bars indicate bloom color. Green indicates no flowers in bloom.



American Meadows Native West

American Meadows Native West mix is composed of 19 species, 7 annuals, 1 biennial and 11 perennials all native to North America (Table 6). However it does contain many species that would not be considered native to the Intermountain or Rocky Mountain Region. Some come from eastern US, coastal western US or from the Southwest, all areas that are very dissimilar from conditions found in our region.

The lack of introduced annuals in the mixture significantly reduced the number of species flowering during the first growing season. Only five species blossomed in 2013, 3 annuals and 2 perennials. The All Native mix was highly red color dominant in 2013 due to the large numbers of Indian blanket. Other prominent species in the floral composition were blackeyed Susan and showy goldeneye.

Table 6. American Meadows Native West Mix flowering color and duration 2013. Colored bars indicate bloom color. Green indicates no flowers in bloom.

		8-Aug	19-Aug	4-Sep	10-Sep	20-Sep	27-Sep
Indian blanket	Ann.						
Farewell to spring	Ann						
Blackeyed Susan	Per.						
Tidytips	Ann						
Showy goldeneye	Per.						
Blue columbine	Per.						
Smooth aster	Per.						
Prairie aster	Bi.						
Deerhorn clarkia	Ann						
Rocky Mountain beeflower	Ann						
Plains coreopsis	Ann						
Fleabane daisy	Per.						
Blanketflower	Per.						
Globe gilia	Ann						
Blue flax	Per.						
Rocky Mountain penstemon	Per.						
Purple prairie clover	Per.						
Prairie coneflower	Per.						
White evening primrose	Per.						

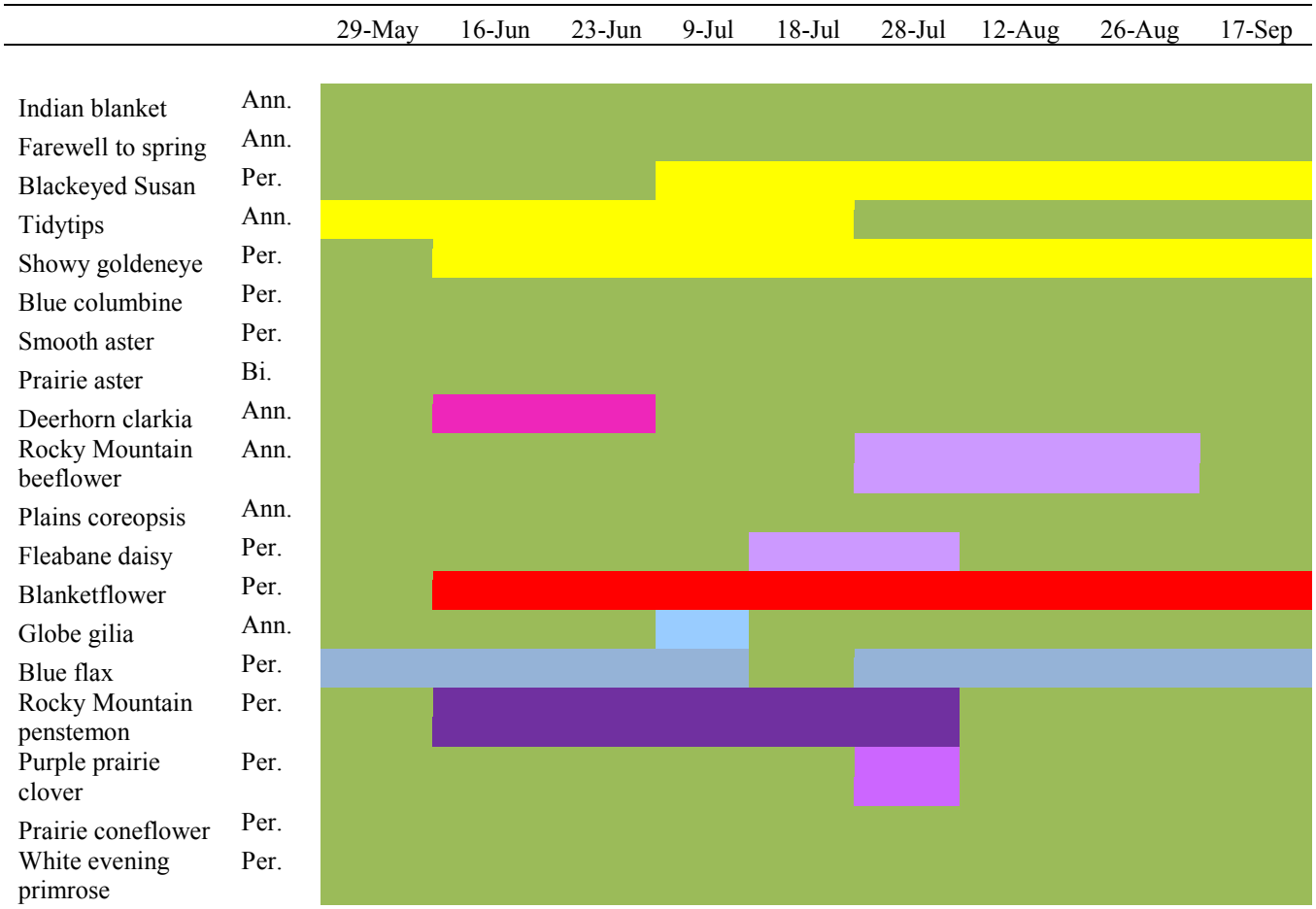
American Meadows Native West

July 22, 2013

August 29, 2013

The American Meadows Native West mix improved in floral diversity in 2014 adding flowers from several perennial species (Table 7). Eleven species flowered in 2014, 4 annuals and 7 perennials. Black-eyed Susan, showy goldeneye, blanket flower, blue flax and Rocky Mountain Penstemon all did well and flowered through most of the season. Tidytips had sustained blooming for most of the mid-summer. The slow development of the perennials last year allowed weedy annual species like prickly lettuce to proliferate.

Table 7. American Meadows Native West Mix flowering color and duration 2014. Colored bars indicate bloom color. Green indicates no flowers in bloom.



Outside Pride Western Wildflower

Outside Pride Western Wildflower Mix consists of 17 native and introduced species with 9 annuals and 8 perennials (Table 8). Of these, 11 flowered in the first growing season, 8 of which were annuals. California poppy, plains coreopsis, corn poppy and cornflower were frequently visited by European honeybees. Indian blanket and showy goldeneye, both native species, were also visited by native pollinators.

Table 8. Outside Pride Western Wildflower Mix flowering color and duration 2013. Colored bars indicate bloom color. Green indicates no flowers in bloom.

		8-Aug	19-Aug	4-Sep	10-Sep	20-Sep	27-Sep
Corn poppy	Ann.						
Plains coreopsis	Ann.						
California poppy	Ann.						
Sweet alyssum	Ann.						
Farewell to spring	Ann.						
Cornflower	Ann.						
Indian blanket	Ann.						
Candytuft	Ann.						
Siberian wallflower	Bi.						
Showy goldeneye	Per.						
Blackeyed Susan	Per.						
Blanketflower	Per.						
Globe gilia	Ann.						
Blue flax	Per.						
Perennial lupine	Per.						
Rocky Mountain penstemon	Per.						
Prairie coneflower	Per.						

Outside Pride Western Wildflower

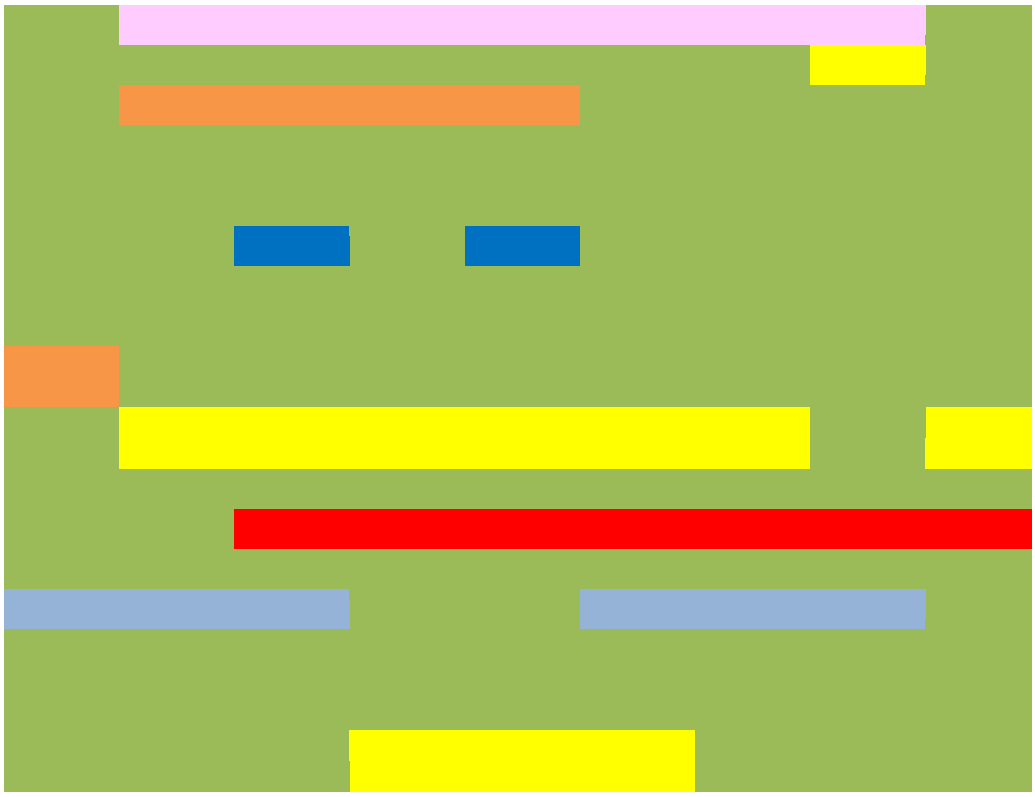
July 22, 2013

August 29, 2013

Outside Pride's Western Wildflower mix contains a mixture of native and introduced species. Introduced annuals like corn poppy and California poppy were abundant in 2014. Native perennials showy goldeneye, blanket flower and blue flax flowered through most of the season. In total 4 annuals, 1 biennial, and 4 perennials flowered in 2014.

Table 9. Outside Pride Western Wildflower Mix flowering color and duration 2014. Colored bars indicate bloom color. Green indicates no flowers in bloom.

		29-May	16-Jun	23-Jun	9-Jul	18-Jul	28-Jul	12-Aug	26-Aug	17-Sep
Corn poppy	Ann.									
Plains coreopsis	Ann.									
California poppy	Ann.									
Sweet alyssum	Ann.									
Farewell to spring	Ann.									
Cornflower	Ann.									
Indian blanket	Ann.									
Candytuft	Ann.									
Siberian wallflower	Bi.									
Showy goldeneye	Per.									
Blackeyed Susan	Per.									
Blanketflower	Per.									
Globe gilia	Per.									
Blue flax	Per.									
Perennial lupine	Per.									
Rocky Mountain penstemon	Per.									
Prairie coneflower	Per.									



Applewood Western Mix

Applewood Seed's Western Mix consists of 20 species, 11 annuals 8 perennials and 1 biennial (Table 10). This mixture has a similar composition to the Outside Pride Western Wildflower mix and contains primarily introduced species. Eight species flowered the first season. Showy goldeneye was the only perennial to flower in 2013.

Table 10. Applewood Western Mix flowering color and duration 2013. Colored bars indicate bloom color. Green indicates no flowers in bloom.

		8-Aug	19-Aug	4-Sep	10-Sep	20-Sep	27-Sep
Corn poppy	Ann.						
Plains coreopsis	Ann.						
California poppy	Ann.						
Sweet alyssum	Ann.						
Farewell to spring	Ann.						
Cornflower	Ann.						
Indian blanket	Ann.						
Showy goldeneye	Per.						
Deerhorn clarkia	Ann.						
Blanketflower	Per.						
Globe gilia	Ann.						
Candytuft	Ann.						
Blue flax	Per.						
Perennial lupine	Per.						
Dwarf evening primrose	Per.						
Pale evening primrose	Bi.						
Palmer penstemon	Per.						
Rocky Mountain penstemon	Per.						
Prairie coneflower	Per.						
Greenthread	Ann.						

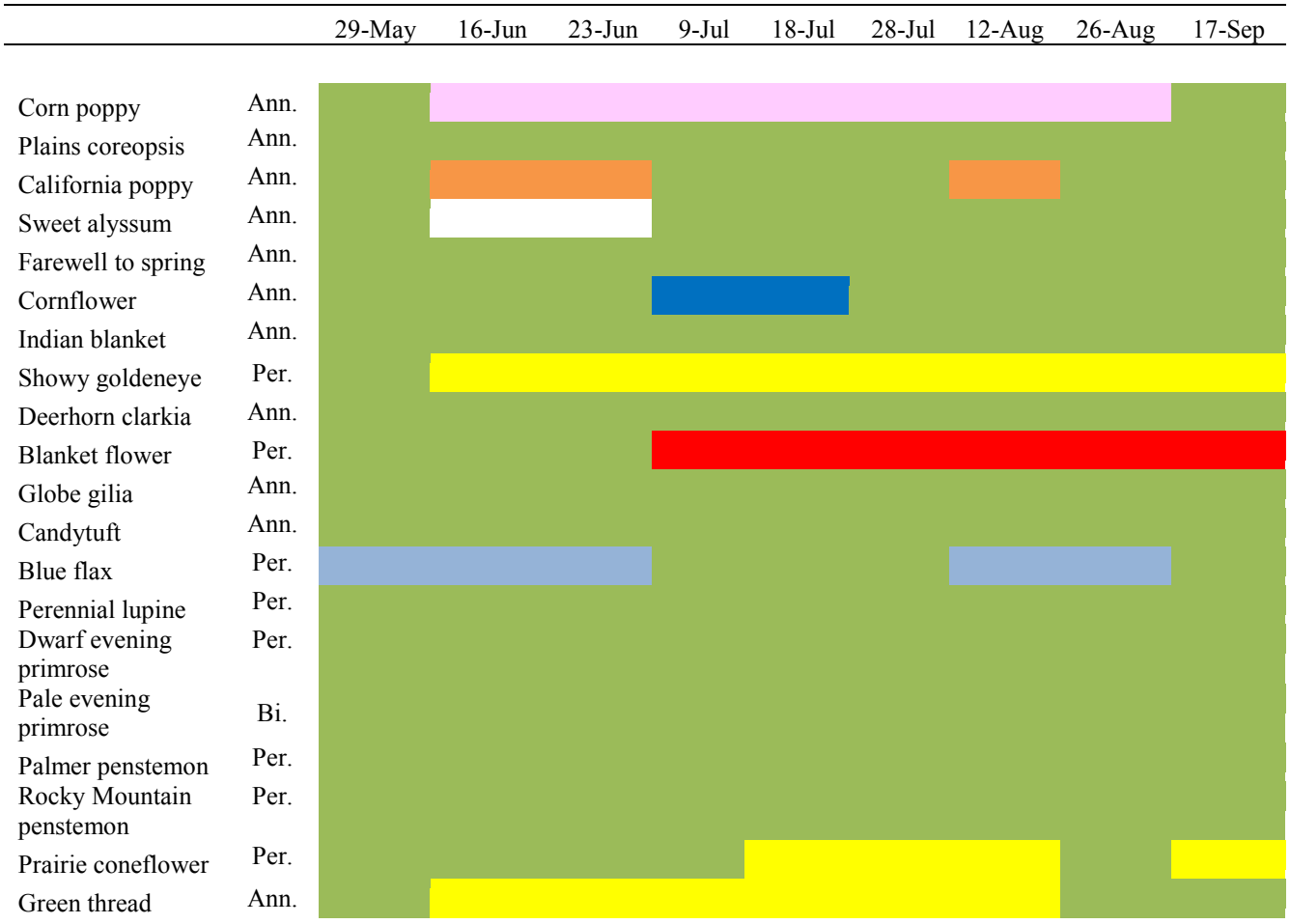
Applewood Western Mix

July 22, 2013

August 29, 2013

Similar to other mixes, the Applewood Western mix had an assortment of perennial natives and introduced annuals. Nine total species flowered in 2014 including 5 annuals and 4 perennials. Blanket flower, showy goldeneye, blue flax, and prairie coneflower flowered consistently in 2014. Corn poppy, California poppy, corn flower and green thread were annuals that returned for the second season from dropped seed.

Table 11. Applewood Western Mix flowering color and duration 2014. Colored bars indicate bloom color. Green indicates no flowers in bloom.



Eden Brothers Western Wildflower Mix

The Western Wildflower Mix from Eden Brothers contains 24 species, 12 annuals, 1 biennial and 11 perennials (Table 12). Flowering during the first season was similar to other mixes containing corn poppy, cornflower, plains coreopsis and wild cosmos. Surprisingly, we did not observe any flowering from California poppy during this season in the Eden Brothers mix.

Table 12. Eden Brothers Western Wildflower Mix flowering color and duration 2013. Colored bars indicate bloom color. Green indicates no flowers in bloom.

		8-Aug	19-Aug	4-Sep	10-Sep	20-Sep	27-Sep
Corn poppy	Ann.						
Cornflower	Ann.						
California poppy	Ann.						
Plains coreopsis	Ann.						
Wild cosmos	Ann.						
Lemon mint	Ann.						
Prairie coneflower	Per.						
Blackeyed Susan	Per.						
Baby's breath	Ann.						
Indian blanket	Ann.						
Sulphur cosmos	Ann.						
Blue columbine	Per.						
Siberian wallflower	Bi.						
Lanceleaf coreopsis	Per.						
Purple coneflower	Per.						
Blanketflower	Per.						
Scarlet flax	Ann.						
Blue flax	Per.						
Perennial lupine	Per.						
Russel lupine	Per.						
Five spot	Ann.						
Rocky Mountain penstemon	Per.						
Drummond phlox	Ann.						
Gloriosa daisy	Per.						

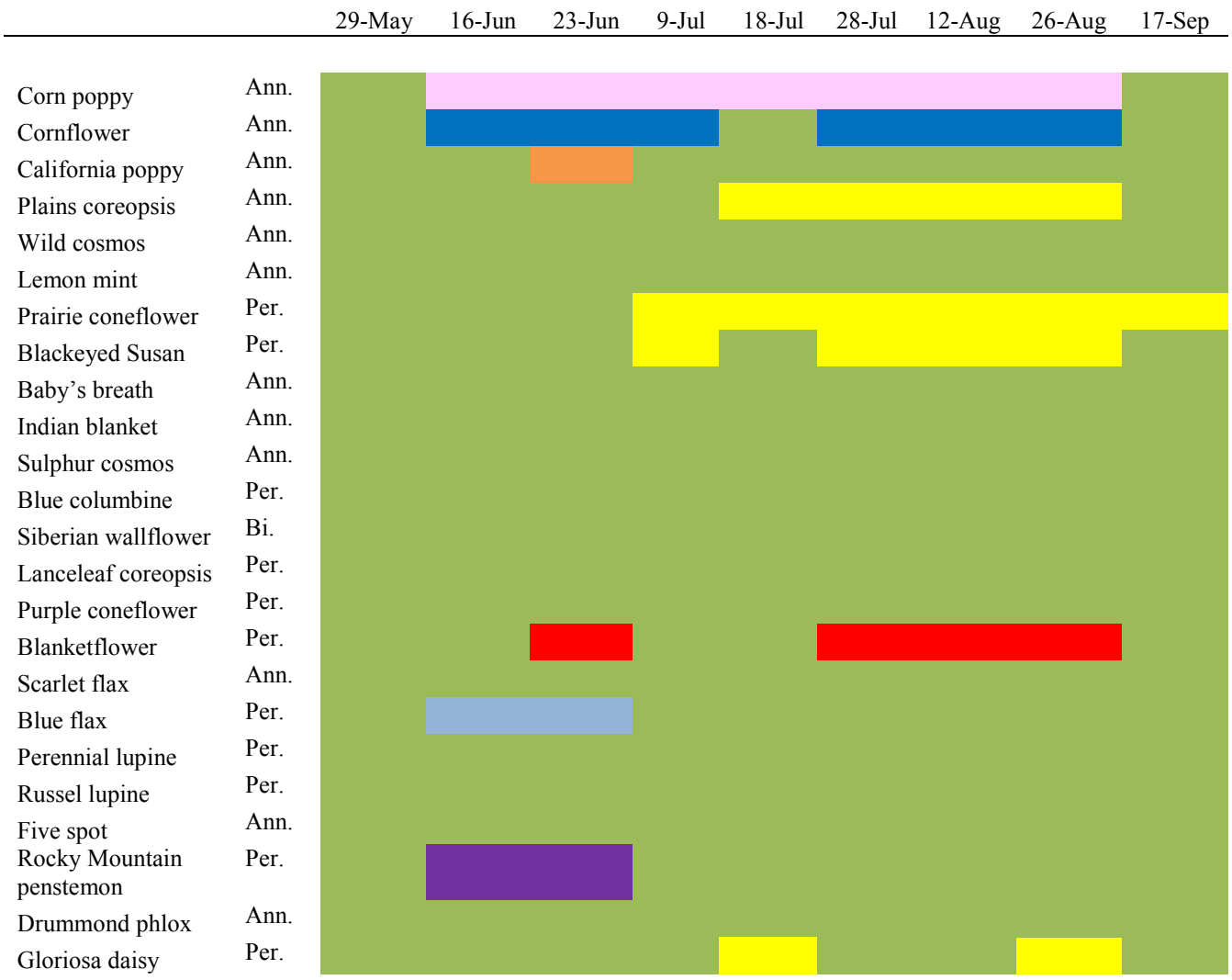
Eden Brothers Western Wildflower Mix

July 22, 2013

August 29, 2013

Ten species in total flowered during 2014 in the Eden Brothers Western Wildflower mix. Four annuals and 6 perennials were represented.

Table 13. Eden Brothers Western Wildflower Mix flowering color and duration 2014. Colored bars indicate bloom color. Green indicates no flowers in bloom.



CONCLUSIONS

Weedy annual species were common throughout the plots. Annual grasses can be significantly reduced by using grass selective herbicides; however we were not able to remove them entirely with a single treatment of sethoxydim. Broadleaf weeds are extremely difficult to control in wildflower plantings, as herbicides used to treat broadleaf weeds will also affect many of the target species in the seed mixtures. Lambs quarters and shepherd's purse were common annual weeds in the plots during 2013, but these decreased significantly in density in 2014 as the target species had become more competitive. Prickly lettuce however increased in density in 2014, especially in those mixes that contained few competitive annual wildflower species.

Of the total 62 species included in the trial, 30 flowered in the first growing season. The vast majority (22 of 30) were annuals, the remainder being 2 biennials and 6 perennials. Flowering was not observed until early August, approximately 11 weeks after planting. Most species had long sustained flowers due to supplemental irrigation and late summer rains. The first frost of the season came on September 19, and all plants had ceased flowering by October 17.

The inclusion of annuals is a good way to get blooms during the first growing season. It is especially important to include annuals in post-fire rehabilitation seed mixtures to provide food for native pollinators that have relatively short foraging ranges and might not be able to reach undisturbed plant communities (Cane 2008).

Insect visitation varied between plots due to species composition and density. Overall, corn poppy, California poppy, cornflower, plains coreopsis, and wild cosmos were very attractive to European honeybees. Tidytips and blanketflower were heavily visited by native bees. Hunt's bumblebee was observed frequently visiting wild cosmos. Butterflies were observed on Indian blanket and blanketflower. All of the flowering species were observed being visited at least once by pollinators.

Eleven of the 62 species planted are cited in the literature as having weedy tendencies (USDA NRCS 2013). Of these, Cornflower, soapwort and Rocky Mountain bee flower are listed as being weedy in western states (Whitson et al 1996). The others are primarily western species that express weedy behavior in the Midwest and eastern US. Rocky Mountain bee flower is native to the PMC service area. It can invade and spread into ditch banks and along roadsides where moisture accumulates. Cornflower and California poppy are a concern. These species are known to escape from "wildflower" seedings and spread.

In addition to inappropriate target species, wildflower mixes can also contain accidental inclusions of noxious weed seed. Seed used for commerce is not to have any prohibited noxious weeds listed in the state the seed is shipped to or used. However, restricted noxious weed seeds may be included as state seed law allows. The best way to know if noxious weed seed is in a mix is with an accurate purity test and seed tag.

A small number of plants evaluated in the trial have known or suspected toxic properties. Three species, yarrow, desert marigold, and soapwort have been shown to cause disease in sheep when consumed in large volumes (Burrows and Tyrl 2001). Yarrow and desert marigold are native and

are commonly present in rangelands used for sheep grazing; however these species should be avoided or used with caution in areas where they might pose a risk to livestock.

In order to prevent the establishment and spread of noxious weeds and other invasive plant species, one must be careful about what seeds are planted. The best way to do this is to use a custom seed mix. If a commercial wildflower mix is used, the mix selected should be appropriate to the region; native species are recommended when possible. Mixes including known invasive or aggressive species such as cornflower should be avoided. Seed mixes should be tested for purity and come with an accurate seed tag. Mixtures should also be clearly labeled with scientific names included, as confusion and uncertainty can arise from the use of common names. Following these steps will help ensure that only appropriate species are planted.

During the second season of our trial, perennial species made up the majority of the floral display. Black-eyed Susan, blanket flower, prairie coneflower, yarrow, blue flax, Rocky Mountain penstemon, and showy goldeneye had numerous flowers and lasted for much of the second season. Flowering began in late May and ended with freezing temperatures in mid-September. Other perennials such as fleabane daisy, and prairie aster had blossom periods limited to late summer. Twelve annual species, California poppy, corn poppy, corn flower, plains coreopsis, Siberian wallflower, tidytips, bird'seye, Green thread, deerhorn clarkia, Rocky Mountain bee flower, globe gilia, and sweet alyssum also returned in 2014. Several species in the various mixes showed no flowering in the first or second year of the trial.

In 2014 there was evidence of volunteering of plants into adjacent plots. Tidytips and corn poppy had spread as much as 30 feet from their original location the previous year.

Use in NRCS Programs

Approximately two-thirds of the original species (39 of 62) flowered in 2013 or 2014 indicating at least moderate adaptation to 14 to 18 inch precipitation sites in southeastern Idaho. Those that did not flower add to the cost of the seed mix and may be being used at the exclusion of more appropriate species. Careful selection of adapted species can reduce the cost of seed mixes as maladapted species are avoided.

The NRCS funds or cost-shares approved pollinator plantings which meet agency specifications. These specifications include seed mixture composition percentages and the rate at which the seed is planted (lb/ac or seeds/ft). To accurately calculate seeding rates, one needs to know: % of each species in the mix by weight, purity of each species, germination or viability of each species and the average number of seeds/lb for each species (Tilley and St. John 2013). This information is commonly lacking in commercial seed mixtures. Of the six mixtures evaluated, only two included percentage information.

Using rough estimates for purity and viability we calculated approximate seeds/ft for the two mixtures where percentages of each species were available based on seeding 10 lbs bulk seed per acre. Based on our calculations, Applewood Seed Western Mix was seeded at approximately 128 seeds/ft and Outside Pride Western Wildflower Mix had 93 seeds/ft. NRCS specifications stipulate a target seeding rate of 75 to 100 seeds/ft for broadcast seeding of small seeded species. These numbers suggest that the recommended rate of 10 lbs/ac closely aligns with NRCS

broadcast seeding rates. Species component percentages must be available to determine whether or not seeding mixtures meet NRCS standards. Mixtures not providing percentages of species components should not be used for NRCS funded seedings.

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USDA United States Department of Agriculture

Appendix. Mix and species information

Common Name	Scientific Name	Origin	Longevity	Eden Brothers Western Wildflower Mix $27/lb	Applewood Seed Western Mix $26/lb	Outside Pride Western Wildflower Mix $23/lb	American Meadows Native West $60/lb	American Meadows Dry Area Mix $27/lb	American Meadows Western Xeriscape Mix $40/lb
					% of mix	% of mix			
Yarrow	*Achillea milliefolium*	N. Am.	Perennial					x	
Blue columbine	*Aquilegia coerulea*	IMW[1] and RMW[2]	Perennial	x			x		
Smooth aster	*Aster laevis*	Eastern US	Perennial				x		
Priarie aster	*Machaerranthera tanacetifolius*	Western US (not PNW[3])	biennial				x		x
Desert marigold	*Baileya multiradiata*	SW	Ann., bi, per.						x
Cornflower	*Centaurea cyanus*	N. Am.	annual	x	7.3	8.13		x	
Siberian wallflower	*Cheiranthus allionii*	Eurasia	Biennial	x		12.19		x	
Garland chrysanthemum	*Chrysanthemum coronarium*	Mediterranean	Annual					x	
Shasta daisy	*Chrysanthemum maximum*	Europe	Rhiz-perr.					x	
Deerhorn clarkia	*Clarkia pulchella*	PNW	Annual		0.92		x		x
Farewell to spring	*Clarkia unguiculata*	California	Annual		1.83	1.34			
Rocky Mountain bee flower	*Cleome serrulata*	N. Am (not SE)	Annual				x		
Lanceleaf coreopsis	*Coreopsis lanceolata*	N. Am (not IMW)	Perennial	x					
Plains coreopsis	*Coreopsis tinctoria*	N. Am (not IMW)	ann, bi, per	x	0.73	1.02	x	x	
Wild cosmos	*Cosmos bipinnatus*	Central Am.	Annual	x				x	
Sulphur cosmos	*Cosmos sulphureus*	Central am.	Annual	x				x	
Purple prairie clover	*Dalea purpurea*	Midwestern US	Perennial				x		
Sweet william	*Dianthus barbatus*	Eurasia	Biennial					x	
African daisy	*Dimorphotheca sinuata*	Africa	Annual					x	
Purple coneflower	*Echinacea purpurea*	Eastern US	Perennial	x					
Fleabane daisy	*Erigeron speciosus*	Western US	Perennial				x		
Common woolly sunflower	*Eriophyllum lanatum*	Western US	Perennial						x
California poppy	*Eschscholzia californica*	California	Annual	x	11	12.19		x	x

Appendix (cont.)

Common Name	Scientific Name	Origin	Longevity	Eden Brothers Western Wildflower Mix	Applewood Seed Western Mix	Outside Pride Western Wildflower Mix	American Meadows Native West	American Meadows Dry Area Mix	American Meadows Western Xeriscape Mix
					% of mix	% of mix			
Blanketflower	*Gaillardia aristata*	Western US	Perennial	x	12.83	8.13	x	x	x
Indian blanket	*Gaillardia pulchella*	Eastern US	Annual		3.67	4.06	x	x	
Globe gilia	*Gilia capitata*	Western US	Annual		1.83	1.34	x		
Bird's eye	*Gilia tricolor*	California	Annual						x
Baby's breath	*Gypsophila elegans*	Eurasia	Annual	x				x	
Showy goldeneye	*Heliomeris multiflora*	Western US (not PNW)	Perennial		1.21	0.81	x		
Candy tuft	*Iberis umbellata*	Mediterranean	Annual		11	16.25			
Tidytips	*Layia platyglossa*	CA, AZ, UT	Annual						x
Baby snapdragon	*Linaria maroccana*	Morocco	Annual					x	
Scarlet flax	*Linum grandiflorum*	Algeria	Annual	x					
Blue flax	*Linum perenne*	Europe	Perennial	x	7.33	12.19	x	x	x
Sweet alyssum	*Lobularia maritima*	Mediterranean	Annual					x	
Birdsfoot trefoil	*Lotus corniculatus*	Eurasia	Perennial					x	
Perennial lupine	*Lupinus perennis*	Eastern US	Perennial	x	14.65	16.25			
Russel lupine	*Lupinus polyphyllus*	Western US	Perennial	x					
Arroyo lupine	*Lupinus succulentus*	California	Annual						x
Blazingstar	*Mentzelia lindleyi*	California	Annual						x
Lemon mint	*Monarda citriodora*	Southern US	Annual	x					
Five spot	*Nemophila maculata*	California	Annual	x					x
Baby blue-eyes	*Nemophila menziesii*	California	Annual						x
White evening primrose	*Oenothera caespitosa*	Western US	Perennial				x		
Evening primrose	*Oenothera lamarckiana*	Europe	biennial					x	
Dwarf eve primrose	*Oenothera missouriensis*	Southern US	Perennial		1.83				
Pale eve primrose	*Oenothera pallida*	Western US	biennial		1.83				x

Appendix (cont.)

Common Name	Scientific Name	Origin	Longevity	Eden Brothers Western Wildflower Mix	Applewood Seed Western Mix % of mix	Outside Pride Western Wildflower Mix % of mix	American Meadows Native West	American Meadows Dry Area Mix	American Meadows Western Xeriscape Mix
Corn poppy	*Papaver rhoeas*	Europe	Annual	x	7.33	2.03		x	
Palmer penstemon	*Penstemon palmeri*	SW	Perennial		1.83				x
Rocky Mountain penstemon	*Penstemon strictus*	Rocky Mtns	Perennial	x	3.67	2.03	x	x	x
California bluebell	*Phacelia campanularia*	California	Annual						x
Drummond phlox	*Phlox drummondii*	Eastern US	Annual	x					
Prairie coneflower	*Ratibida columnaris*	Midwestern US	Perennial	x	1.84	2.03	x	x	x
Gloriosa daisy	*Rudbeckia gloriosa*	Eastern US	Perennial	x				x	
Blackeyed susan	*Rudbeckia hirta*	N. am (not SW)	ann, bi, per	x			x	x	
Soapwort	*Saponaria officinalis*	Eurasia	Perennial						x
Ccatchfly	*Silene armeria*	Europe	Annual					x	
Gooseberryleaf globemallow	*Sphaeralcea grossulariifolia*	Western US	Perennial						x
Greenthread	*Thelesperma filifolium*	Midwestern US	Annual		7.33				x
Creeping thyme	*Thymus praecox*	Eurasia	Perennial						x
Strawberry clover	*Trifolium fragiferum*	Eurasia	Perennial						x
Johnny jump-up	*Viola tricolor*	Eurasia	Annual						x

[1] Intermountain West
[2] Rocky Mountain West
[3] Pacific Northwest

Comparative Evaluation
Basin wildrye and Thickspike wheatgrass
IDPMC-T-1201-RA (Basin wildrye)
IDPMC-T-1202-RA (Thickspike wheatgrass)
August 21, 2013
Loren St. John PMC Team Leader
Derek Tilley, PMC Agronomist
Natural Resources Conservation Service
Plant Materials Center
Aberdeen, Idaho

Introduction

In cooperation with Joe Robbins, Agricultural Research Service (ARS) – Forage and Range Research Laboratory, the Aberdeen Plant Materials Center (PMC) planted comparative evaluations of basin wildrye and thickspike wheatgrass to evaluate the performance of some promising accessions in comparison to existing released varieties available on the market. Basin wildrye (*Leymus cinereus*) is a tall, coarse, long-lived native bunchgrass and is useful for wildlife habitat and cover. It is also useful in calving pasture for its protective cover from wind. Poor seedling vigor however can result in poor stands. 'Magnar' basin wildrye released by the Aberdeen PMC and 'Trailhead' released by the Bridger, MT PMC have been used in the Great Basin, Intermountain West and northern Great Plains. The ARS requested that we evaluate accessions UTBWC1, UTBWS2 and UTBWS1 to compare them with Magnar and Trailhead.

Thickspike wheatgrass (*Elymus lanceolatus* ssp*. lanceolatus*) is a long-lived, native, sod-forming grass widely distributed in the northern part of the Intermountain West and northern Great Plains and is well-suited for erosion control on medium to coarse-textured soils. 'Critana' was released by the Bridger, MT PMC and 'Bannock" was released by the Aberdeen PMC. ARS requested that we evaluate accession UTTS11-1 and compare it with Bannock and Critana.

Materials and Methods

A randomized block design with 3 replications for each species was planted in field P8 at the PMC on May 3, 2012. Seed of each entry was planted in plots 7 x 20 feet long with 10 inch row spacing using a modified Tye® drill. The seeding rate for each species and accession was 8 pounds PLS/acre. Seed was mixed with rice hulls to facilitate seed flow through the drill and for drill calibration. Seeding depth was ¼-½ inch deep into a firm, weed-free seedbed. Figure 1 is the plot map for the comparative evaluations. The site was irrigated to field capacity prior to seeding and irrigated after planting to establish and maintain stands. Weeds were controlled by mowing during the establishment year. Plots were irrigated to approximate 14 inches annual precipitation. The plots were swathed in late October at the end of each season to approximately 4-inch height and residue was removed.

Forage yield samples were collected from the middle two rows for a length of 4 feet in the middle of each plot with a mechanical plot harvester. Samples were weighed and grab samples were taken from each accession, weighed fresh. The samples were then placed in a drying oven set at 60° C for approximately 5 days to obtain percent dry weight in order to calculate dry forage yield per acre. In 2013 seed production was ranked on a 1 to 9 scale based on a visual

estimate of each plot. In 2014 seed harvests were conducted by hand harvesting seed from 3 feet of the center two rows in each plot. In the 2014 season, all forage harvest and plant height measurements were made on July 9, 2014. Basin wildrye seed was harvested on July 19. Thickspike wheatgrass seed was harvested between July 9 and July 19.

Statistical analysis was conducted using Statistix 8 analytical software. Significant differences were tested using an ANOVA followed by means separation using a Least Significant Difference (LSD) test when p values were lower than 0.05.

The plots will be evaluated through the 2015 growing season at which time a summary final report will be developed.

2012 Evaluations

On May 14, plots were beginning to emerge. By the end of July, all plots had established and plant height data was collected on July 30. Table 1 summarizes the plant height data and observational notes.

Table 1. Summary of 2012 evaluation data of thickspike wheatgrass and basin wildrye accessions.

	Plant Height	Notes
	------(cm)------	
Thickspike wheatgrass		
Bannock	65.3	Some flowering
Critana	38.0	No flowering
UTTS11-1	65.0	Some flowering
Basin wildrye		
Magnar	59.3	No flowering, typical blue color
Trailhead	61.7	No flowering, typical green color
UTBWC1	60.0	No flowering, green color
UTBWS1	61.7	No flowering, green color
UTBWS2	60.0	No flowering, green color

Bannock and UTTS11-1 thickspike wheatgrass were nearly identical in plant height and both accessions had some flowering. Critana was substantially shorter and was not flowering. There were no discernible differences in plant vigor between the accessions and all plots established well.

The basin wildrye accessions showed minimal differences in plant height and none of them flowered during the first growing season. Magnar displayed its typical bluish-colored leaves, and Trailhead displayed its typical greenish-colored leaves. The non-released accessions displayed the greenish-colored leaves very similar to Trailhead. There were no discernible differences in plant vigor between the accessions and all plots had a good establishment of plants.

2013 Evaluations

The first evaluation was completed on April 25, 2013 for both the thickspike wheatgrass and the basin wildrye accessions. Percent stand, plant height, and vigor ratings were observed and recorded. The thickspike wheatgrass plots were evaluated a second time on July 15, and seed

production ranking and forage yield data was also collected at this time. The basin wildrye accessions were evaluated a second time on August 6. Results from 2013 are summarized in Tables 2 and 3.

Plant height for the thickspike accessions did not differ significantly at either date. Plant heights in April ranged from 23.2 cm for Critana to 28.2 cm for UTTS11-1. At the July evaluation, Bannock was the tallest accession (97.2 cm). Percent stand and vigor ratings also failed to show significant differences. Percent stand ranged from 86.3 for UTTS11-1 to 91.3 for both Bannock and Critana, and vigor between the plots in April was fairly uniform between the accessions. UTTS11-1 had the best vigor rating in July. Seed production ranking and forage yield had statistically significant differences with Bannock having the best seed production ranking and UTTS11-1 having the largest forage yield.

Table 2. Summary of 2013 evaluation data for thickspike wheatgrass.

	Plant Height	Percent Stand	Vigor[1]		Plant Height	Vigor	Seed Prod. Est.[2]	Dry Forage
	----cm----				----cm----			---lb/ac---
	----------4/25/13----------				----------7/15/13----------			
Bannock	27.7	91.3	2.4		97.2	2.7	1.5 a	7380 b
Critana	23.2	91.3	2.6		80.6	3.5	2.9 b	6125 b
UTTS11-1	28.2	86.3	2.4		93.9	2.3	2.2 c	11641 a

[1]Vigor and seed production rank rated on 1 to 9 scale with 1 being best and 9 being worst
[2]Means followed by the same letter are not significantly different at $p < 0.05$

Table 3. Summary of 2013 evaluation data for basin wildrye.

	Plant Height	Percent Stand	Vigor[1]		Plant Height	Vigor[2]	Seed Prod. Est.	Dry Forage
	----cm----				----cm----			---lb/ac---
	----------4/25/13----------				----------8/6/13----------			
Magnar	16.0	85.0	3.3		165.0 a	2.3 a	2.7	6772
Trailhead	15.3	78.7	3.7		153.3 b	3.0 b	3.0	6264
UTBWC1	15.0	80.7	3.7		155.0 b	3.0 b	3.0	7175
UTBWS1	13.0	75.3	4.0		158.3 b	3.0 b	3.0	7004
UTBWS2	16.7	69.7	3.3		153.3 b	3.0 b	3.0	7127

[1]Vigor and seed production rank rated on 1 to 9 scale with 1 being best and 9 being worst
[2]Means followed by the same letter are not significantly different at $p < 0.05$

Plant height in April for the basin wildrye accessions ranged from 13.0 cm for UTBWS1 to 16.7 cm for UTBWS2 but differences were not statistically significant. Plant height at the August evaluation found Magnar to be the tallest at 165.0 cm and was statistically different from the other accessions. Percent stand ranged from 69.7 percent for UTBWS2 to 85.0 percent for Magnar. Magnar had the best vigor rating at both evaluations and was significantly better at the August evaluation. Magnar also had the best seed production ranking. UTBWC1 had the greatest forage yield at 7175 pounds per acre but there were no significant differences in yield between the accessions.

2014 Evaluations

No significant differences were detected between accessions for any character evaluated in 2014. Thickspike wheatgrass accessions ranged in height from 59 to 65 cm. UTTS11-1 had the greatest seed yield of 460 lb/ac. The lowest average seed yield was Critana with 312 lb/ac. Bannock had the greatest biomass production with nearly 4,000 lb/ac but did not differ statistically with UTTS11-1, the lowest forage producer of 2014 with 2,580 lb/ac.

Table 4. Summary of 2013 evaluation data for thickspike wheatgrass.

	Plant Height[1]	Seed Yield[2]	Dry Forage
	----cm----	---lb/ac---	---lb/ac---
	----------2014----------		
Bannock	65.0	340	3970
Critana	59.3	312	2900
UTTS11-1	65.2	460	2580

[1]Forage harvest and plant height measurements made 7/9/2014.
[2]Seed was harvested between 7/9 and 7/19.

Basin wildrye accessions similarly failed to show significant differences in 2014 for any evaluated character. Magnar had the tallest plants with an average height of 185 cm, while all other accessions had average heights ranging from 170 to 176 cm. Magnar also produced the most above ground biomass with over 8,300 lb/ac. The other accessions with the exception of UTBWC1 all had biomass production over 8,000 lb/ac. UTBWC1 had an average forage yield of 6,730 lb/ac. Accession UTBWS2 showed the greatest seed production with 771 lb/ac. UTBWC1 had the lowest seed production value with just under 600 lb/ac.

Table 5. Summary of 2013 evaluation data for basin wildrye.

	Plant Height	Seed Yield	Dry Forage
	----cm----	---lb/ac---	---lb/ac---
	----------2014----------		
Magnar	185	725	8340
Trailhead	170	665	8180
UTBWC1	172	592	6730
UTBWS1	174	717	8060
UTBWS2	176	771	8190

Following are photographs of each of the accessions at the second evaluation in 2013.

Bannock thickspike wheatgrass July 15, 2013

Critana thickspike wheatgrass July 15, 2013

UTTS11-1 thickspike wheatgrass July 15, 2013

Magnar basin wildrye August 6, 2013

Trailhead basin wildrye August 6, 2013

UTBWC1 basin wildrye August 6, 2013

UTBWS1 basin wildrye August 6, 2013

UTBWS2 basin wildrye August 6, 2013

2014 COVER CROP DEMONSTRATION

Derek Tilley, PMC Manager

INTRODUCTION

The use of cover crops to build soil health is gaining traction in the U.S.; however many of the species used in cover cropping are not familiar to Idaho farmers or NRCS field office personnel. Likewise, many cover crop species are poorly understood in Idaho as to their adaptation, growth habit, and production value. Display plantings of commonly used cover crop varieties are a useful tool in educating conservation-minded individuals on the many available species and how they might fit into their farming rotation.

The purpose of the display is to allow the public and NRCS staff to view a wide variety of species with potential for cover cropping practices and to gather biomass production data to help determine species applicability.

MATERIALS AND METHODS

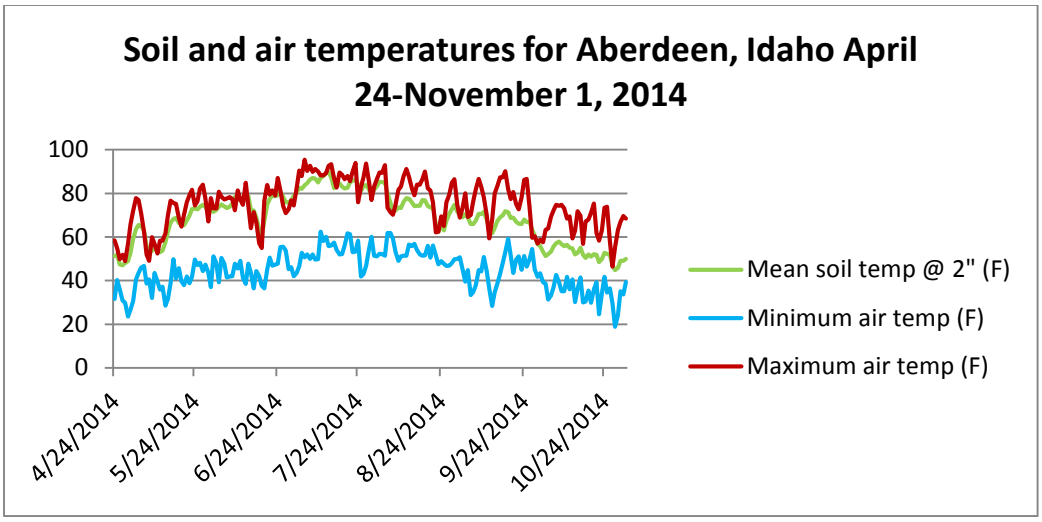
The display included 35 accessions divided into 6 functional plant groups: cool season grasses, cool season broadleaf plants with weak taproots, cool season broadleaf plants with a large taproot, legumes, warm season broadleaf plants, and warm season grasses (see Appendix). Because cover crops can be planted at different times of year depending on crop rotation, the cover crop display was planted on April 24 and again on August 19, 2014. The April planting was scheduled to simulate a full-season cover crop/fallow period while the August planting was scheduled to follow a typical grain harvest in southeast Idaho.

Soil on the farm is a Declo silt loam. The plots were watered regularly throughout the season. No fertilizer was applied to the demonstration. A cover crop cocktail mixture consisting of barley, spring pea, lentil, turnip, radish, hairy vetch, rape, oat and red clover was planted in the areas immediately surrounding the demonstration plots. Seeding rates are shown in the appendix.

The majority of the spring planted display was evaluated on July 5 (72 days after planting). Some species however (arugula, buckwheat, mustard and radish) flowered earlier than the rest of the display, and these were evaluated on June 20 (57 days after planting) prior to chemical termination to prevent seed set. The summer planting was evaluated on October 6 (48 days after planting). For each evaluation three, 0.25 m^2 samples were taken from each plot. The samples were air dried and weights averaged and extrapolated to lbs/ac.

Soil temperatures at the time of the spring planting were just reaching 50° F with air temperatures dropping below freezing for six days in late April and early May. High temperatures reached the low 90's during July and August. The first fall frost occurred on October 3.

Authors name, title, address, contact information



RESULTS AND DISCUSSION

Small grains were the dominant biomass producers in the spring planting with barley, oat, ryegrass and winter wheat all scoring in the top ten. Spring barley produced the most biomass in the spring planting with over 4 tons of dried material. Several mustard species (rape, mustard, radish and turnip) also had high biomass production ranging from 3360 to 6720 lbs/ac. Many legumes had intermediate production with the exception of spring pea which produced 4600 lbs. Warm season broadleaf plants and grasses all fared poorly in the spring planting with several not establishing in large enough quantities to warrant evaluation.

Biomass totals were significantly reduced in the summer planting for most accessions due to the shorter growing period. Small grains and mustards again topped the list. A few warm season species had better establishment from the summer planting. Sunflower, chicory and pearl millet benefitted from warmer soil temperatures and longer days.

Table 1. Aboveground biomass of all species listed highest to lowest production lbs/ac.

	Spring		Summer
Spring barley	8550	Hunter hybrid turnip	2960
Rape	6720	Spring barley	2400
Winter oat	5940	Winter oat	2300
Ryegrass	5730	Radish (Daikon)	2080
Mustard	5090	Ryegrass	1810
Spring pea	4600	Purple top turnip	1600
Cocktail mix	4230	Sunflower	1560
Triticale	3980	Winter wheat	1450
Winter wheat	3840	Mustard	1430
Lentil	3460	Cocktail mix	1410
Radish (Daikon)	3370	Collards	1380
Purple top turnip	3360	Arugula	1380
Collards	3170	Triticale	1370
Phacelia	2860	Lentil	1170
Hunter hybrid turnip	2750	Austrian winter pea	1110
Wildflower mix	2700	Safflower	980
Chickling vetch	2670	Wildflower mix	850
Hairy vetch	2570	Rape	850
Common vetch	2150	Spring pea	810
Austrian winter pea	2070	Phacelia	690
Safflower	1700	Common vetch	670
Arugula	1640	Hairy vetch	600
Beet	1350	Beet	530
Flax	1290	Red clover	520
Proso millet	1110	Chickling vetch	500
Chickpea	960	Proso millet	490
Red clover	930	Chicory	440
Buckwheat	850	Chickpea	400
Crimson clover	590	Pearl millet	320
Sorghun/Sudangrass	590	Sorghum/sudangrass	300
Sunflower	510	Crimson clover	290
Chicory	390	Flax	120
Cowpea	0	Buckwheat	0
Field corn	0	Cowpea	0
Grazing corn	0	Field corn	0
Pearl millet	0	Grazing corn	0

Spring barley had the greatest biomass production of all the cool season grasses for both the spring and summer planting with 8500 and 2400 lbs respectively. The winter grains (oat, wheat and triticale) had excellent biomass production. Most of the growth from the winter grains was low-lying and would be effective at reducing erosion but would not be optimal for grazing.

Table 2. Aboveground biomass of cool season grasses listed high to low from spring planting.

	Spring	Summer
Barley	8550	2400
Winter oat	5940	2300
Ryegrass	5730	1800
Triticale	3980	1370
Wheat	3840	1450

Of the broadleaf plants with weak taproots, rape and mustard showed excellent biomass production from the spring planting. Rape however did not produce well from the summer planting yielding only 850 lbs biomass/acre. Phacelia, a wildflower planted to attract pollinators, also showed good growth from the spring planting and was in full flower at the time of evaluation. The summer planting of phacelia did not flower. Flax biomass production was limited producing less than 1300 lbs/acre from the spring planting and only 120 lbs/acre from the summer planting.

Table 3. Aboveground biomass of weak rooted broadleaf plants listed high to low from spring planting.

	Spring	Summer
Rape	6720	850
Mustard	5090	1430
Phacelia	2860	690
Arugula	1640	1380
Flax	1290	120

The strong taprooted broadleaf plants (all in the mustard family with the exception of beets) had moderate aboveground biomass production. It should be noted that the taproot of purple top turnip sits largely above ground, but was not included in the biomass evaluation. Hunter hybrid turnip generally produces more leaf matter than standard turnip as shown in the summer evaluation. Beets had poor production compared to the other species in the category.

Table 4. Aboveground biomass of broadleaf plants with strong taproots listed high to low from spring planting.

	Spring	Summer
Turnip (purple top)	3360	1600
Radish (Daikon)	3370	2080
Collards	3170	1380
Hunter hybrid turnip	2750	2960
Beet	1350	530

Many legumes responded favorably to a spring planting with several species producing between one and two tons per acre. Spring pea had the highest production from the spring planting with 4600 lbs/acre. Lentil and Austrian winter pea were the top performers from the summer planting, both with over 1000 lbs/acre. Cowpea, a warm season legume, established in limited numbers in spring and summer and was not harvested for evaluation.

Table 5. Aboveground biomass of legumes listed high to low from spring planting.

	Spring	Summer
Spring pea	4600	810
Lentil	3460	1170
Chickling vetch	2670	500
Hairy vetch	2570	600
Common vetch	2150	670
Austrian winter pea	2070	1110
Chickpea	960	400
Red clover	930	520
Crimson clover	590	290
Cowpea	0	0

Although the wildflower mix was included in the warm season broadleaf category, the precise species included in the planted mix were not provided. Cornflower (*Centaurea cyanus*) was the most abundant species observed and accounted for more than 90% of the harvested biomass. Of the remaining warm season broadleaf species, safflower had significantly greater production than all others from the spring planting. Safflower is grown in southeast Idaho in dryland wheat rotations and is proven to be adapted to our region. Annual sunflower did not establish well from the spring planting, but the summer seeding produced over 1500 lbs of biomass per acre. The summer planting did not, however, have enough growing time to produce flowers.

Table 6. Aboveground biomass of warm season broadleaf plants listed high to low from spring planting.

	Spring	Summer
Wildflower mix	2700	850
Safflower	1700	980
Buckwheat	850	0
Sunflower	510	1560
Chicory	390	440

Warm season grasses struggled to establish and produce significant biomass. Proso millet produced 1100 lbs/ac from the spring planting and nearly 500 lbs/ac from the summer planting. Sorghum/sudangrass had 590 and 300 lbs/ac in the spring and summer planting respectively, while pearl millet produced 320 lbs from the summer planting, but failed to establish in the spring. Field and grazing corn establishment was spotty and did not produce enough plants to evaluate.

Table 7. Aboveground biomass of warm season grasses listed high to low from spring planting.

	Spring	Summer
Proso millet	1110	490
Sorghum/Sudangrass	590	300
Pearl millet	0	320
Field corn	0	0
Grazing corn	0	0

CONCLUSION

Temperatures at the time of the spring seeding likely affected the germination of the warm season species resulting in low establishment rates and minimal biomass production with the exception of proso millet. Summer planting of warm season species had noticeably better establishment; however the short season (48 days) and relatively low temperatures failed to produce high yields.

The multi-species cocktail mix (rates shown in Table 8) produced 4200 lbs of biomass per acre from the spring planting and 1400 lbs/ac from the summer planting. While not as productive as solid stands of grains or mustards, the cocktail mix adds above and below-ground diversity to promote soil health and reduce erosion.

Table 8. Cocktail mix seeding rates.

	Lb/ac
Barley	10
Spring pea	15
Lentil	5
Turnip	1
Radish	2
Hairy vetch	3
Rape	1
Oat	5
Red clover	1
Total	43

In our display, the cool season broadleaf species were separated into groups based on root size; however it also valuable to understand the familial relationship between species. Plants in the mustard family (Brassicaceae) including mustard, rape, turnip, arugula and collards do not create mycorrhizal associations and thus do not support soil aggregation. The large taproot of some species however is valuable in breaking hard pan layers and creating water infiltration sites. Non-mustard broadleaf species such as flax or phacelia should not be dismissed. Although they often produce less biomass than mustards, they will form mycorrhizal associations, so they might be a good choice in addition to a large-taprooted mustard.

None of the plants in the wildflower mix flowered from either planting. Most commercially available wildflower mixes contain a large component of perennial species that would not be suitable for a single-season cover crop application. To effectively provide nectar or pollen to beneficial insects, wildflower mixes should contain primarily annual species known to emerge and flower quickly.

Seeding rates used in the design of this demonstration were recommendations pooled from multiple sources. Some may be too high and could be reduced. Doing so would lower costs and decrease within-row competition, potentially resulting in an increase in overall biomass production.

Appendix. Species plot map and seeding rate (lbs/ac).

Cool Season Grass		Cool Season BL		Cool Season BL (large taproot)		Legumes		Legumes		Warm Season BL		Warm Season Grass
Winter oat (75)		Arugula (3)		Turnip (10)		Spring pea (100)		Chickling vetch (50)		Buckwheat (50)		Sorghum/sudan grass (35)
Spring barley (75)		Flax (4)		Hunter forage turnip (10)		Common vetch (20)		Chickpea (95)		Safflower (20)		Pearl millet (25)
Winter wheat (60)		Rape/canola (15)		Collards (2)		Hairy vetch (25)		Lentil (80)		Chicory (3)		Proso millet (35)
Triticale (60)		Brown mustard (15)		Beet (4)		Crimson clover (20)		Austrian winter pea (70)		Sunflower (4)		Field corn (25)
Ryegrass (15)		Phacelia (10)		Daikon radish (12)		Red clover (10)		Cowpea (30)		Wildflower mix (10)		Grazing corn (25)

Legume Cover Crop Winter Kill Evaluation

Study Number: IDPMC-T-1303-RA
Derek J. Tilley, PMC Agronomist
Loren St. John, PMC Team Leader
Natural Resources Conservation Service
Plant Materials Center
Aberdeen, Idaho

Cover crops have been shown to mediate soil erosion and compaction, increase water infiltration and storage, improve soil biodiversity, and increase organic matter and nutrient cycling. Additionally, legumes in a symbiotic relationship with Rhizobium bacteria have the further benefit of fixing soil nitrogen into a form useable by other plants thus decreasing fertilizer input requirements.

Late summer planted cover crops need to be terminated prior to planting the primary crop the following spring. Many commonly used legumes terminate naturally due to a low tolerance for freezing temperatures. Others with high frost tolerance persist in a dormant state through the winter and resume photosynthesis and nitrogen fixation when temperatures increase in the spring. Information regarding frost tolerance and adaptation to Idaho climates however is sparse for many leguminous cover crop species. To better ascertain which legume cover crops naturally winter kill and which over winter and require termination, the Aberdeen PMC installed a multi-species trial including several legume crops suggested for use in Idaho.

Nine commonly used legume cover crop species were planted in 7x50 ft plots at the PMC Pearl Farm on August 7, 2013. Species included in the trial were chickling vetch, sun hemp, chickpea, berseem clover, spring pea, cowpea, lentil, crimson clover and hairy vetch. Plots were seeded at industry recommended rates and depths using a modified Tye Drill with a width of 80 inches (8 openers at 10 inch spacing). First frost occurred on October 5, 2014 (Bureau of Reclamation 2014).

Stands were observed 30 days after planting (DAP). All species with the exception of chickpea and berseem clover had established good stands. At 70 DAP (October 16) the sun hemp had already died from early frosts. On March 12 hairy vetch and crimson clover showed moderate levels of frost damage but most plants appeared to be alive. On March 24 plants of hairy vetch and crimson clover were for the most part vigorous and green. A 0.25m² sample frame was harvested to estimate above ground air-dried biomass yield. Hairy vetch produced 3,300 lbs/ac of biomass, and crimson clover produced 1,500 lbs/ac.

Chickpea and berseem clover never established well and were not evaluated for winter kill. Of the remaining seven, only hairy vetch and crimson clover survived over winter to produce spring growth. Hairy vetch produced more than twice as much biomass as crimson clover and provided significantly more cover. Sun hemp, spring pea, cowpea and lentil could be used in cover crop mixes planted in spring and summer but would not be appropriate for fall cover crop mixtures because of winterkill.

Hairy vetch. March 24, 2014.

Crimson clover. March 12, 2014 showing frost damage.

By March 24, 2014 crimson clover had recovered from frost.

Nevada Bluegrass Initial Evaluation Planting

2014 Final Report
Study Number: IDPMC-P-0816-RA
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Introduction

Nevada bluegrass (*Poa secunda* ssp. *nevadensis*) is a large statured subspecies of the Sandberg bluegrass complex (Majerus et al. 2011). It can be found in the foothills and mountains of southern Idaho, northern Utah and Nevada, eastern Oregon and Washington and western Montana and Wyoming. Nevada bluegrass is similar to Sandberg bluegrass, but is considerably larger in stature, approximating the size of big bluegrass (*Poa secunda* ssp. *ampla*). This subspecies is a perennial bunchgrass with culms as much as 100 cm (40 in) tall. Basal leaves typically reach a length of 25 cm (10 in) with a width of 1 to 3 mm (1/16 to 3/32 in). Nevada bluegrass has distinctive long acuminate ligules from 1.5 to 6 mm (1/16 to ¼ in) long. The narrow panicles are 10 to 18 cm (4 to 7 in) long with yellowish-green to purplish-tinged spikelets. Nevada bluegrass can be distinguished from Sandberg bluegrass by its glabrous (hairless) to scabrous (rough) lemma, long decurrent ligules and large stature. The species can be wind pollinated, self-fertile, or apomictic (Monsen et al. 2004).

Nevada bluegrass is found in 10 inch and greater rainfall areas in sagebrush steppe plant communities including mountain foothills and mountains from Alaska to southern California, through Nevada to Arizona and Colorado. In the Intermountain Region plants are commonly found in the lower foothills into the mountains of southern Idaho, northern Nevada and Utah, eastern Oregon and Washington and western Montana and Wyoming.

There are no releases of Nevada bluegrass selected specifically for use in the Aberdeen PMC service area. Bridger PMC has recently released Opportunity Germplasm Nevada bluegrass for use in mine spoil contaminated soils in Wyoming and Montana (Majerus and Majerus 2008).

Because of the small stature and early maturity, most species of Sandberg bluegrass complex do not provide much usable forage; however, Nevada bluegrass can be an important forage producer for larger animals. Sandberg bluegrass and its subspecies are usually minor components of many grassland communities, but are considered among the six most important rangeland grasses of the Intermountain and Pacific Northwest regions (USDA Forest Service 1937).

The anticipated use of commercially available Nevada bluegrass seed is for inclusion in native mixtures for wildlife habitat, reclamation of disturbed sites, restoration of native rangeland, and conservation plantings. Nevada bluegrass is a good forage producer and has value in native species rehabilitation and site recapture.

Materials and Methods

Seed was collected from native sites during the summer of 2008. Seed was air dried and then cleaned to approximately 97% purity. Cleaned seed was placed in cold-dry storage (ca 50º F, 20% RH) until planting. Viability was estimated in January 2010 using the kerosene heater "popping" method outlined in Tilley et al. (2010) and in-house germination tests.

Greenhouse Trial

On January 14, 2010 Aberdeen PMC initiated a greenhouse trial to evaluate seedling emergence. Seed was sown into 12 x 18 inch greenhouse trays filled with a soil mix containing 1 part coconut fiber peat, 1 part compost and 1 part perlite. The seed was sown into rows at 50 seeds/linear foot. Seeding depth was 0 to ¼ inches. The trays were watered with overhead irrigation. Temperatures in the greenhouse averaged between 50 and 75 degrees with a 17 hour photoperiod.

Three germination indices were calculated in this trial. A germination rate was determined by using the method described by Maguire (1962). The number of seedlings obtained at each counting was divided by the number of days after planting, and the values obtained at each count were summed at the end of the test as follows:

$$\text{Germination rate} = \left(\frac{\text{Number of seedlings}}{\text{Days after planting}}\right) + \ldots + \left(\frac{\text{Number of seedlings}}{\text{Days after planting}}\right)$$

Days to 50% germination (D_{50}) and days between attainment of 10% and 90% germination ($D_{10\text{-}90}$) were obtained by plotting percent germination versus days after planting, in a quadratic regression. Germinants were counted upon visual detection of the cotyledon. Values obtained were then subjected to an analysis of variance with an alpha of 0.05 to determine significance. Means were separated using a LSD (least significant difference) test. Average total germination percentages are also reported but were not analyzed for significance.

Field Trial

Experimental design of the field trial was a randomized complete block with four replications. Individual plots were 20 feet long and contained a single row with rows planted on three foot centers. The trial contains primarily Nevada bluegrass, but also includes several collections of Sandberg bluegrass and big bluegrass. The experimental design also included plots of known industry standards (Mountain Home, Opportunity, Hanford Source, Sherman, and High Plains) for comparison.

Soil at the site is a Declo silt loam with pH of 7.4 to 8.4. Average annual precipitation is 9 inches. The planting site was prepared in the fall of 2009 and spring of 2010 with herbicide and tillage applications. Plots were planted with a belt-seeder on June 14, 2010 at a depth of 0-1/4 inch. The plots were planted at a target seed rate of 50 seeds/linear foot using an estimated 1 million seeds per pound based on Ogle et al. (2009), which lists an estimated 925,000 seeds/pound and USDA (2009) which lists 1,049,000.

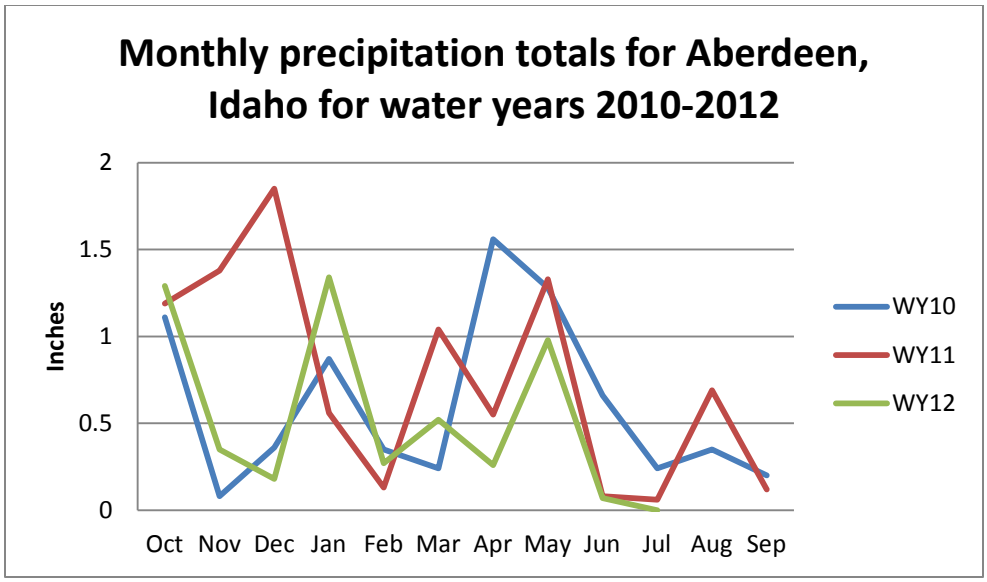
On September 12, 2010 the plots were evaluated for percent stand, plant density and seedling vigor. Percent stand was measured using a twenty foot rope marked with one foot increments stretched the length of the plot and anchored at either end. Plants intercepting the one foot increments were summed and recorded as a percentage. Plant density was measured by counting seedlings found in the middle two feet of row and converted to average number of plants per foot of row. Representative plants in each plot were measured for plant height. Plant heights were not analyzed for significance. Only accessions with measureable plants are reported for 2010.

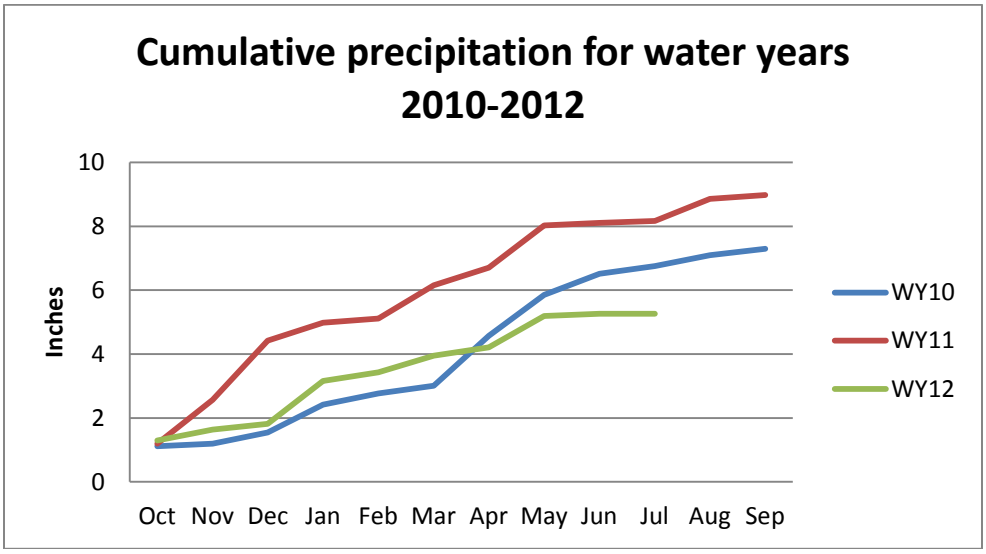
In 2011, percent stand, plant density and height were evaluated on May 2. Seed and forage harvests were timed to maximize the yield in each individual plot. This occurred between July 12 and 18. For biomass and seed yield, all plants in a plot (including seed) were hand harvested using a scythe. The material was then air dried for 2 weeks. Dried weights were then obtained from the total material before the seed was cleaned off and weighed.

In 2012 the plots were evaluated for plant density on June 15 and then harvested for seed yield and forage yield on July 18. Plant density was recorded by counting all of the plants in the plot and converting to average plants per foot. Other data were obtained as in 2011. Many plots in 2012 contained very few plants. Only those accessions with good stands were analyzed in 2012.

All data were analyzed using an Analysis of variance. Means of statistically different data were separated using a least significant difference (LSD) test. Accessions are listed in the table from best percent establishment to worst.

The plots were watered to provide approximately 14 to 16 inches of total accumulated water for the year; the typical moisture requirement for seed production of the species. Cumulative natural precipitation totaled 7.3 inches in water year 2010 and 8.98 inches in water year 2011. By the end of July 2012, Aberdeen had received a total of 5.26 inches of precipitation.





Advanced Evaluation Planting 2013

Due to superior performance in numerous evaluations, Nevada bluegrass accession 9076622 was planted in a side-by-side comparison with Opportunity Germplasm in 2013. The goal of the evaluation was to determine if accession 9076622 could outperform the industry standard when planted in a larger scale agronomic setting. Four, 500 ft rows of each entry were planted at 36 inch row spacing and grown for maximum seed and forage production on June 4, 2013. The trial was irrigated and weeds controlled for maximum production. The trial was swathed on June 30, 2014 and a 12 ft section of four rows was collected from each accession for evaluating forage yield. The sample was air dried for 21 days prior to weighing.

Results

Greenhouse Trial

There was a wide range of germination percentages and rates of germination detected between accessions (table 2). Accession 9076611 had the best recorded germination, the shortest D_{10-90} and the second shortest D_{50} rating in the trial. Accession 9076622 had the shortest D_{50} rating and the fourth highest germination.

Table 2. Germination characteristics

Accession	Germination	Germination rate[1]	D_{50}[2]	D_{10-90}[3]
	---%---		--days--	--days--
9076611	91	22.89 a	8.32 a-b	4.08 a
9076592	100	21.89 a-b	9.17 b-e	5.15 a-f
9076586	92	20.34 a-c	9.02 a-d	5.00 a-e
9076622	76	19.84 a-d	8.04 a	6.08 d-j
9076584	87	18.87 b-e	9.12 b-e	5.09 a-e
9076638	68	17.46 c-f	8.43 a-b	4.80 a-c
9076646	81	17.28 c-f	9.19 b-e	5.17 a-f
9076593	75	17.10 d-f	8.87 a-c	4.44 a
9076616	73	17.10 d-f	9.14 b-e	5.33 a-g
9076639	79	17.10 d-f	9.05 b-e	4.70 a-b
9076655	84	15.86 e-g	9.77 c-i	6.23 e-k
9076642	74	15.25 f-h	9.28 b-f	4.97 a-d
9076608	67	15.04 f-h	8.89 a-c	4.96 a-d
9076596	62	13.34 g-i	9.10 b-e	4.99 a-e
9076653	67	12.78 g-i	9.70 c-h	5.83 b-h
9076606	61	12.27 h-j	9.28 b-f	5.02 a-e
9076618	51	11.31 i-j	9.01 a-d	4.88 a-d
9076587	52	11.05 i-k	9.19 b-e	5.29 a-g
9076605	45	9.12 j-l	9.56 c-g	5.93 b-h
9076624	48	7.90 k-l	10.54 g-i	5.94c-h
9076602	40	6.39 l-m	10.55 g-i	6.64 h-k
9076650	29	6.35 l-m	9.05 b-e	5.94 b-h
9076594	36	6.07 l-n	10.23 f-i	6.33 f-k
9076609	28	4.54 m-o	10.66 h-i	7.29 j-k
9076623	22	4.40 m-o	9.62 c-g	5.30 a-g
9076604	23	4.24 m-o	9.89 d-i	5.72 b-h
9076615	19	3.67 m-o	9.77 c-i	6.00 c-i
9076628	22	3.58 m-o	10.72 i	7.43 k
9076649	21	3.25 m-o	10.70 i	7.23 i-k
9076654	15	3.11 n-o	9.90 d-i	5.72 b-h
9076610	17	2.85 n-o	10.03 e-i	6.52 g-k
9076621	12	2.15 o	9.71 c-h	5.78 b-h
LSD (0.05)		3.22	0.99	1.24

[1] Germination rate is a comparative value with no associated unit of measure; larger # means faster germ.
[2] Days to 50% germination.
[3] Days between 10% and 90% germination

Field Trial

Opportunity germplasm had significantly better initial year establishment in the field trial than any other accession (table 3). Opportunity also had the highest plant density with 19 plants/ft², which was significantly better than any other accession. The best performer of the non-released accessions was 9076622 with 57% establishment and 8 plants/ft².

Table 3. Field establishment evaluation Sept. 12, 2010

Accession	Establishment	Density	Height[1]
	----%----	Plants/ft²	cm
Opportunity	88 a	19 a	4.0
9076622	57 b	8 b	2.75
Sherman	37 bc	5 bcd	6.0
9076615	36 c	4 bcd	5.5
9076610	33 c	9 b	1.75
9076618	33 c	5 bcd	2.0
9076609	29 c	6 bc	2.3
9076649	21 cd	4 bcd	2.0
9076623	17 cde	2 cd	4.0
9076605	1 de	1 cd	4.0
LSD (0.05)=	varies	varies	

[1]Height not analyzed for significance.

In 2011 Opportunity continued to have the highest rated stand and plant density (table 4). Opportunity also had the greatest seed yield at 25 lbs/ac and the third greatest forage yield with 324 lb/ac. Accession 9076622 performed comparably to Opportunity in most aspects; however accession 9076622 had significantly lower forage and seed production.

Table 4. Field trial evaluations 2011

Accession	% stand	Density	Height	Seed Yield	Forage Yield
	----%----	Plants/ft²	cm	Lb/ac	Lb/ac
Opportunity	86.9 a	8.4 a	4.5 b-c	25 a	324 a
9076622	76.3 a-b	7.5 a-b	4.5 b-c	15 b	216 b
9076615*	65.8 a-c	6.1 a-e	8.8 a	15 b	328 a
9076609	64.5 a-c	6.9 a-d	5.3 b	13 b-c	216 b
9076610	63.2 a-c	7.1 a-c	4.3 b-d	8 c-d	204 b-c
9076618	63.2 a-c	6.5 a-d	4.3 b-d	7 c-e	192 b-c
9076623	63.2 a-c	5.5 a-g	3.0 d-f	5 d-f	90 d-e
Sherman*	60.5 b-d	3.5 d-i	9.3 a	13 b-c	394 a
9076649	56.6 b-e	6.6 a-d	3.5 c-e	8 c-d	124 c-d
High Plains	55.3 b-f	3.6 d-i	2.8 e-g	0 f	0 f
9076602	46.1 c-g	6.4 a-d	1.8 f-g	0 f	0 f
9076654	46.1 c-g	3.6 d-i	2.5 e-g	0 f	0 f
9076605	43.4 c-h	4.5 b-h	3.0 d-f	1 e-f	60 d-f
9076586	42.1 c-i	5.6 a-f	2.3 e-g	0 f	0 f
9076606	38.2 d-j	2.1 g-i	2.0 f-g	0 f	0 f
9076584	35.5 e-j	4.5 b-h	2.3 e-g	0 f	0 f
9076650	34.2 e-j	5.0 a-h	1.8 f-g	0 f	0 f
Mt. Home	34.2 e-j	4.1 b-i	2.0 f-g	0 f	0 f
9076593	34.2 e-j	5.1 a-h	2.5 e-g	0 f	0 f
9076616	31.6 f-j	4.1 b-i	2.5 e-g	0 f	0 f

9076653	31.6 f-j	3.8 c-i	2.3 e-g	0 f	0 f
9076631	30.3 g-j	4.6 b-h	2.8 e-g	0 f	0 f
9076611	29.0 g-j	3.5 d-i	2.5 e-g	0 f	0 f
9076638	28.9 g-j	5.0 a-h	1.5 g	0 f	0 f
9076608	27.6 g-j	4.4 b-i	3.0 d-f	1 f	30 e-f
Hanford Source	26.3 g-j	2.8 e-i	1.8 f-g	0 f	0 f
9076642	25.0 g-j	1.8 h-i	2.3 e-g	0 f	0 f
9076604	25.0 g-j	2.5 f-i	2.3 e-g	0 f	0 f
9076587	21.1 h-j	2.1 g-i	2.1 e-g	0 f	0 f
9076596	18.4 i-j	1.0 i	2.0 f-g	0 f	0 f
9076592	17.1 j	1.9 h-i	2.3 e-g	0 f	0 f
9076646	17.1 j	2.6 f-i	2.0 e-g	0 f	0 f
9076639	15.8 j	1.9 h-i	2.5 e-g	0 f	0 f
9076655	15.8 j	1.9 h-i	2.3 e-g	0 f	0 f
LSD (0.05)=	24.2	3.5	varies	7	84

* *Poa ampla*

In 2012 six accessions including Opportunity and Sherman had significant stands in all four replicates. No statistical differences were detected among the accessions for plant density, seed yield or forage yield. Plant densities were significantly lower than those reported from 2011. This is likely a reflection of the larger size and increased competition of individual plants.

Table 4. Field trial evaluations 2012

Accession	Density	Forage Yield	Seed Yield
	Plants/ft²	Lb/ac	Lb/ac
Opportunity	2.7	1323	271
9076622	1.9	581	112
Sherman*	1.9	1391	189
9076618	1.8	525	67
9076649	1.7	682	103
9076615*	1.4	883	132
LSD (0.05)=	NA	NA	NA

* *Poa ampla*

2013 AEP

Under large scale agronomic production practices Opportunity Germplasm had greater establishment and yielded significantly greater forage than accession 9076622 (1500 lbs/ac and 738 lbs/ac respectively).

Opportunity Germplasm Nevada bluegrass (left 4 rows) grown next to accession 9076622 Nevada bluegrass (right 4 rows) in a side-by-side comparison. Opportunity Germplasm had significantly greater forage production.

Discussion

First year seedling establishment was low for all accessions with the exception of Opportunity. Only 10 of forty accessions had visible germination. In 2011 stands were detected in more plots. Several accessions increased significantly in establishment and density and compared favorably with Opportunity during 2011. In 2012 no statistically significant differences could be detected between Opportunity, Sherman and the four accessions evaluated.

2012 was the final year of evaluation. The four accessions remaining in 2012 showed promise enough to warrant further evaluation. All showed good persistence for a minimum of two years of seed production, and all produced fair to good forage and seed yields. All were ranked high during the 2011 and 2012 evaluations for forage and seed yield. Accession 9076622 also ranked among the highest for germination characteristics and initial stand. See the appendix for additional information on the original collection locations of the accessions.

After promising performance in the greenhouse and initial field trial, accession 9076622 was evaluated next to the industry standard Opportunity Germplasm Nevada bluegrass. Opportunity outperformed accession 9076622 in establishment and forage biomass production.

The results of this trial indicate that none of the collected accessions performed significantly better than the two releases currently available, Opportunity Germplasm Nevada bluegrass and Sherman big bluegrass. It is the decision of Aberdeen PMC at this time that none of the collected accessions warrant further development for release.

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Accession	Species	State	County	Lat. / Long.	El. (ft)	Location	Plant community
9076584	POSE	ID	Bingham	43 6' 41", -112 50' 54"	4560	Powerline rd, N of Aberdeen	Basin big sage, rabbitbrush
9076586	POSE/PONE	ID	Bingham	43 6' 41", -112 50' 54"	4560	Powerline rd, N of Aberdeen	Basin big sage, rabbitbrush
9076587	POSE	ID	Power	42 15' 40", -112 45' 44"	5000	Curlew Ntl Grassland, S of Twin Springs in rocky roadside post burn	ARTR, PUTR, PSSP, POSE
9076592	POSE	NV	Elko	41 4' 4", -114 31' 31"	6400	Road to Pequop summit ca 1 mi W of Oasis	ARTR, POSE
9076593	POSE	NV	Elko	41 6' 57", -114, 47' 33"	6200	N side of I-80 at Moor exit (360) near train tracks	PJ
9076594	POSE	NV	Elko	41 2' 27", -115 1' 49"	6600	Road to Angel Lake, exit 351 from Wells, NV	ARTRV, black sage, Juniper, LECI
9076596	POSE	NV	Elko	40 18' 56", -115 29' 36"	6700	FR 113 from Ruby Lake, top of low hill opposite large granite batholith	ARTRv, PUTR
9076602	POSE	UT	Juab	39 24' 43", -111 53' 23"	5900	Off UT hwy 28, E of Yuba state park near small cabin	PJ
9076604	PONE	UT	Box Elder	41 56' 15", -112 28' 34"	6000	N of Valley, UT off hwy 84 exit 20, E of crop field on rocky knob	ARTR, Stipa commata
9076605	PONE	ID	Bingham	43 7' 1", -112 48' 40"	4400	Coffee Point Rd, ca 600 m N of 600 S	ARTRtr, STCO, ELEL
9076606	POSE	ID	Bingham	43 7' 1", -112 48' 40"	4400	Coffee Point Rd, ca 600 m N of 600 S	ARTRtr, STCO, ELEL
9076608	POSE	ID	Power	42 11' 17", -112 45' 6"	4990	Meadowbrook Rd in post burn	PSSP, STCO, POSE, CHVI
9076609	PONE	ID	Power	42 11' 17", -112 45' 6"	4990	Meadowbrook Rd in post burn	PSSP, STCO, POSE, CHVI
9076610	PONE	ID	Power	42 9' 34", -112 49' 36"	5670	Cow Canyon Rd jct w/ Meadowbrook rd	PONE, AGCR, PSSP
9076611	POSE	ID	Power	42 5' 39", -112 50' 15"	5100	Cow Canyon in burned PJ	PJ, STCO, POSE
9076615	POAM	UT	Box Elder	41 48' 41", -113 35' 12"	5860	Dove Creek, W of Rosette	ARTRtr, CHNA, CHVI, PJ
9076616	POSE	NV	White Pine	41 3' 57", -114 31' 23"	6400	Pequop (east exit) N of I-80 on rd to summit	PJ, ARTR
9076618	POSE	NV	White Pine	41 2' 27", -115 1' 49"	6600	Angel Lake Rd, SW of Wells	ARTRV, black sage, Juniper, LECI
9076621	POSE	NV	White Pine	39 32' 3", -115 47' 17"	6250	Diamond Mts, W of Newark Valley, S of Goicochea ranches	one needle pinyon, cliffrose, ARTRtr
9076622	PONE	NV	Eureka	39 29' 8", -115 56' 54"	6900	Windfall Cyn off hwy 50	ARTR, CHNA, LECI
9076623	PONE/POAM	NV	White Pine	39 11' 49", -114 41' 42"	7300	Cave Lake Loop, S of Ely in disturbed area	PJ, ARTR, LECI
9076624	POSE	UT	Millard	38 55' 11", -112 12' 22"	7000	FR100, E of Fillmore on road cut	Cercocarpus, Acer, Juniper, Quercus
9076628	POSE	UT	San Pete	39 30' 36", -111 44' 5"	6000	Chicken Creek Cyn, E of Levan on red rocky slopes	Acer, Quercus
9076631	POSE	UT	Duchesne	40 25' 15", -110 22' 54"	7160	21000 W (road to Moon Lake) N of Mountain Home, UT in rocky soil	Juniper, black sage, PSSP, needlegrass
9076638	POSE	ID	Lincoln	42 54' 52", -113 45' 53"	4300	Kamima to Carey Rd N of Kamima in rocky knoll	ARTR, AGCR, POSE
9076639	PONE	ID	Lincoln	43 8' 12", -113 46' 5"	4300	Kamima to Carey Rd, N of Kamima above Laidlaw Corrals	ARTR, AGCR, POSE
9076642	PONE	ID	Blaine	43 25' 29", -114 0' 57"	5200	Little Wood River, 0.5 mi SE of dam	ARTR, PONE
9076646	POSE	ID	Lincoln	43 6' 22", -114 4' 49"	4460	N of Richfield	ARTR
9076649	PONE	ID	Camas	43 20' 32", -114 35' 19"	5000	Roadside on Hwy 20. Possible seeding	ARTR
9076650	PONE	ID	Ada	43 36' 30", -115 57' 0"	3070	Lucky Peak Res on FR 268 (Side Gulch Rd)	PUTR, chokecherry
9076653	PONE	ID	Elmore	43 37' 9", -115 42 48"	4400	Arrow Rock Res. Side Gulch Rd.	ARTR, PUTR
9076654	PONE	ID	Elmore	43 33' 30", -115 36' 53"	4700	Long Gulch Rd. (FR 113)	
9076655	POSE	ID	Owyhee	42 59' 2", -116 28' 28"	3720	Triangle Rd from Oreana	ARTRwy, POSE, BRTE

Evaluation of Cover Crop Species for Wind Erosion Protection

Study Number: IDPMC-T-1304
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In natural ecosystems, vegetative cover serves a variety of purposes. It prevents soil erosion, replenishes ground water and controls flooding by enhancing infiltration and reducing runoff (Perry 1994). Vegetative cover can be increased with a diverse array of species as niches are filled to their fullest extent (Wang and others 2012). In traditional farming practices, these functions are lost due to biosimplification (replacing nature's diversity with a small number of cultivated plants) and during periods of bare (fallow or tilled) soil (Altieri 1999). The net result of simplified biodiversity is a loss of ecosystem function and the need for constant human inputs (Swift and Anderson 1993).

Increasing living cover and diversity has many benefits. Increased living, above-ground diversity influences the soil fauna in the rhizosphere which can improve soil structure. Diverse soil biota can produce organic compounds that bind aggregates, create biopores, and promote humification (Hendrix and others 1990). Uncovered soils are more prone to erosion, have greater temperature fluctuations, and have a reduced diversity of living organisms. Earthworms and other beneficial animals help bind soil particles together; however, an uncovered soil surface will freeze significantly faster than a protected soil, thus increasing mortality rates in earthworms (Davies 1973). The loss of earthworms and other animals causes a deterioration of soil health and structure.

Cover crops have been shown to mediate erosion and compaction, increase water infiltration and storage, improve soil biodiversity, and increase organic matter and nutrient cycling (Salon 2012). It has also been demonstrated that diversity of plant functional groups has a greater impact on ecosystem processes than diversity of species (Tilman and others 1997). Thus cover crops are more effective when they consist of a varied suite of plant functional groups (broadleaf, grasses, legumes), and not simply a diverse mixture of species.

Wind erosion is a major problem throughout the Aberdeen PMC service area. Wind erosion physically removes the most fertile part of the soil (organic matter, clay, and silt) and lowers soil productivity. This loss in productivity increases the costs of producing crops. Blowing soil can reduce seedling survival and growth, depress crop yields, and increase the susceptibility of plants to certain types of stress, including diseases (Lyon and Smith 2010).

Cover crops and crop residue can reduce wind erosion by reducing the wind velocity at the soil surface, and by increasing the size of soil aggregates (Lyon and Smith 2010). Residues and cover crops also prevent much of the wind from contacting the soil particles (Lyon and Smith 2010). The efficacy of a cover to reduce erosion depends on the percent cover, height, position in relation to the wind direction, and soil type (Table 1).

Table 1. Effect of nonerodible soil cover on relative soil loss reduction compared to bare soil (From Lyon and Smith 2010).	
Soil cover (%)	*Relative soil loss reduction (%)*
0	0
10	35
20	60
30	70
40	80
50	85
60	90
70	93
80	96
90	98
100	99

Orientation of vegetative cover also plays a role in its ability to reduce wind erosion. Standing residues are more effective at slowing wind speed at the surface than residues of the same quantity lying flat on the soil surface (Lyon and Smith 2010). There is also a correlation between residue height and the reduction of wind erosion. Taller residue is more effective at reducing wind energies and the effects of erosion (Lyon and Smith 2010).

Materials and Methods

On August 7, 2013 we installed a randomized complete block trial using a modified Tye Drill with a width of 80 inches (8 spouts at 10 inch spacing). The plots were 7'x 50' with four replications. Nine individual species were planted along with a cocktail mix composed of the same nine species (Table 2). The plots received irrigation until mid-September when water was no longer available. The plots were not fertilized. First frost occurred on October 5, 2014 (Bureau of Reclamation 2014).

Table 2. Seeding rate for individual species plots and cocktail mix.		
	Full stand rate	Cocktail rate
	----------Lb/ac----------	
Wheat	75	10
Austrian pea	70	15
Lentil	80	5
Turnip	3	1
Radish	12	2
Hairy Vetch	30	3
Rape	15	1
Oat	75	5
Crimson clover	15	1

Plots were evaluated in the first growing season at 30, 70 and 90 days after planting (DAP). Plots were again evaluated early the following spring on April 5. At each date plots were evaluated for aboveground biomass, percent cover, and plant height. Biomass was obtained by clipping two,

0.25 m² sections randomly located within each plot. Harvested materials were air dried for 14 days prior to weighing. Percent cover was determined using a 45 ft line intercept running diagonally through the plots. Data points were recorded at each ft marker. Plant height was measured as the estimated average plant height within each plot.

Results

Biomass

Biomass yields of the single species could essentially be separated into the three functional groups during the first growing season. Mustards were high-yielding at the 30, 70 and 90 day evaluations. Rape, which does not produce a significant taproot like turnip or radish, consistently had the highest above ground yields of the mustards, and yielded statistically greater biomass than turnip and radish at 30 DAP, and radish at 70 DAP (Table 3). The cocktail mix, which included high percentages of mustards, also fell into this category (Figure 1). Fall yields of the small grains, oat and wheat, were somewhat lower than mustard yields and were generally intermediate between the mustards and the legumes. The evaluated legume species almost always had the lowest biomass yields in the fall and spring, with the exception of hairy vetch in the spring evaluation. Most yields decreased going from fall to spring. Hairy vetch, however, began regrowth early in the spring and at the time of evaluation had increased its biomass by 2.4X from the last fall evaluation. Others that increased slightly from fall to spring included oat, wheat, lentil, Austrian pea and crimson clover.

Figure 1. Cocktail mix 30 DAP.

Several legumes managed to over winter at least to some degree. Hairy vetch seemed unaffected by the cold winter as shown by the increased growth the following spring. Crimson clover showed some losses to the cold, but much of the stand seemed intact at the spring evaluation. Very few Austrian pea and Lentils had green tissues in the early spring, and these were completely dead by mid-April.

Table 3. Pounds per acre above ground biomass at 30, 70 and 90 days after planting and at April 5 the following spring.					
		30 DAP[1]	70 DAP	90 DAP	2014
		----------Lb/ac----------			
Rape		1223 a	7621 a	8427 a	5493 b
Turnip		867 b	6659 ab	6987 ab	5885 b
Radish		795 bc	6055 bc	6917 ab	4566 bc
Cocktail		582 cd	5122 cd	7032 ab	4780 bc
Oat		484 d	4520 de	6050 b	6385 a
Wheat		335 de	3341 e	3126 c	4708 bc
Lentil		143 ef	1099 f	1422 cd	2425 d
Austrian pea		120 ef	1275 f	2143 cd	1676 e
Crimson clover		77 f	969 f	1099 d	1498 e
Hairy vetch		41 f	844 f	1412 cd	3353 c
LSD (0.05)		248	1484	1930	1277

[1]Means followed by the same letter do not differ significantly at p=0.05.

Cover

The mustards all provided excellent cover of living leaves in the fall evaluations (Table 4). Despite being winter killed, the mustard cover remained high in the spring as the leaves left a film of dried tissue covering the soil. The cocktail mix, having a slightly reduced amount of mustard compared to a full stand, had somewhat lower cover values. The difference in cover was however only statistically significant from the highest ranking cover at the 30 DAP evaluation.

Figure 2. Radish and other mustards produced a mat of dried leaves which protects the soil and reduces weed emergence.

The small grains formed a distinct middle group concerning cover values. In the spring evaluation however, oat cover increased because most of the plants were lying down. Wheat stalks remained largely upright and did not see as dramatic an increase in cover going into spring (Figure 3).

Figure 3. Wheat (left) with a more upright habit provided significantly less cover in the spring evaluation than oat (right) which had lain over.

The legumes provided little cover in the fall evaluations compared to the other species groups. Austrian winter pea and lentil did not survive the winter and only provided cover with dead material. Two species however, hairy vetch and crimson clover, did not winter kill. Hairy vetch increased significantly in cover in the spring and had the added benefit of fixing soil nitrogen.

Table 4. Percent cover at 30, 70 and 90 days after planting and at April 5 the following spring.

		30 DAP[1]	70 DAP	90 DAP	2014
		----------% cover----------			
Rape		80.4 a	99.0 a	97.0 a	91.0 a
Turnip		72.5 ab	98.5 a	90.5 a	84.0 a
Radish		69.4 ab	98.0 a	96.0 a	88.7 a
Cocktail		61.9 b	93.3 ab	93.0 a	85.7 a
Oat		31.3 c	80.0 b	73.8 b	92.3 a
Wheat		24.4 cd	52.5 c	51.3 c	69.0 b
Lentil		13.9 cd	41.3 c	45.0 cd	30.0 c
Crimson clover		12.0 d	40.0 c	31.3 d	32.3 c
Austrian pea		10.3 d	42.5 c	46.3 cd	33.3 c
Hairy vetch		8.0 d	47.5 c	46.3 cd	90.3 a
LSD (0.05)		17.7	14.2	16.1	11.0

[1]Means followed by the same letter do not differ significantly at p=0.05.

Plant Height

In the 30 and 70 DAP evaluations, mustards and small grain heights were generally not separable statistically. At the 90 DAP evaluation, wheat was significantly taller than all other plants in the trial, followed by oat which did not differ statistically from rape and radish. Of the legumes, lentil has a rather erect growing habit and was significantly taller than crimson clover and hairy vetch, both prostrate creeping vines. Austrian pea, while creeping in nature, also had enough growth in the fall to elevate it above hairy vetch and crimson clover.

In the spring, all of the mustard species effectively covered the ground; however after killing frost they deteriorate and lay flat on the soil surface and added little in the way of height. Wheat retained its upright habit in the spring and had the tallest heights in the trial. Oat however had mostly lodged, reducing height but increasing its cover value. The legumes all remained relatively low to the ground.

Table 5. Average plant height (cm) at 30, 70 and 90 days after planting and at April 5 the following spring.

		30 DAP[1]	70 DAP	90 DAP	2014
		----------cm----------			
Rape		21.3 a	49.3 ab	35.5 bc	5.0 bcd
Radish		20.3 a	39.5 c	32.0 bcd	2.3 e
Cocktail		19.5 ab	41.5 bc	29.3 cd	2.8 de
Oat		18.0 ab	45.0 abc	38.3 b	7.5 b
Wheat		18.0 ab	50.5 a	46.3 a	17.5 a
Turnip		16.3 b	41.8 bc	27.5 d	1.8 e
Austrian pea		7.0 c	17.0 d	11.8 e	1.3 e
Hairy vetch		7.0 c	4.3 e	4.3 f	5.8 bc
Lentil		6.8 c	16.3 d	13.8 e	3.8 cde
Crimson clover		4.3 c	6.0 e	4.8 f	3.3 cde
LSD (0.05)		3.4	7.9	6.7	2.5

[1]Means followed by the same letter do not differ significantly at p=0.05.

Conclusions

Each of the functional groups examined filled a specific niche in providing soil protection. Mustards provide early dense cover in the fall and develop a protective coating of leaf tissue in the spring. The small grains with their vertical stature add moderate amounts of cover but also add height and structure in the fall and spring to reduce wind speed. The legumes, while limited in their fall cover value, add soil nitrogen for growth. Over wintering legumes such as hairy vetch also provide spring cover and provide a living root system which feeds the soil micro-fauna.

The cocktail mix did not provide the best ranking of any of the three evaluated characters, but did offer a combination of traits not available from a single species. High levels of cover from mustards, height from small grains, and nitrogen fixation and photosynthetically active overwintering legumes, together provided a good measure of all of the desired characteristics sought for soil protection from wind erosion.

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United States Department of Agriculture

2014 STUDY REPORT
Aberdeen Plant Materials Center, Aberdeen, ID

INFLUENCE OF PLANTING DATE ON FORAGE RADISH IN SOUTHEAST IDAHO

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INTRODUCTION

Forage, or Daikon radish, *(Raphanus sativus* var. *longipinnatus)* is one of the most widely used species for cover crop plantings (Figure 1). Radishes produce large amounts of above ground biomass that protect the soil from erosive forces and reduce weed establishment (Malik et al 2008; Ngouajio and Mutch 2004; Weil et al 2006). They can also produce a large taproot reaching lengths of 0.5 m or more which can be beneficial to soil health in a variety of ways. The large and long taproot is able to penetrate hard pan layers opening new soil otherwise restricted from weaker rooted species (Ngouajio and Mutch 2004; Williams and Weil 2004). The roots provide food for worms and other beneficial soil organisms. They also break down over winter and create large bio pore spaces for water infiltration (Weil and Williams 2003). Finally, radish roots scavenge nitrogen and other nutrients from the soil, ultimately to release them the following spring as the plant tissues break down (Ngouajio and Mutch 2004; Williams and Weil 2004).

Figure 1. Daikon radish. Photo by William Durham, NRCS.

Cover crop radishes are typically planted in late summer and early fall following grain harvests. Allowing radishes 30 to 60 days for growth prior to winterkill has been shown to provide good root development and allow canopies to close (Ngouajio and Mutch 2004; Sundermeir 2008). Radishes planted earlier in the season have been observed to bolt and produce flowers instead of sending resources to root production (Banga and Smeets, 1956; Garner and Allard 1923; Verschoor and Rethman 1992). Flowering in radishes is stimulated by photoperiod. Early bolting radishes produce a smaller root, create less desirable forage (Dickinson 1982), and can create a volunteer weed problem after seed set (Ngouajio and Mutch 2004). Studies indicate however there is some variation among radish cultivars with some bolting earlier or later than others (Banga and Smeets 1956).

Farmers in the Aberdeen PMC service area are interested in a radish that can be used for season-long cover crop plantings and subsequent grazing. The desired radish should produce a large, deep taproot for water infiltration, aeration, soil building. It should also have large amounts of above ground leafy cover for erosion control and for forage.

Several varieties of forage radish are currently available on the commercial market. Graza radish tolerates multiple grazing, and has persisted up to a year without flowering in Oregon and Louisiana (PGG Seeds 2014). Anecdotal evidence from Northern Idaho indicates that Graza radish did not bolt when Daikon and Nitro did from spring plantings, but the varieties could not be confirmed.

This study was created to evaluate multiple radish varieties for flowering and root production when planted at different times (varying photoperiods) in Southeast Idaho.

MATERIALS AND METHODS

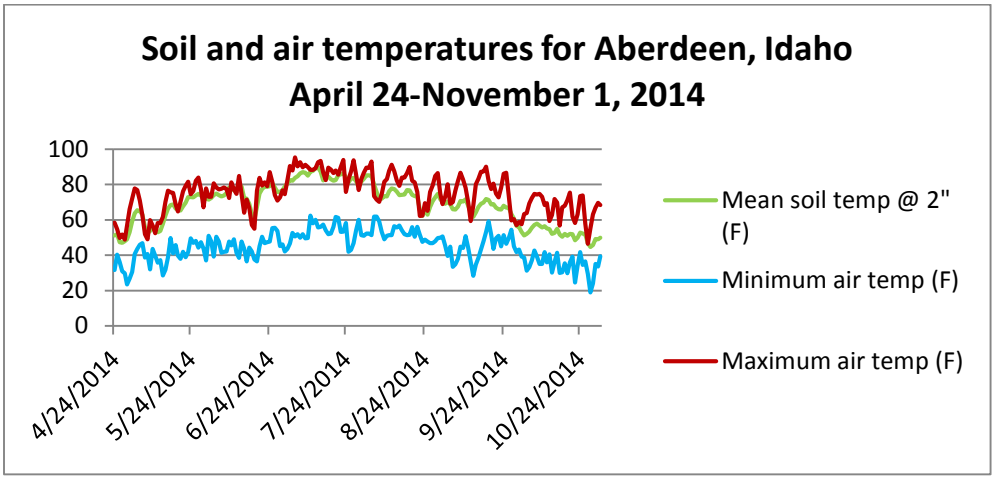
Single row plots of five commercially available forage radish varieties were planted at monthly increments beginning on April 28, 2014 and ending on August 28, 2014. The varieties were seeded into 40 ft rows at a rate of 12 lbs/ac (approximately 7 seeds/ft) with a belt seeder at a depth of 0.25 to 0.5 inches. The plots were irrigated as needed throughout the growing season with no supplemental fertilizer applied. Glyphosate was applied at 32 oz/ac to unplanted areas on June 16 and again on July 27 to reduce weed pressure during establishment of subsequent plantings.

The plots were evaluated periodically to observe the percentage of plants bolting or producing flowers. Eight randomly chosen plants were harvested on October 28 from each plot of the June, July and August plantings to measure above and below ground biomass, and root length. Plants were divided into root and leaf components and dry matter yields were determined separately.

Data were analyzed using the Statistix 8 Analytical software and subjected to an analysis of variance with a significance level of $p<0.05$ using each of the eight collected plants as a pseudo-replication.

Due to early weed pressure, the May planting was terminated on July 1.

Soil temperatures at the time of the April planting were just reaching 50° F with air temperatures dropping below freezing infrequently in late April and early May. High temperatures reached the low 90's during July and August. The first fall frost occurred on October 3.



RESULTS AND DISCUSSION

Flowering

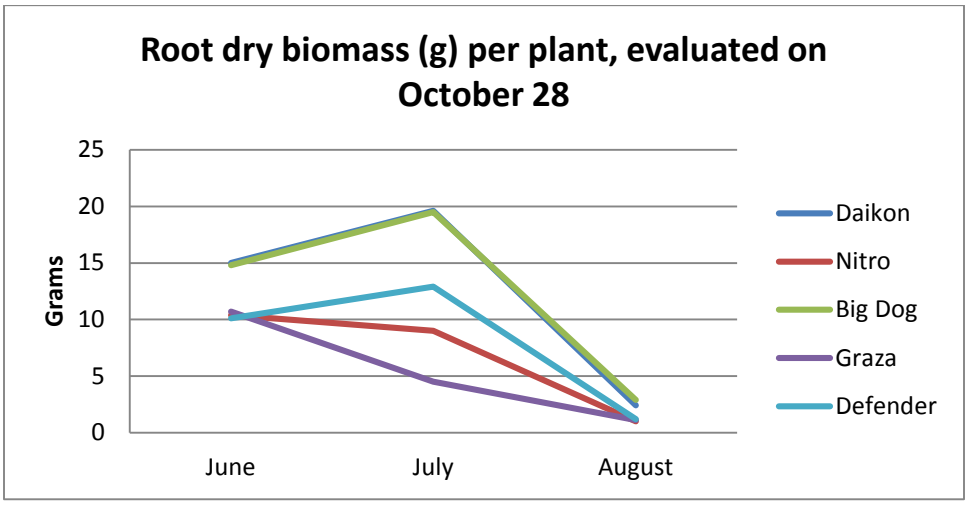
April planting: Nitro and Daikon flowered earliest from the April planting with 80% and 70% flowering respectively on June 23, 56 days after planting (DAP). Big Dog and Defender were intermediate with 50 and 25% flowering. By June 27 (60 DAP) those four varieties had bolted and were all completely in flower. Graza did not show signs of flowering until July 14 (70 DAP) when the first plants started to bolt. However by July 25 (81 DAP), the Graza plants were all struggling from a flea beetle infestation resulting in the termination of the April planting before Graza had produced any flowers.

May planting: The may planting was terminated prior to evaluation due to excessive weed pressure.

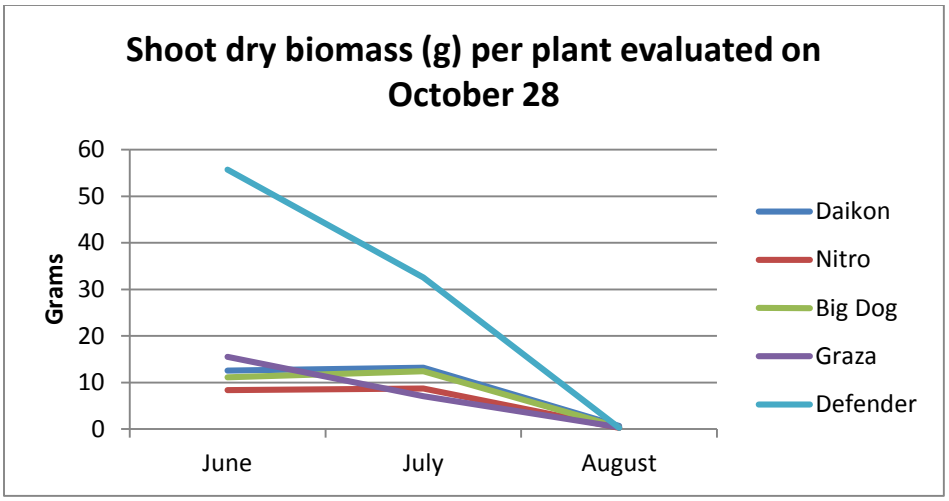
June planting: On September 1 (65 DAP), approximately 20% of the Daikon plants and 50% of the Defender plants were flowering; the other varieties had not begun to bolt. On October 1 (95 DAP), Defender had reached 100% flowering while roughly 50% of the Daikon plants were in flower. Daikon reached 100% flowering on October 28 (122 DAP). Despite flowering and fruit production in Defender and Daikon, inspection of the pods revealed no viable seed. Big Dog, Nitro and Graza never initiated bolting from the June planting.

July planting: The only variety to flower from the July planting was Defender, which had attained 5% flowering as of October 28 (92 DAP).

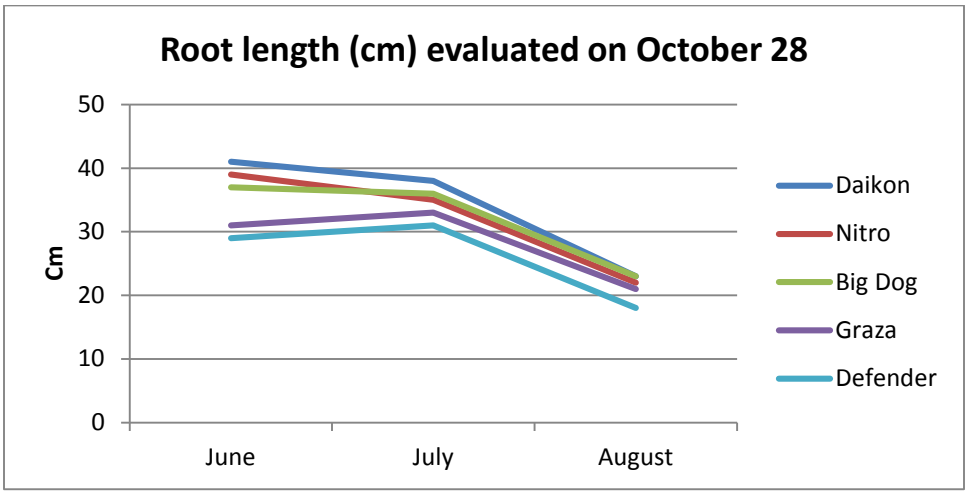
Biomass



Root biomass did not differ between varieties for any planting date. Despite the upward trend of Big Dog, Defender and Daikon shown in the graph, no significant differences were detected for any variety going from June to July planting dates. The August planting produced significantly less biomass than the July planting for Daikon, Big Dog and Defender, where June to August differences were significant for only Daikon and Big Dog.



Defender shoot biomass from the June and July plantings were significantly greater than all other varieties from any planting, largely as a result of increased stem production during bolting. Defender shoot dry matter decreased significantly from the June to July planting and again from July to August as fewer plants initiated bolting. Graza biomass from the June planting was significantly greater than the August planting. Other varieties did not differ significantly in shoot biomass production from June to July or from July to August.



Graza and Defender had significantly shorter roots than other varieties from the June planting. No significant differences were observed between June and July plantings for any variety; however we did see a significant decrease in root length from July to August for all varieties tested. August planted varieties did not differ from one another significantly in root length.

CONCLUSION

There were no detectable differences between varieties in any measure from the August planting in our test. This would appear to indicate that most varieties are well-suited for late season plantings in Southeast Idaho. However, the August planted radishes from this trial appeared much smaller than those from other Idaho plantings (pers. obs.). This may be the result of the applied seeding rate being too high, or could be due to environmental factors.

Planting in late June resulted in significant flowering only by Defender and Daikon. Delaying planting until late July however resulted in all varieties remaining essentially in a vegetative stage until winter frost. No plants seeded on June 28 and later produced viable seed, so volunteering and creating a potential weed problem does not appear to be an issue from mid-summer plantings.

Early bolting varieties like Defender produced the largest amounts of above ground biomass (Figure 2); however the high quantities of stem are less desirable forage than the leafy greens (Dickinson 1982). Early bolting in Defender resulted in significantly reduced root lengths; however Graza, a non-bolting forage radish also produced shorter roots than the remaining varieties.

Graza radish was bred for maximum forage production and multiple harvests. Graza radish is a fast-growing, drought tolerant, forage radish which can be grazed multiple times as it rapidly regrows after grazing (SeedToday.com). Graza acts essentially as a biennial, producing a rosette of leaves in the first season and bolting during the second year. In our trial Graza radish was among the last varieties to initiate flowering from the early plantings, and did not show any indicators of bolting from the mid- to late-summer planting dates. Periodic grazing followed by regrowth would likely have increased dry matter yields for Graza. However, root lengths from April seeded Graza compared with those from early bolting Defender.

Figure 2. Defender radish shoot biomass decreased significantly from the June to July planting (left to right) as bolting and flowering stems were more prevalent from the earlier planting. Average root biomass increased from June to July but not significantly.

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United States Department of Agriculture

2014 STUDY REPORT
Aberdeen Plant Materials Center, Aberdeen, ID

CORN/COVER CROP INTERSEEDING TRIAL

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Marlon Winger, State Agronomist, Boise, Idaho

INTRODUCTION

Post-harvest silage corn fields leave little residue which leaves the soil surface exposed to wind and rain, and increases the risk of soil erosion. The interseeding of cover crops has been seen as a potential way to introduce highly productive species to cover the soil and reduce erosion potential (Bosworth 2006). Interseeded cover crops like clover and cereal rye have also been used to augment fall and winter grazing (Bosworth 2006).

In general, small-seeded species with vigorous growth characteristics like legumes and brassicas are suitable for in-season seeding. Commonly used species in corn interseeding include cereal rye and clover species. Cereal rye, however, is highly invasive in the Intermountain Region and is generally avoided by farmers (Ogle et al 2012).

Interseeding into silage corn poses several challenges. First, the cover crop species must be vigorous enough to produce useful amounts of above-ground biomass, while not inhibiting corn production. Second, the cover crops have to be seeded late enough in the growing season to not impede corn establishment but early enough that there is still ample sunlight penetrating the corn canopy for development of the cover crop. Mutch and Martin (2010) indicate that planting the V4 to V8 corn stage provides enough light penetrating the canopy for seed germination and establishment.

Interseeding is often done with specialized equipment so young corn plants will not be damaged. High-clearance or aerial seeding equipment is necessary if the cover crop seeding takes place after canopy closure. Aerial seeding is becoming more popular due to its ability to cost-effectively seed a large number of acres in a timely manner; however, timing is critical as broadcast seeding into standing corn can result in large quantities of seed falling into the corn leaf axils never reaching the soil surface (pers. obs.). In order to place seed more precisely, some growers have converted high-clearance spraying or detasseling equipment into cover crop seeders. To accommodate for lost seed and for low establishment rates typical of broadcast seeding, aerial and high-clearance methods require higher seeding rates compared to other establishment methods; in some cases, 50 to 100% more seed is recommended relative to drilling. (Ogle et al 2012)

Specialized equipment like the Penn State Cover Crop Interseeder and Applicator has been developed to plant directly into established corn (Roth et al 2014). The Interseeder plants multiple cover crop rows between 30 inch corn rows, and simultaneously applies nitrogen and herbicide. These methods have been shown to effectively establish cover crops in standing corn; however the equipment is costly and uncommon in the Intermountain West.

In this trial we seeded a low-cost, simple cover crop mixture into established corn using techniques and equipment familiar to southern Idaho farmers to evaluate biomass production and forage yields at 3 seeding rates with two seeding methods.

MATERIALS AND METHODS

Roundup-ready corn was seeded with Planet Jr seeders on May 15 at 36 inch row spacing. The corn was irrigated regularly and allowed to reach a height of 8 to 10 inches. Then Glyphosate was applied at 32 oz/ac on June 16 to control emergent weeds.

The cover crop mix used consisted of turnip, oat, red clover and field pea at three rates using two seeding methods (table 1). The drill treatment was seeded at 10 lbs/acre. The two broadcast mixes were seeded at twice and four times the drill rate (20 lbs/ac and 40 lbs/ac respectively). The rates used were reduced from standard full stand cover crop seeding rates to account for the space given to corn establishment. Clover seed was pre-inoculated by the seed vendor with the appropriate strain of rhizobium.

Table 1. Species used and seed rate (lb/ac)

Species	Drill	BC2X	BC4X
Turnip	0.4	0.8	1.6
Oat	5	10	20
Field pea	4	8	16
Red clover	1	2	4
Total Mix	10.4	20.8	41.6
Estimated Cost/ac	$5.90	$11.80	$23.60

On June 23, the cover crop mixes were drilled or broadcast between corn rows by offsetting the Plant Jr seeders. The drill seeding was planted to a depth of ½ to ¾ inch. Broadcast rows were seeded by dropping the seed on the soil surface and allowing a packer wheel to press the seed lightly into the soil. Each treatment consisted of four cover crop rows nested in 5 corn rows. Treatment blocks were arranged in a randomized complete block design with six replications. No additional fertilizer was added to the planting.

On October 27 a ten foot section of the middle two rows was harvested beginning at 30 ft and again at 60 ft in each plot. Timing of the harvest corresponded with typical corn harvests in Southern Idaho. Harvested material was air-dried or, in the case of turnip roots, oven dried prior to weighing. Data were analyzed using the Statistix 8 Analytical software and subjected to an analysis of variance with a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Corn establishment was uniform however we did observe differences in corn height and color throughout the field. These differences did not correlate with cover crop treatments, but were more likely reflections of soil inconsistencies due to previous year's plantings and fertilizer applications.

No significant differences were observed between seeding treatments for any species or for the combined cover crop mix (table 2). Red clover established from all treatments but differences were not statistically significant ($p=0.15$). Total production of red clover was minimal ranging from 3 lbs/ac from the drill seeded treatment to 20 lbs/ac from the 2X broadcast treatment. Field pea and oat establishment

was only observed in the drill seeded plots, but treatment differences were not significant (p=0.40 and 0.20 respectively). Establishment of field pea in the drill rows was poor and resulted in only 4 lbs/ac of useable biomass. Oat establishment was also uneven in drill rows and yielded only 44 lbs/ac. Turnip seed established from all planting treatments, but there was no significant difference in biomass production between the treatments (p=0.67). Turnip yields ranged from 620 lbs/ac from the BC2X treatment to 1030 lbs/ac from the BC4X treatment. Total production of the mix added between 640 lbs (BC2X) to 1028 lbs (BC4X) of useable forage (p=0.68).

Table 2. Dried biomass production after 126 days.

	Red Clover	Field Pea	Oat	Turnip	Total Mix
Drill	3	4	44	764	816
BC2X	20	0	0	621	640
BC4X	10	0	0	1017	1028
P=	0.15	0.40	0.20	0.67	0.68

CONCLUSION

Using conventional equipment and providing no supplemental fertilizer, our cover crop treatments added 640 to 1030 lbs of above ground biomass. The additional ground cover would effectively reduce erosion potential or provide forage for livestock grazing.

Oat and pea, both large seeded species that are typically planted ½ to 2 inches deep, had no establishment from broadcast seeding. Seed of those species was too large to get incorporated into the soil and was likely eaten off the surface by birds or rodents. Broadcasting however was effective for establishing the small seeded turnip which produced the majority of the observed biomass with abundant leaf growth and a large edible root. Clover establishment was surprisingly poor. The total forage added by clover, oat and pea were minimal even in the drill seeded treatment.

Drilling the cover crop mix at 10 lbs/ac did not differ significantly in biomass production from broadcasting at 20 and 40 lbs/ac. If drilling equipment is available, this seems to be the most cost effective means of establishing a cover crop mix into standing corn. Our results indicate that high seed rates are necessary to compensate for lost seed and poor seed to soil contact resulting from broadcast seeding. However the doubling the broadcast rate from 20 top 40 lb/ac did not significantly increase forage production in our study.

Corn plantings are typically done with 22 to 30 inch spacing. The tighter corn spacing means less sunlight is able to penetrate through the canopy to the cover crop; however, 30 inch spacing has been shown to be sufficient for cover crop establishment (Roth et al 2014). We used 36 inch row spacing due to equipment limitations, and assumed the increased light would improve germination and biomass production. More testing is needed to determine the effect of various row spacing on cover crop and corn production.

It is possible to use conventional seeding equipment to establish cover crops between corn rows in Southeast Idaho. Relatively low rates of seed (10 to 40 lbs/ac) can yield significant biomass for erosion control and fall grazing. Seeding method should be considered when choosing species. Large, deep-seeded species should not be used in broadcast seedings.

Interseeded cover crop between corn rows on August 20 (58 days after seeding).

Broadcast seeded cover crop at 40 lbs/ac on October 9 (108 days after planting).

A large turnip provides good ground cover and valuable forage.

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CURLEW NATIONAL GRASSLAND OFF-CENTER EVALUATION: 2014 PROGRESS REPORT

Derek J. Tilley, PMC Manager

ABSTRACT

In 2010, 63 accessions of 35 species of native and introduced grasses, forbs and shrubs were planted in a replicated display nursery at the Curlew National Grassland in Power County, Idaho. Introduced bunchgrasses, such as Russian wildrye (*Psathrostachys juncea*), Siberian wheatgrass (*Agropyron fragile*), and crested wheatgrass (*A. cristatum*), exhibited superior establishment and persistence over native grass species. However, several native grasses including bottlebrush squirreltail (*Elymus elymoides*) had fair to good establishment. Native and introduced forbs had poor establishment and plant densities decreased over time. The locally collected Bonneville big sagebrush had the highest rated stand establishment and persistence of all evaluated shrub entries. Volunteer crested wheatgrass densities decreased with higher establishment rates of target species; however no difference in density of annual bromes could be detected regardless of target species density.

INTRODUCTION

In November of 2010, the Aberdeen Plant Materials Center (PMC) installed a multi-species planting at an off-center test site located on the USDA-Forest Service Curlew National Grassland located approximately 30 miles south of American Falls, Idaho in cooperation with the Caribou/Targhee National Forest. The trial contains 63 accessions of 35 species of native and introduced grasses, forbs and shrubs adapted for use in MLRA 13 Eastern Idaho Plateaus (13 to 18-inch plus precipitation areas (Table 1). The goal of this trial is to evaluate the adaptability of new conservation releases in mid-elevation big sagebrush/grass ecosystems and compare their establishment, production, and longevity against traditionally recommended released plant materials. The site will also serve as a display nursery for the Forest Service and other conservation practitioners to view plant species and releases in a natural setting.

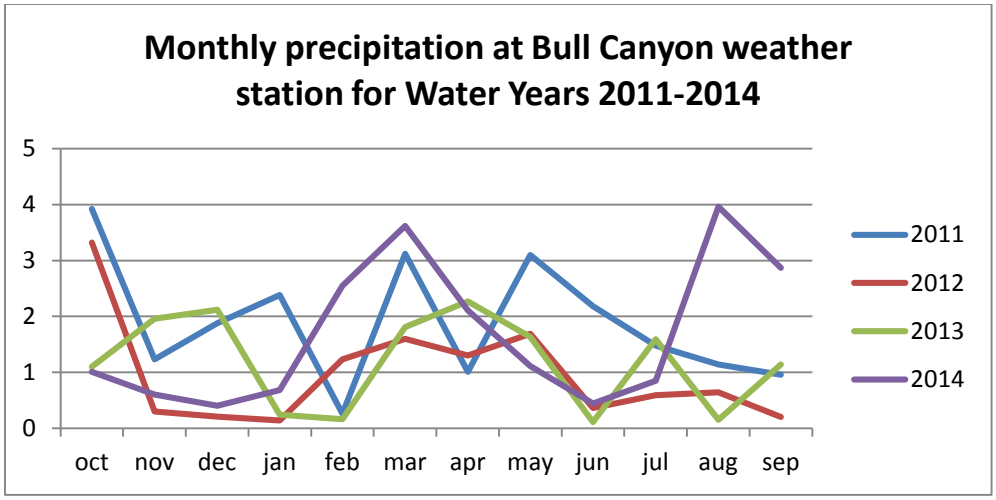
The Curlew test site historically supported a Bonneville big sagebrush/bluebunch wheatgrass plant community. For several decades, however, it has been dominated by crested wheatgrass and bulbous bluegrass. Climatic conditions are semi-arid with mean annual precipitation ranging from 12 to 25 inches The frost free period is approximately 90 days or less. The soil at the site is classified as a Samaria-Pollynot complex, 4 to 12 percent slopes, silt loam, well-drained and deep (> 80 inches to limiting layer). The elevation is 5,216 ft.

Weather

There are no weather stations located near the Curlew site or in nearby locations with similar elevation and conditions. The closest weather station is the Bull Canyon weather station located 11 miles north of the Curlew study site at an elevation of 6,418 ft. During water year 2011, Bull Canyon recorded 22.7 inches of precipitation. The Curlew study site, being lower in elevation,

probably received less precipitation than Bull Canyon, but the Curlew test site received normal to above normal precipitation for the year (University of Utah, 2012).

Precipitation was very low throughout the Intermountain West in 2012. The Bull Canyon weather station recorded below average precipitation with a cumulative total of 11.58 inches through September, 2012. Water year 2013 was somewhat better for precipitation in the region with a cumulative total of 14.3 inches through September 4, 2013 at the Bull Canyon station. During 2014 the Bull Canyon station reported 20.2 inches of precipitation, much of that coming from an abnormally wet August in which the region received nearly four inches of rain.



MATERIALS AND METHODS

The study area was burned by wildfire in 2006. In the fall of 2009 the study site was plowed and packed, followed by applications of 16 oz/ac 2, 4-D and 64 oz/ac glyphosate on June 18, 2010 and July 29, 2010. The trial was planted on November 17, 2010 using a modified Tye® seed drill with a width of 80 inches (8 rows at 10 inch spacing). Experimental design is a randomized complete block with three replications. Appendix 1 is a plot map of the planting. Each plot is one drill width wide (80 in) and 20 ft long. Seeding depths are dependent on species and were planted according to Ogle et al (2010). Species were seeded at a target rate of 20 to 30 pure live seeds (PLS) per ft² for large seeded species (<500,000 seeds per pound) and 40 to 50 PLS/ft² for smaller seeded species (>500,000 seeds/lb). Pure live seed values were determined by seed lab results or best estimates when lab results were not available. All seed was mixed with rice hulls as an inert carrier to improve seed flow according to St. John et al (2005).

Disturbed areas adjacent to the trial were planted to seed mixture consisting of 40% Anatone bluebunch wheatgrass, 20% Sherman big bluegrass, 15% Bannock thickspike wheatgrass, 10 percent Magnar basin wildrye, 5% Maple Grove Lewis flax, 5% Richfield firecracker penstemon, 5% Great Northern western yarrow, and 0.25 lbs/ac Snake River Plains fourwing saltbush.

The plots were mowed to a height of approximately four inches on September 29, 2011 for weed control.

Plant Density

Plant densities of target species were measured using a frequency grid based on that described by Vogel and Masters (2001). The grid measured approximately 40 x 41 inches, having four ten-inch columns (to incorporate 1 drill row per column) and five rows, totaling 20 cells. The first grid was laid on the rows approximately one grid length (40 inches) into the plot. Counts were made of the cells that contained at least one plant. The grid was then flipped repeatedly into the plot and densities recorded four more times for a total of five. Total area for one grid is approximately 1m². Total area evaluated is therefore approximately 5m². A conservative estimate of plant density (plants/m²) is the total number of cells containing at least one plant divided by five. It is important to note that because cells with plants were counted and not the number of plants per cell, the best possible score is 100 hits per five frames which converts to 20 plants/m^2 or 1.85 plants/ft^2. Actual plant density may be higher than the numbers indicated below. For plants/ft², divide by 10.76.

Data were analyzed using the Statistix 8 Analytical software and subjected to an analysis of variance with a significance level of $p<0.05$. In cases where significance was detected, means were separated using a Least Significant Difference (LSD) all pairwise comparison. Analyses were broken into five groups: 1) all species, 2) native grasses, 3) introduced grasses, 4) forbs, and 5) shrubs. All tables have been arranged with accessions ranked from highest to lowest plant density at the time of the 2011 evaluation.

Initial plant establishment was measured on July 11, 2011. Plant density data were also collected on June 14, 2012, June 20, 2013 and June 27, 2014. Seeded crested wheatgrass plots were not evaluated in 2014, as it had become too difficult to discern target plants from volunteers.

Densities of volunteer crested wheatgrass (*Agropyron cristatum*) and annual bromes (*Bromus* spp.) were evaluated in the test plots with frequency grids on August 13, 2012 and June 27, 2014. One density frame was evaluated for each accession in the center of the plots of replications 1 and 3. These data will be used to track long term persistence and competition of introduced perennial and annual grasses among the seeded species.

Establishment and performance of the cover crop seeding mixture was evaluated on August 14, 2012 and June 20, 2013. Eight density frames (two on each side of the planting) were evaluated. Cover class frequency data was also recorded on August 14, 2012 using a 60 meter (200 ft) line-intercept transect on each side of the planting.

Forage Production

On June 26, 2013, biomass clippings were taken from all accessions with densities greater than 5.4 plants/m² (0.5 plants/ft²). Five representative plants were clipped from plots in each replication. The plants were air dried for 10 days and then weighed. Plant density values were then used to calculate lbs/acre (table 8).

Table 1. Species and accessions

Bluebunch wheatgrass (*Pseudoroegneria spicata*)
- Anatone
- Goldar
- P-7
- P-33

Snake River wheatgrass (*Elymus wawawaiensis*)
- Secar
- Discovery

Western wheatgrass (*Pascopyrum smithii*)
- Recovery
- Rosana
- Arriba

Slender wheatgrass (*Elymus trachycaulus*)
- First Strike
- Pryor

Basin wildrye (*Leymus cinereus*)
- Washoe
- Magnar
- Trailhead
- Continental

Bluegrass (*Poa* spp.)
- Sherman big bluegrass
- Opportunity Nevada bluegrass
- Mt. Home Sandberg bluegrass
- High Plains Sandberg bluegrass
- Reliable Sandberg bluegrass

Green needlegrass (*Nassella viridula*)
- Cucharas

Fescue (*Festuca* spp.)
- 9076469 Idaho fescue
- Covar sheep fescue
- Durar hard fescue

Streambank/Thickspike wheatgrass (*Elymus lanceolatus*)
- Sodar
- Bannock
- Critana

Squirreltail (*Elymus elymoides* and *E. multisetus*)
- Fish Creek bottlebrush squirreltail
- Sand Hollow big squirreltail
- Toe Jam Creek bottlebrush squirreltail
- Wapiti bottlebrush squirreltail
- 9019219 bottlebrush squirreltail
- 9092275 bottlebrush squirreltail

Forbs
- Maple Grove Lewis flax (*Linum lewisii*)
- Appar blue flax (*Linum perenne*)
- Richfield firecracker penstemon (*Penstemon eatonii*)
- Great Northern western yarrow (*Achillea millefolium*)
- Antelope prairie clover (*Dalea candida*)
- Silverleaf phacelia (*Phacelia hastata*)
- 9076577 Douglas' dustymaiden (*Chaenactis douglasii*)
- NBR-1 basalt milkvetch (*Astragalus filipes*)
- Don falcata alfalfa (*Medicago sativa* ssp. *falcata*)
- Timp northern (Utah) sweetvetch (*Hedysarum boreale*)
- Delar small burnet (*Sanguisorba minor*)
- Sainfoin (*Onobrychis viciifolia*)
- Lutana cicer milkvetch (*Astragalus cicer*)
- Stillwater prairie coneflower (*Ratibida columnifera*)

Shrubs
- Bonneville big sagebrush (*Artemisia tridentata* subsp. X *bonnevillensis*)
- Snake River Plains fourwing saltbush (*Atriplex canescens*)
- Wytana fourwing saltbush (*A. canescens*)
- Northern Cold Desert winterfat (*Krascheninnikovia lanata*)

Altai wildrye (*Leymus angustus*)
- Mustang

Crested wheatgrass (*Agropyron cristatum*)
- Ephraim
- Hycrest
- Hycrest II
- Nordan

Russian wildrye (*Psathrostachys juncea*)
- Bozoisky Select
- Bozoisky II

Siberian wheatgrass (*Agropyron fragile*)
- Vavilov
- Vavilov II

Meadow brome (*Bromus biebersteinii*)
- Regar
- Cache

RESULTS AND DISCUSSION

2011

Establishment densities ranged from essentially zero plants to 13 plants/m² in 2011 (Table 4). Eight out of the top ten species to establish were introduced grasses, four of which were crested wheatgrass accessions. The highest ranking native grasses were Fish Creek bottlebrush squirreltail and Pryor slender wheatgrass, both of which are short-lived perennials commonly used as a nurse crop with longer lived species in a seed mixture. In general, forbs had moderate establishment success, while the shrub accessions, with the exception of Bonneville big sagebrush, had low establishment numbers during the first year of evaluation.

Native grasses had a broad range of establishment densities (Table 5) ranging from 0.2 plants/m² for Sand Hollow Germplasm big squirreltail (*Elymus multisetus*) to 11.6 plants/m² for Fish Creek Germplasm bottlebrush squirreltail (*E. elymoides*) in 2011. Introduced grasses all had excellent establishment (Table 6). The lowest plant density recorded was 6.7 plants/m² from Bozoisky Russian wildrye. Cache meadow brome had the highest density with 13.0 plants/m². Forbs (Table 7) generally had lower establishment numbers than the grasses; however good stands were observed in many plots. All shrub species had low initial establishment (Table 8). No significant differences were detected between means.

2012

Despite drought conditions in 2012, plant densities of native grasses did not generally show dramatic decreases. Slender wheatgrass and squirreltail accessions, known to be short lived perennials, decreased or maintained 2011 densities. Bluebunch wheatgrass densities stayed essentially the same as 2011, with the exception of Anatone which increased in density from 7.6 to 9.5 plants/m². The rhizomatous grass species western wheatgrass, thickspike wheatgrass, and streambank wheatgrass all increased in density from 2011 to 2012.

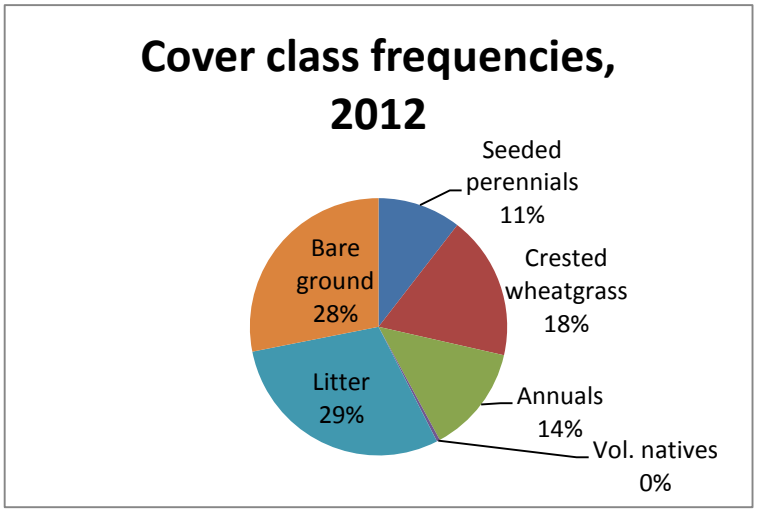
Introduced grass species accessions either increased or decreased in densities from 2011 to 2012. The highest densities were obtained by Hycrest II, Ephraim, and Hycrest crested wheatgrass with 14.1, 12.5 and 11.7 plants/m² respectively. However these numbers may be inflated due to volunteering from the existing soil seed bank. Cache and Regar meadow brome both decreased under drought stress although Cache maintained a good stand with 10.7 plants/m². Vavilov II Siberian wheatgrass maintained approximately 7 plants/m² while Vavilov decreased from 9.6 plants/m² to 4.2 plants/m².

Forb densities declined significantly from 2011 to 2012 with many accessions being nearly eliminated from the plots. Don falcate alfalfa and Appar blue flax (both introduced species) maintained the best stands with 3.3 and 3.2 plants/m² respectively.

Among the shrub entries, Bonneville big sagebrush and Snake River Plains fourwing saltbush had fair stands with 2.0 and 0.7 plants/m² respectively.

Densities of volunteer crested wheatgrass and annual bromes are listed in tables 5-8. These data will be used to track persistence and expansion of introduced species over time. The average density of crested wheatgrass and annuals bromes throughout all of the evaluated plots in 2012

was 7.0 plants/m² and 5.7 plants/m² respectively. No relationship between target species density and density of crested wheatgrass or annual bromes was discernable during 2012.



In the cover crop areas surrounding the test plots, seeded perennials made up 11% of the cover (6% bluebunch wheatgrass, 2% big bluegrass, 2% thickspike wheatgrass, and 1% blue flax) during 2012. Other seeded cover crop species were observed but not recorded in the line-intercept transects. Bare ground and litter made up the majority of the cover classes with 28 and 29% respectively. Volunteer crested wheatgrass accounted for 18% of the total cover. Annual grasses, including bulbous bluegrass (*Poa bulbosa*), cheatgrass (*Bromus tectorum*) and an unidentified annual brome comprised 14% of the ground cover. Incidental volunteer native forbs including tapertip hawksbeard (*Crepis acuminata*) and lesser rushy milkvetch (*Astragalus convallarius*) made up less than 1% of the total cover. Plant density measurements for the cover crop are provided in table 3.

Table 2. Dry forage biomass yields from the entries with the top 15 plant density values in 2013.

	June 26, 2013
	---(lbs/acre)---
Hycrest II	2,400 a
Vavilov II	1,480 b
Hycrest	1,480 b
Bozoisky II	1,280 b-c
Nordan	1,040 b-d
Bozoisky Select	1,020 b-d
Ephraim	940 c-d
Cache	560 d-e
Bannock	440 e
P-7	420 e
Anatone	400 e
Discovery	340 e
Fish Creek	300 e
Rosana	260 e
Arriba	120 e
LSD (0.05)	500

2013

Seven of the top ten recorded densities in 2013 were from introduced grasses. Crested wheatgrass and Russian wildrye varieties appear well-adapted to the site conditions. Most introduced grasses decreased slightly but seem to be well-established. The Russian wildrye

accessions, however, both increased in density from 2012 to 2013. This species is known to take time for establishment and increases over the first few years are expected.

Several native grasses appeared to be holding at acceptable densities. Fish Creek bottlebrush squirreltail continued to look good and had the highest plant density for native species followed by Rosana western wheatgrass and Anatone bluebunch wheatgrass. Short-lived perennials such as slender wheatgrass are steadily decreasing and giving way to longer lived species as would be expected. Rhizomatous perennials such as western wheatgrass and thickspike/streambank wheatgrass are increasing in density as plants spread.

Forbs continued to show low plant densities in general. Appar blue flax had the best density with 3.0 plants/m² in 2013, but due to high variability was not statistically different from other accessions.

In 2013 Bonneville big sagebrush had significantly greater plant density than all other shrubs with an average density of 2.9 plants/m², nearly five times the density of the next best shrub accession.

In total, eight introduced and seven native grasses had densities over 5.4 plants/m² (0.5 plants/ft²) and were clipped and weighed for forage yield (Table 2). The introduced grasses all had higher forage yields than the native grasses. Hycrest II crested wheatgrass had significantly greater forage produced than all other accessions with an average of 2,400 lbs/acre. In contrast, Bannock thickspike wheatgrass had the best forage yields among the native accessions with 440 lbs/acre.

The native seed mixture that was applied to the areas surrounding the test site was evaluated in 2011 and 2013. Crested wheatgrass densities decreased from 9.9 to 5.1 plants/m² between 2011 and 2013 (Table 3). Similarly, annual bromes decreased from 9.3 to 1.1 plants/m² in the same time period. Bulbous bluegrass densities remained essentially unchanged. Many of the seeded natives also showed decreases in density from 2011 to 2013; however two forbs, western yarrow and Lewis flax, both increased. Overall totals showed a large decrease in volunteer species from 2011 to 2013 (23.1 plants/m to 9.8 plants/m²). Seeded natives exhibited a much less dramatic decrease from 10.0 to 6.4 plants/m².

Table 3. Species densities (plants/m²) found in the seed mixture[1] planted area adjacent to the demonstration plots.

		Density[2]	
		July 11, 2011	June 20, 2013
Volunteer species		---------- (plants/m ²)---------	
	Crested wheatgrass	9.9	5.1
	Cheatgrass	9.3	1.1
	Bulbous bluegrass	3.4	3.6
	Bonneville big sagebrush	0.5	0.0
	Total	23.1	9.8
Seeded species			
	Bluebunch wheatgrass	5.3	2.6
	Big bluegrass	2.5	1.4
	Thickspike wheatgrass	2.0	1.1
	Western yarrow	0.1	0.9
	Douglas' dustymaiden	0.1	0.0
	Lewis flax	0.0	0.4
	Total	10.0	6.4

[1] Seeding mix included: 40% Anatone bluebunch wheatgrass, 20% Sherman big bluegrass, 15% Bannock thickspike wheatgrass, 10 percent Magnar basin wildrye, 5% Maple Grove Lewis flax, 5% Richfield firecracker penstemon, 5% Great Northern western yarrow, and 0.25 lbs/ac Snake River Plains fourwing saltbush.
[2] Not analyzed for statistical significance

2014

Fish creek bottlebrush squirreltail had highest plant density with 10.4 plants/m²; significantly greater than all other entries with the exception of Bozoisky II. Other native species accessions in the top ten densities included Discovery Snake River wheatgrass (6.1 plants/m²), Sodar streambank wheatgrass (5.8 plants/m²), Toe Jam Creek bottlebrush squirreltail (5.6 plants/m²), and Rosanna western wheatgrass (3.9 plants/m²). Almost all entries in the trial decreased in density from 2013 to 2014. Exceptions include two bottlebrush squirreltail accessions (Fish Creek and Toe Jam Creek), Discovery Snake River wheatgrass, and two sod-forming grasses (Sodar Streambank wheatgrass and Critana thickspike wheatgrass), which are expected to spread via rhizomes. Introduced cultivars of Russian wildrye and Siberian wildrye all scored in the top ten densities. Cache meadow brome continued to decline in density from 6.8 to 3.9 plants/m², but was still in the top ten.

Bonneville sagebrush again had significantly greater establishment density than all other shrub accessions ($p=0.02$). With a plant density of 2.9 plants/m it had not changed since 2013. Though not measured for statistical significance, Bonneville sagebrush plots had the lowest densities of annual bromes, approximately one-third as many plants/m as the remaining shrub entries. Densities of crested wheatgrass however, appeared to be comparable among the shrub plantings.

Forb densities were low with no significant differences detected. Maple Grove Lewis flax had the highest plant density with 0.8 plants/m². Six other accessions were observed with at least one plant in the evaluated frames: Appar blue flax, Timp northern sweetvetch, Great Northern yarrow, Delar small burnet, sainfoin and NBR-1 basalt milkvetch. Several entries had zero plants/m²: Antelope prairie clover, Douglas' dustymaiden, Don alfalfa, Lutana vetch, Phacelia, Richfield firecracker penstemon, and Stillwater prairie coneflower.

Significant differences in crested wheatgrass were detected when all species were compared, ($p=0.01$). In general, more established target species resulted in fewer crested wheatgrass plants/m. No significant differences were detected in annual brome establishment regardless of target species densities ($p=0.09$). However, six of the top ten target densities scored in the bottom ten annual brome densities.

Table 4. Plant density (plants/m²) for all entries from 2011-2014.

Accession	Density July 11, 2011	June 14, 2012	June 20, 2013	June 27, 2014	Accession (cont.)	Density July 11, 2011	June 14, 2012	June 20, 2013	June 27, 2014
	---------- (plants/m ²)----------					---------- (plants/m ²)----------			
Cache	13.0 a	10.7 a-d	6.8 a-f	3.9 c-h	Recovery	4.3 h-q	5.8 e-n	4.5 e-l	1.7 h-l
Hycrest II	12.1 a-b	14.1 a	9.9 a	--	NBR-1	4.0 i-q	0.0 q	0.5 o-p	0.1 l
Fish Creek	11.6 a-c	9.1 b-f	9.8 a	10.4 a	Durar	3.9 i-q	5.5 e-o	3.2 g-p	1.0 h-l
Nordan	11.6 a-c	8.7 b-g	6.5 a-g	--	9076469	3.8 i-q	2.9 i-q	0.1 p	0.0 l
Pryor	11.5 a-d	2.0 k-q	0.1 p	0.0 l	Bannock	3.6 j-q	6.5 d-k	6.1 b-h	3.1 d-l
Ephraim	11.1 a-e	12.5 a-b	9.7 a	--	Opportunity	3.5 j-q	4.4 f-q	0.3 o-p	0.1 l
Vavilov	9.6 a-f	4.2 g-q	4.7 d-k	6.7 b-c	Washoe	3.5 j-q	0.7 p-q	0.5 o-p	0.3 k-l
Bozoisky II	9.5 a-g	9.0 b-f	9.9 a	7.3 a-b	Phacelia	3.3 k-q	0.7 p-q	0.1 p	0.0 l
Hycrest	9.0 a-h	11.7 a-c	8.1 a-d	--	Secar	3.3 k-q	4.9 e-p	3.3 g-p	3.4 d-k
Covar	8.5 a-i	8.9 b-g	2.1 i-p	1.3 h-l	9019219	3.1 k-q	2.6 j-q	1.8 j-p	0.8 h-l
Delar	8.1 b-j	1.2 n-q	1.2 l-p	0.2 l	Sherman	3.1 k-q	4.2 g-q	1.7 j-p	1.1 h-l
Maple Grove	8.1 b-j	1.3 n-q	1.1 l-p	0.8 h-l	Trailhead	3.1 k-q	2.5 j-q	2.9 h-p	2.5 f-l
Anatone	7.6 b-k	9.5 a-e	6.9 a-f	3.8 c-j	Continental	2.4 l-q	1.8 l-q	2.8 h-p	2.5 f-l
Don	7.6 b-k	3.3 h-q	1.7 j-p	0.0 l	High Plains	2.4 l-q	2.5 j-q	3.2 g-p	2.6 f-l
Timp	7.6 b-k	0.6 p-q	1.2 l-p	0.4 k-l	9092275	2.3 l-q	0.9 o-q	0.1 p	0.0 l
Regar	7.5 b-k	4.5 f-q	2.5 i-p	0.3 k-l	Magnar	2.3 l-q	0.5 p-q	1.1 l-p	0.4 k-l
Vavilov II	7.5 b-k	7.7 c-h	9.1 a-b	5.1 b-g	Bonneville sage	1.5 m-q	2.0 k-q	2.9 h-p	2.9 d-l
Appar	7.0 c-l	3.2 h-q	3.0 h-p	0.5 k-l	Great Northern	1.5 n-q	0.9 o-q	0.9 m-p	0.3 k-l
Mustang	6.8 d-l	2.5 j-q	2.5 i-p	1.9 g-l	Richfield	1.5 n-q	0.4 p-q	0.5 o-p	0.0 l
Bozoisky	6.7 e-l	5.7 e-n	7.5 a-e	6.7 b-c	Wapiti	1.3 o-q	0.1 q	0.1 p	0.0 l
Sodar	6.7 e-l	7.4 c-i	3.9 f-n	5.8 b-e	Lutana	1.2 o-q	0.1 q	0.1 p	0.0 l
Critana	6.6 e-l	6.4 d-l	3.7 f-o	3.9 c-i	Stillwater	1.1 p-q	0.1 q	0.0 p	0.0 l
First Strike	6.3 f-m	2.0 k-q	0.6 n-p	0.0 l	Cucharas	0.9 q	0.5 p-q	0.2 p	0.9 h-l
P-7	6.2 f-n	6.7 d-j	5.5 c-i	2.7 e-l	Mt. Home	0.9 q	1.0 o-q	1.9 j-p	1.6 h-l
Sainfoin	5.9 f-o	0.5 p-q	0.7 n-p	0.2 l	Reliable	0.7 q	1.3 n-q	1.5 k-p	1.2 h-l
P-33	5.8 f-p	4.5 f-q	4.3 e-m	2.9 d-l	Snake River Plains	0.5 q	0.5 p-q	0.6 n-p	0.7 j-l
Goldar	4.7 g-q	6.1 d-m	2.7 i-p	1.2 h-l	Wytana	0.3 q	0.1 q	0.3 o-p	0.7 j-l
Rosana	4.5 h-q	8.2 b-g	8.7 a-c	3.9 c-h	Sand Hollow	0.2 q	0.0 q	0.0 p	0.1 l
Toe Jam	4.5 h-q	5.7 e-n	5.1 d-j	5.6 b-f	Antelope	0.1 q	0.0 q	0.0 p	0.0 l
Dustymaiden	4.4 h-q	1.7 l-q	0.3 o-p	0.0 l	NCD Winterfat	0.1q	0.1 q	0.0 p	0.0 l
Discovery	4.4 h-q	5.5 e-o	5.4 c-i	6.1 b-d					
Arriba	4.3 h-q	8.7 b-g	5.5 c-i	3.8 c-j					
LSD (0.05)	4.8	4.7	3.5	3.1					

Table 5. Plant density (plants/m²) for native grasses, volunteer crested wheatgrass and introduced annual bromes from 2011-2014.

	Target Species Density				Crested Wheatgrass Density[1]		Annual Brome Density[1]	
Accession	July 11, 2011	June 14, 2012	June 20, 2013	June 27, 2014	August 13, 2012	June 27, 2014	August 13, 2012	June 27, 2014
	---------- (plants/m ²)----------				-------- (plants/m ²)-------		------- (plants/m ²)-------	
Fish Creek	11.6 a	9.1 a	9.8 a	10.4 a	4	3.9	5.5	5.4
Pryor	11.5 a	2.0 c-h	0.1 j-k	0.0 d	2.5	8.1	3	12.9
Anatone	7.6 a-c	9.5 a	6.9 a-c	3.8 b-c	6	5.1	3.5	8.9
Sodar	6.7 a-d	7.4 a-c	3.9 c-i	5.8 b	7.5	6.5	2	11.3
Critana	6.6 a-d	6.4 a-e	3.7 c-j	3.9 b-c	5.5	4.6	9.5	9.9
First Strike	6.3 a-e	2.0 c-h	0.6 i-k	0.0 d	10.5	6.7	4.5	9.4
P-7	6.2 a-f	6.7 a-d	5.5 b-e	2.7 b-d	7	4.9	6.5	9.4
P-33	5.8 b-f	4.5 a-h	4.3 c-h	2.9 b-d	9.5	6.5	7.5	11.9
Goldar	5.7 b-g	6.1 a-f	2.7 d-k	1.2 c-d	11	7.9	4	11.3
Rosana	4.5 b-g	8.2 a-b	8.7 a-b	3.9 b-c	6.5	5.4	4	8.5
Toe Jam Creek	4.5 b-g	5.7 a-h	5.1 c-g	5.6 b	5	5.1	4.5	7.3
Discovery	4.4 b-g	5.5 a-h	5.4 b-f	6.1 b	7.5	6.1	2	10.5
Arriba	4.3 b-g	8.7 a	5.5 b-e	3.8 b-c	7	4.8	1	12.2
Recovery	4.3 b-g	5.8 a-g	4.5 c-h	1.7 c-d	5	5.7	4	10.0
9076469	3.8 b-g	2.9 b-h	0.1 k	0.0 d	9	6.2	8.5	12.2
Bannock	3.6 b-g	6.5 a-e	6.1 b-d	3.1 b-d	10	6.7	5	10.9
Opportunity	3.5 b-g	4.4 a-h	0.3 j-k	0.1 d	3.5	7.8	8.5	6.2
Secar	3.3 b-g	4.9 a-h	3.3 c-k	3.4 b-d	4.5	5.1	11	12.6
Sherman	3.1 b-g	4.2 a-h	1.7 g-k	1.1 c-d	8.5	6.9	2	10.5
9019219	3.1 b-g	2.6 b-h	1.8 g-k	0.8 c-d	6.5	5.9	10.5	12.3
High Plains	2.4 c-g	2.5 b-h	3.2 d-k	2.6 b-d	11.5	9.1	3	10.0
9092275	2.3 c-g	0.9 e-h	0.1 j-k	0.0 d	9	7.9	7	10.0
Wapiti	1.3 d-g	0.1 g-h	0.1 k	0.0 d	7	5.9	7.5	12.3
Cucharas	0.9 e-g	0.5 f-h	0.2 j-k	0.9 c-d	7.5	6.4	3	10.2
Mountain Home	0.9 e-g	1.0 d-h	1.9 f-k	1.6 c-d	6	5.1	11	13.8
Reliable	0.7 f-g	1.3 d-h	1.5 g-k	1.2 c-d	7	5.6	1.5	5.8
Sand Hollow	0.2 g	0.0 h	0.0 k	0.1 d	4.5	5.8	12.5	15.2
LSD (0.05)	5.5	5.7	3.5	3.6				

[1] Not analyzed for statistical significance

Table 6. Plant density (plants/m²) for introduced grasses, volunteer crested wheatgrass and introduced annual bromes from 2011-2014.

	Target Species Density				Crested Wheatgrass Density[1]		Annual Brome Density[1]	
Accession	July 11, 2011	June 14, 2012	June 20, 2013	June 27, 2014	August 13, 2012	June 27, 2014	August 13, 2012	June 27, 2014
	---------- (plants/m ²)----------				----- (plants/m ²)-----		----- (plants/m ²)-----	
Cache	13.0 a	10.7 a-c	6.8 a-c	3.9 a-c	2.5	4.1	2.5	6.3
Hycrest II	12.1 a-b	14.1 a	9.9 a	--	NA	--	5.5	--
Nordan	11.6 a-c	8.7 a-d	6.5 a-c	--	NA	--	2.5	--
Ephraim	11.1 a-c	12.5 a-b	9.7 a	--	NA	--	6.5	- -
Vavilov	9.6 a-c	4.2 d-e	4.5 b-c	6.7 a-b	0.5	3.5	2.5	5.1
Bozoisky II	9.5 a-c	9.0 a-d	9.9 a	7.3 a	2	1.3	3	2.0
Hycrest	9.0 a-c	11.7 a-b	8.1 a-b	--	NA	--	14	--
Covar	8.5 a-c	8.9 a-d	2.1 c	1.3 b-c	10	7.8	3	7.9
Regar	7.5 b-c	4.5 d-e	2.5 c	0.3 c	3.5	6.8	1.5	6.3
Vavilov II	7.5 b-c	7.7 b-e	9.1 a-b	5.1 a-c	NA	2.4	3	5.7
Mustang	6.8 c	2.5 e	2.5 c	1.9 b-c	8.5	4.7	4	11.2
Bozoisky	6.7 c	5.7 c-e	7.5 a-b	6.7 a-b	6.5	3.3	2	4.2
Durar	3.9 c	5.5 c-e	3.2 b-c	1.0 b-c	7	5.9	4	8.3
LSD (0.05)	5.0	5.7	4.8	5.1				

[1] Not analyzed for statistical significance

Table 7. Plant density (plants/m²) for all forbs, volunteer crested wheatgrass and introduced annual bromes from 2011-2014.

	Target Species Density				Crested Wheatgrass Density[1]		Annual Brome Density[1]	
Accession	July 11, 2011	June 14, 2012	June 20, 2013	June 27, 2014	August 13, 2012	June 27, 2014	August 13, 2012	June 27, 2014
	---------- (plants/m ²)----------				----- (plants/m ²)----		----- (plants/m ²)----	
Delar	8.1 a	1.2	1.2	0.2	2	6.1	10.5	10.5
Maple Grove	8.1 a	1.3	1.1	0.8	5.5	4.1	12	17.9
Don	7.6 a-b	3.3	1.7	0.0	7.5	6.1	2	12.1
Timp	7.6 a-b	0.6	1.2	0.4	9.5	8.3	11	11.0
Appar	7.0 a-c	3.2	3.0	0.5	5	4.1	15	14.3
Sainfoin	5.9 a-d	0.5	0.7	0.2	10	8.1	12	7.5
Douglas' dustymaiden	4.4 b-e	1.7	0.3	0.0	6	10.2	1	9.0
NBR-1	4.0 c-e	0.0	0.5	0.1	10.5	7.2	2	12.5
Phacelia	3.3 d-f	0.7	0.1	0.0	10.5	7.3	4.5	8.5
Great Northern	1.5 e-f	0.9	0.9	0.3	7	5.5	8	16.6
Richfield	1.5 e-f	0.4	0.5	0.0	5	3.5	10.5	12.5
Lutana	1.2 e-f	0.1	0.1	0.0	3	5.1	14.5	12.1
Stillwater	1.1 e-f	0.1	0.0	0.0	7	4.8	3	12.4
Antelope	0.1 f	0.0	0.0	0.0	10	8.3	5	5.8
LSD (0.05)	3.4	N/A	N/A	N/A				

[1] Not analyzed for statistical significance

Table 8. Plant density (plants/m²) for shrubs, volunteer crested wheatgrass and introduced annual bromes from 2011-2014.

	Target Species Density				Crested Wheatgrass Density[1]		Annual Brome Density[1]	
Accession	July 11, 2011	June 14, 2012	June 20, 2013	June 27, 2014	August 13, 2012	June 27, 2014	August 13, 2012	June 27, 2014
	---------- (plants/m ²)----------				------ (plants/m ²)------		------ (plants/m ²)------	
Bonneville big sagebrush	1.5	2.0	2.9 a	2.9 a	8.5	5.9	1.5	3.9
Snake River Plains	0.5	0.7	0.6 b	0.1 b	6.5	4.7	4.5	10.6
Wytana	0.3	0.1	0.3 b	0.7 b	5.5	7.1	6.5	11.6
Northern Cold Desert	0.1	0.1	0.0 b	0.0 b	10	6.4	1.5	10.5
LSD (0.05)	N/A	N/A	1.4	1.5				

[1] Not analyzed for statistical significance

CONCLUSION

High densities of volunteer crested wheatgrass at the Curlew seeding are noteworthy. A second year of chemical fallow prior to planting the test accessions to control crested wheatgrass and annual weeds may have significantly reduced competition and led to a more complete plant community conversion. However, deferring planting until the fall of 2011 may have resulted in decreased germination rates of seeded species due to inadequate moisture during the establishment period.

Introduced bunchgrasses have shown excellent establishment and persistence, but should only be recommended in highly-disturbed, critical area plantings.

Most native species did not perform as well as their introduced counterparts, but several grasses have performed well enough to be recommended. Fish Creek and Toe Jam Creek bottlebrush squirreltail both appear to be well-adapted to site conditions on Curlew National Grassland. Bottlebrush squirreltail is a short-lived, early-seral species which can be used in seeding mixtures to capture a site and allow slower growing species to establish. It should not be planted as a single species or as a large component of a seed mixture as the plants are expected to decrease over time. Other natives with fair performance include accessions of several bunchgrasses and rhizomatous sod-forming grasses.

Forbs have done poorly with low establishment and very little persistence with all forb species averaging less than 1 plant/m² in 2014. Locally collected Bonneville big sagebrush had excellent establishment and persistence and should be the most broadly recommended shrub. Other shrub species have fared poorly in this trial.

This progress report documents data from the first four growing seasons at the Curlew off-center evaluation. The site will be excluded from grazing and evaluated again in 2019.

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Fence

Anatone	9076469	Timp	Rosanna	Critana	Secar	Stillwater	Don	Magnar
Goldar	Covar	Delar	Antelope	Cucharas	Wapiti	NBR-1	Maple Grove	Hycrest
P-7	Sodar	Sainfoin	Sand Hollow	Don	Wytana	Sherman	Rosanna	Timp
P-33	Bannock	Lutana	N. C. Desert	Washoe	MACA	Antelope	Great Northern	Bozoisky Sel.
Secar	Critana	MACA	Pryor	Maple Grove	Magnar	High Plains	Secar	Sand Hollow
Discovery	Fish Creek	Stillwater	CHDO	Great Northern	Nordan	9076469	9019219	Wapiti
Recovery	Sand Hollow	WY big sage	Sherman	Anatone	Arriba	Sainfoin 2 bu	Mt. Home	P-7
Rosanna	Toe Jam	S. R. Plains	NBR-1	Trailhead	Durar	First Strike	Critana	S. R. Plains
Arriba	Wapiti	N. C. Desert	Reliable	Timp	Opportunity	Mustang 2 bu	Sodar	Pryor
First Strike	9019219	Wytana	Hycrest	Appar	Sainfoin	Goldar	Phacelia	Cucharas
Pryor	9092275	Mustang	P-33	9019219	P-7	Ephraim	Trailhead	Wytana
Washoe	Maple Grove	Ephraim	Sodar	Recovery	Covar	Bannock	Toe Jam	WY big sage
Magnar	Appar	Hycrest	Mustang	Phacelia	Bozoisky II	Appar	P-33	Discovery
Trailhead	Richfield	Hycrest II	High Plains	Mt. Home	Stillwater	Continental 2 bu	Opportunity	Vavilov
Continental	Great Northern	Nordan	Vavilov	WY big sage	Fish Creek	Hycrest II	Delar 2 bu	Lutana
Sherman	Durar	Bozoisky Sel.	9092275	First Strike	Bozoisky Sel.	Recovery	Anatone	Reliable
Opportunity	Antelope	Bozoisky II	Delar	Ephraim	Cache	Cache	Bozoisky II	Regar
Mt. Home	Phacelia	Vavilov	Discovery	9076469	Goldar	9092275	Richfield	Durar
High Plains	CHDO	Vavilov II	Richfield	Regar	S. R. Plains	N. C. Desert	Covar	CHDO
Reliable	NBR-1	Regar	Lutana	Toe Jam	Vavilov II	Vavilov II	Fish Creek	Arriba
Cucharas	Don	Cache	Bannock	Hycrest II	Continental	Washoe	MACA 2 bu	Nordan

Rep. 1

Rep. 2

Rep. 3

Aberdeen Plant Materials Center

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United States Department of Agriculture

Challis Demonstration Plantings Summary
1980 - 2013

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Introduction

Six demonstration plantings were seeded in the Challis, Idaho NRCS Field Office service area in Custer County, Idaho between 1980 and 1982 as a part of the Challis Experimental Stewardship Program. The objective of these plantings was to determine and display species and cultivars (varieties) of grasses, forbs, legumes and shrubs adapted for use in rangeland rehabilitation and the improvement of wildlife habitat. Many agencies, including USDA NRCS (SCS), USDI BLM, USDA FS and Idaho Department of Lands contributed to the establishment of this project. Long term demonstration planting evaluations were the responsibility of USDA NRCS.

Climate

The average annual precipitation for Challis is 7.70 inches. However, the foothill areas receive more precipitation, as much as 20 inches or more at higher elevations to the north, west and south of Challis. The growing season is quite short in most of the area, from 50 to 100 days. During this growing period, about 30 to 40 percent of total annual precipitation typically falls at lower, warmer elevation sites. Most of this growing season precipitation occurs from mid-April to early-June with June through August being fairly dry. The heaviest 1-day precipitation amount during the period of record was 1.85 inches at Challis on July 10, 1983. The years between 1982 and 1984 were good precipitation years as total annual amounts were between 2 and 3.5 inches above average. This likely resulted in good initial establishment of many of the species at the demonstration plantings. Between the years of 1985 and 1989, precipitation was below average. 1988 in particular was a drought year with the area only receiving 4.77 inches of precipitation. In effect, the mid 1980s through the next 20 years were either average or drier than average for the area with the occasional occurrence of a slightly above average precipitation year.

Materials and Methods

Six fenced enclosure sites were seeded, Jeff's Flat, Round Valley, Bradbury Flat (two plantings), Centennial Flat, Gooseberry Creek and Spud Alluvial (figure 1). Each enclosure was divided into two areas with one half left with native vegetation and the other half scalped and prepared for seeding. All seedings were made in the scalped area. Drilled areas were worked with a spring tooth harrow for seedbed preparation. Grasses, legumes, and forbs were seeded in 3 rows, one foot apart, 30 feet long with a John Deere double disc drill with packer wheels. The shrubs were greenhouse grown transplants individually planted in 100 foot rows 5 feet apart with 3 foot within row spacing.

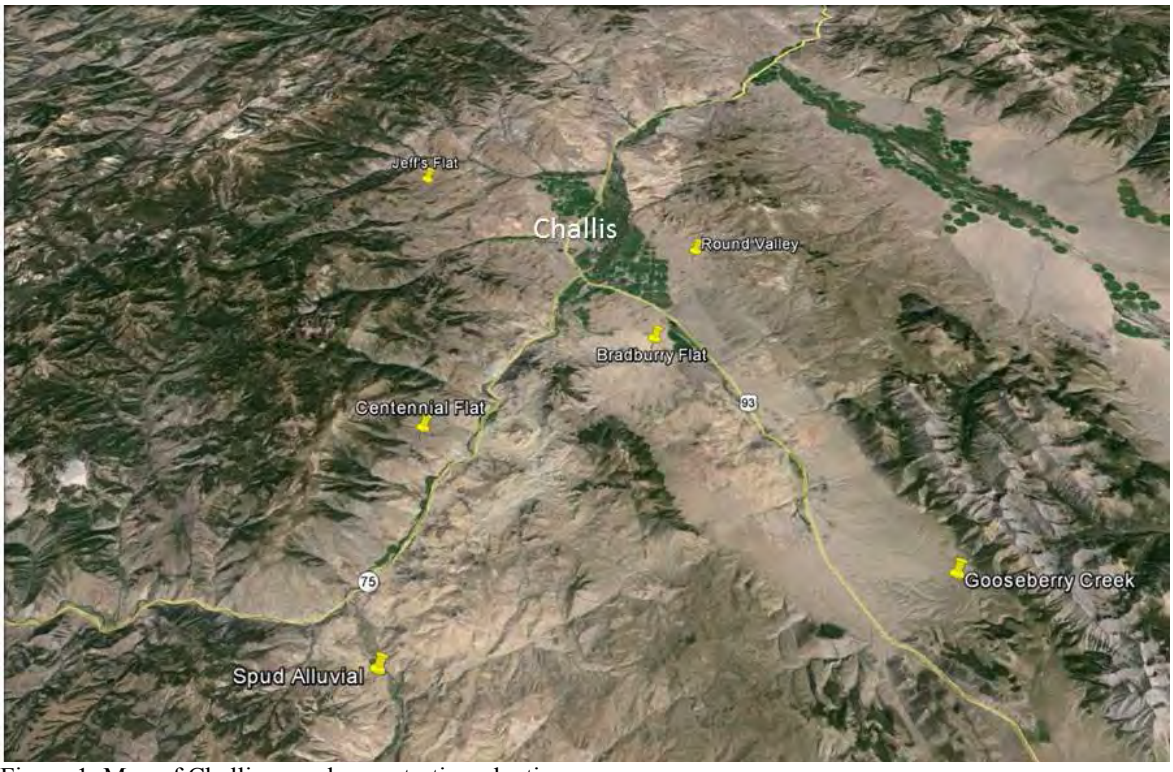

Figure 1. Map of Challis area demonstration plantings.

The plantings were evaluated every 3- 4 years by many NRCS employees. Plant characteristics evaluated and rated include establishment, stand, survival, plant density, plant vigor, resistance to insects, resistance to drought, ability to spread, height, competitive ability, plant production estimates and seed production. However evaluations were not consistent through the 30(+) years. This report summarizes all available evaluations for stand, plant density and the species' estimated ability to spread.

In some years, stand rating was rated on a 1-9 scale (1 being best and 9 being worst), while in other years it was rated on a percent cover basis. This report lists evaluations as they were conducted in the field and a valid comparison of species and accessions can be inferred.

The method of evaluating ability to spread varies from one evaluation to the next. In some cases a single rating is given. In other cases ability to spread was divided into spread by seed and vegetative spread (rhizomatous) and given separate ratings. In a few instances it seems that only vegetative spread is considered as all non-rhizomatous species were given a "non-applicable" rating. In this report we attempt to capture the intention of the evaluator. In instances where separate ratings for vegetative and seed spread were recorded, we provide here the average of those scores.

Several accessions being investigated in this study were formally released in later years following the establishment of these plantings. To avoid confusion, the current release names are given.

Many accessions in the six plantings either failed to establish or did not persist. Rather than filling the attached tables with zeros, the authors have chosen to leave cells blank in which there is no rating due to a failed stand. This should make the report easier to read.

Spud Alluvial

The Spud Alluvial demonstration site is located approximately 30 miles southwest of Challis (44.228549, -114.299698). This site lies at an elevation of 5570 ft and receives 7 to 11 inches mean annual precipitation. The soils at the location are Whiteknob gravelly loam with 2 to 8% slopes. The native plant community is dominated by Wyoming big sagebrush and bluebunch wheatgrass.

Records indicate that the ground was frozen and rocky at the time of seeding with the resulting seedbed being fair at best. Despite poor seeding conditions, 16 of 24 planted species established to some extent.

The Spud Alluvial demonstration planting area, July 2007.

Spud Alluvial stand rating							
	1989[1]	1992[1]	1995[1]	1999[1]	2003[2]	2007[2]	2013[2]
GP-52 synthetic alfalfa	5	8	3	7			
BC-79 synthetic alfalfa	4	8	7	7			
RS-1 bluebunch x quackgrass	8	7			85		
RS-2 bluebunch x quackgrass	7	5			85		
Fairway crested wheatgrass	2	2	1		85	87	30
Immigrant forage kochia	7	6	1		50	85	70
Scarlet globemallow	8	8					
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax							
Paiute orchardgrass							
Ephraim crested wheatgrass	6	7	3	5	75	15	30
Barton western wheatgrass		9			2		
Topar pubescent wheatgrass	7	9	9	9			
Whitmar beardless wheatgrass	5	4	2	1	70	35	2
P-27 Siberian wheatgrass	3	2	2	1	90	90	60
Goldar bluebunch wheatgrass	5	8	4	7	25	2	
Secar Snake River wheatgrass	3	3	3	3	80	50	15
Nezpar Indian ricegrass							
Magnar basin wildrye							
Vinall Russian wildrye	5	3	2	3	85	75	25
Bozoisky Select Russian wildrye	3	3	2	3	85	85	20
Yellow sweetclover				*	*		
Nordan crested wheatgrass	3	2	2	*	*	95	70

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method
* No record of evaluation

Mark Olson and Dan Ogle evaluating the Spud Alluvial demonstration site in 2007.

Spud Alluvial plant density[1]							
	1989	1992	1995	1999	2003	2007	2013
GP-52 synthetic alfalfa	0.4		0.4				
BC-79 synthetic alfalfa	0.4		0.1				
RS-1 bluebunch x quackgrass	0.1				1.5		
RS-2 bluebunch x quackgrass	0.3				1.5		
Fairway crested wheatgrass	1.1		2.0		1.5	0.7	0.4
Immigrant forage kochia	0.1		1.0	2.0	2.0	1.0	1.0
Scarlet globemallow	0.1						
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax							
Paiute orchardgrass							
Ephraim crested wheatgrass	0.5		1.0	2.0	1.0	0.2	0.4
Barton western wheatgrass					0.1		
Topar pubescent wheatgrass	0.4		0.1	1.0			
Whitmar beardless wheatgrass	0.5		1.0	1.0	1.0	0.3	
P-27 Siberian wheatgrass	1.0		1.5	1.0	1.5	1.25	0.8
Goldar bluebunch wheatgrass	0.5		0.4	7.0	0.3	0.1	
Secar Snake River wheatgrass	0.3		0.8	0.7	0.75	0.8	0.3
Nezpar Indian ricegrass							
Magnar basin wildrye							
Vinall Russian wildrye	0.3		1.0	1.5	1.0	0.8	0.5
Bozoisky Select Russian wildrye	0.3		0.9	0.5	0.75	1.0	0.3
Yellow sweetclover							
Nordan crested wheatgrass	1.0		1.5	*	*	1.5	0.7

[1] Plants/ft²

* No record of evaluation

Immigrant forage kochia, P-27 Siberian wheatgrass, Vinall Russian wildrye, and Nordan crested wheatgrass all had fair to good stands at the time of the 2013 evaluation. Ephraim and Fairway crested wheatgrass, Secar Snake River wheatgrass and Bozoisky Russian wildrye also had fair plant densities throughout much of the life of the planting. The 7.0 plants/ft² recorded for Goldar bluebunch wheatgrass in 1999 is most likely a mistake made while recording the data. There is a footnote on the evaluation sheet stating that only 5 plants remained in the entire plot. Dividing those 5 plants by the 90 ft² area of the plot comes to 0.06 plants/ft².

Spud Alluvial ability to spread[1]							
	1989	1992	1995	1999	2003	2007	2013
GP-52 synthetic alfalfa			5	7			
BC-79 synthetic alfalfa			7	7			
RS-1 bluebunch x quackgrass							
RS-2 bluebunch x quackgrass							
Fairway crested wheatgrass	4.5		3			5	5
Immigrant forage kochia	2		2	3	1	1	1
Scarlet globemallow							
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax							
Paiute orchardgrass							
Ephraim crested wheatgrass	4		4	5		7	5
Barton western wheatgrass					7		
Topar pubescent wheatgrass	6		7				
Whitmar beardless wheatgrass			4	7	4		
P-27 Siberian wheatgrass	3		3	6			5
Goldar bluebunch wheatgrass			6	9			
Secar Snake River wheatgrass			5	5			7
Nezpar Indian ricegrass							
Magnar basin wildrye							
Vinall Russian wildrye			4	5	7	5	7
Bozoisky Select Russian wildrye	7		4	7	7	3	7
Yellow sweetclover							
Nordan crested wheatgrass	5		3	*	*	2	3

[1] rated on a 1-9 scale (1=best, 9= worst)
* No record of evaluation

Numerous Immigrant forage kochia volunteers were observed in 2003. In 2007, Immigrant forage kochia was reported outside of the exclosure and by 2013 (30+ years), had spread 30-50 feet (approximately 1- 2 ft/year) from the original planting. In 2013, the Russian wildrye, rated with low ability to spread, had spread via seed approximately10 feet beyond the plots, but it was unclear which accession had moved. The site is dominated by crested and Siberian wheatgrasses both inside and outside the exclosure making it difficult to determine what has moved from which plots of those species.

Centennial Flat

The Centennial Flat demonstration planting site is located at 44.353729, -114.302423, approximately 10 miles southwest of Challis. The elevation of the site is approximately 6,100 ft elevation, and the soils are Venum-Cronks complex gravelly loam. The area receives an estimated 8 to 12 inches mean annual precipitation and is dominated by Wyoming big sagebrush and bluebunch wheatgrass.

No evaluation occurred in 2013. There was also no record of an evaluation of this site in 1999.

Centennial Flat demonstration planting site, 2007.

Centennial Flat stand rating

	1989[1]	1992[1]	1995[1]	2003[2]	2007[2]
GP-52 Synthetic alfalfa	7	4	2	10	10
BC-79 Synthetic alfalfa	5	4	2	3	15
RS-1 bluebunch x quackgrass		8		25	
RS-2 bluebunch x quackgrass		4		15	
Fairway crested wheatgrass	5	2		75	
Lutana cicer milkvetch	2	7	7		1
Canbar Canby's bluegrass		5			
Immigrant forage kochia					
Scarlet globemallow	9	3	9	1	3
Bandera Rocky Mt. penstemon					
Cedar Palmer's penstemon					
Appar blue flax	7	2	6		
Paiute orchardgrass	9				
Ephraim crested wheatgrass	2	3	1	85	70
Barton western wheatgrass		4		5	5
Topar pubescent wheatgrass	3	4	3	1	15
Whitmar beardless wheatgrass	6	5	7	25	65
P-27 Siberian wheatgrass	2	3		0	2
Goldar bluebunch wheatgrass	7	3	4	25	25
Secar Snake River wheatgrass	8	4	4	50	40
Nezpar Indian ricegrass					
Magnar basin wildrye					
Vinall Russian wildrye	6	4	3	60	60
Bozoisky Russian wildrye	5	4	2	45	40
Yellow sweetclover					
Ladak alfalfa	9	7	9	1	
Nordan crested wheatgrass	3	2	2	70	75

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

This site had the best diversity in establishment of the six plantings. Only Immigrant forage kochia, Bandera penstemon, Palmer's penstemon, Nezpar Indian ricegrass and Magnar basin wildrye failed to establish. Ephraim crested wheatgrass, Whitmar beardless wheatgrass, Vinall and Bozoisky Russian wildrye and Nordan crested wheatgrass all had high stand ratings from the 2007 evaluation. Most accessions maintained some level of a stand throughout the life of the planting, either with long-lived plants or by natural seed recruitment and spread.

Centennial Flat plant density and spread	**Density**[1]				**Spread**[2]			
	1989	1995	2003	2007	1989	1995	2003	2007
GP-52 Synthetic alfalfa	0.2	1	0.1	0.1	7	3	5	5
BC-79 Synthetic alfalfa	0.3	1	0.05	0.2	7	3	5	4
RS-1 bluebunch x quackgrass			0.5					
RS-2 bluebunch x quackgrass			0.25					
Fairway crested wheatgrass	0.5		1.0		5		7	
Lutana cicer milkvetch	0.1	0.2		0.1	7	3		7
Canbar Canby's bluegrass								
Immigrant forage kochia								
Scarlet globemallow	0.7	0.1	0.1	0.1	9	7		6
Bandera Rocky Mt. penstemon								
Cedar Palmer's penstemon								
Appar blue flax	0.2	0.5			5	5	6	
Paiute orchardgrass								
Ephraim crested wheatgrass	1.3	1.6	1.25	0.8	3	1		5
Barton western wheatgrass	0		0.25	0.1			7	4
Topar pubescent wheatgrass	1.4	1.0	0.1	0.3	1	3		4
Whitmar beardless wheatgrass	0.1	0.1	0.25	1.0	4	5	5	3
P-27 Siberian wheatgrass	0.9	1.5	0	0.1	2	5		9
Goldar bluebunch wheatgrass	0.2	0.5	0.5	0.5	4	3	5	5
Secar Snake River wheatgrass	0.1	0.3	0.75	0.5	4	5	5	5
Nezpar Indian ricegrass								
Magnar basin wildrye								
Vinall Russian wildrye	0.6	0.5	0.75	0.7	3	5		7
Bozoisky Russian wildrye	0.4	0.5	0.25	0.3	2	5		5
Yellow sweetclover								
Ladak alfalfa		0.5	0.1				6	
Nordan crested wheatgrass	0.8	1.0	0.75	1.0	2	5	6	7

[1] Plants/ft²
[2] rated on a 1-9 scale (1=best, 9= worst)

Good densities were achieved by several accessions at the Centennial Flat site. Most of these (Ephraim crested wheatgrass, Goldar bluebunch wheatgrass, Secar Snake River wheatgrass, Vinall Russian wildrye and Nordan crested wheatgrass) established well and maintained vigorous stands. Whitmar beardless wheatgrass had poor initial plant densities but increased over time to rival Nordan crested wheatgrass at the 2007 evaluation.

Jeff's Flat

The Jeff's Flat demonstration planting is located approximately 6 miles northwest of Challis (44.542114, -114.341991) at an elevation of 6,600 ft. The soils at the site are Nielsen-Gaciba association gravelly loam soils. Average annual precipitation ranges from 12 to 16 inches, supporting a bluebunch wheatgrass, Idaho fescue and mountain big sagebrush plant community.

The Jeff's Flat site could not be visited in 2013 due to wildfires. There were also no records of an evaluation for 1995 due to road maintenance issues.

Jeff's Flat demonstration planting area, 2007.

Jeff's Flat stand rating

	1989[1]	1992[1]	1999[1]	2003[2]	2007[2]
GP-52 Synthetic alfalfa	7	4	9	2.5	5
BC-79 Synthetic alfalfa	7	4	9	2.5	3
RS-1 bluebunch x quackgrass	8	5			
RS-2 bluebunch x quackgrass	8	6			
Fairway crested wheatgrass	1	2			
Delar small burnet					
Lutana cicer milkvetch	7	8	9		
Manchar smooth brome		8	1	50	25
Baylor smooth brome	7	6		50	10
Covar sheep fescue	5	2	1	45	75
Durar hard fescue	7	3	5	75	90
Bandera Rocky Mountain penstemon					
Cedar Palmer's penstemon					
Appar blue flax		5			
Whitmar beardless wheatgrass	3	3			
Paiute orchardgrass					
Ephraim crested wheatgrass	2	4	7	25	10
P-27 Siberian wheatgrass	1	3	9	40	20
Greenar intermediate wheatgrass	4	5	9	65	5
Sherman big bluegrass	5	6			
Magnar basin wildrye	5	8		5	5
Vinall Russian wildrye	2	3		3	8
Bozoisky Russian wildrye	3	3	5	5	8
Yellow sweetclover	2				5
Ladak alfalfa		4			
Nordan crested wheatgrass	3	3			

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

P-27 Siberian wheatgrass, Fairway crested wheatgrass, Ephraim crested wheatgrass, Vinall Russian wildrye and yellow sweetclover produced the best initial stands. Yellow sweetclover, a biennial, apparently disappeared for several seasons (very typical for the species) but had a modest stand in 2007. Over time the wheatgrasses and wildryes were surpassed by Covar sheep fescue and Durar hard fescue which had the top stand ratings in 2007. The adjacent plots of smooth brome appear to have been difficult to discern. In 1989, Manchar smooth brome was rated as having no established plants while Baylor smooth brome was rated as a 7. In the 1999 evaluation Manchar had obtained a 1 rating, while Baylor scored a 0. Separating the two cultivars from one another is nearly impossible and no conclusions of performance should be taken at an accession level, but as a generalization for the species.

Jeff's Flat plant density and spread	**Density**[1]				**Spread**[2]			
	1989	1999	2003	2007	1989	1999	2003	2007
GP-52 Synthetic alfalfa	0.1	1.0	1.0	0.1	7	4	7	N/A
BC-79 Synthetic alfalfa	0.1	1.0	1.0	0.1	7	4	7	N/A
RS-1 bluebunch x quackgrass								
RS-2 bluebunch x quackgrass								
Fairway crested wheatgrass	0.8				7			
Delar small burnet	0							
Lutana cicer milkvetch	0	1.0						
Manchar smooth brome	0	4.0	4.5	0.3		5	1	3
Baylor smooth brome	0.2		4.5	0.1	3		1	3
Covar sheep fescue	0.2	3.0	1.5	1.5		1	9	3
Durar hard fescue	0.2	1.0	3.0	2.0	3	7	7	1
Bandera Rocky Mountain penstemon								
Cedar Palmer's penstemon								
Appar blue flax								
Whitmar beardless wheatgrass	0.2				3			
Paiute orchardgrass								
Ephraim crested wheatgrass	1.5	1.0	0.5	0.1	2	2	0	N/A
P-27 Siberian wheatgrass	1.4	1.0	0.75	0.2	2	7	7	N/A
Greenar intermediate wheatgrass	0.2	1.0	4.0	0.1	3	9	1	3
Sherman big bluegrass	0.8				5			
Magnar basin wildrye	0.2		0.1	0.1	5		0	N/A
Vinall Russian wildrye	0.8		0.1	0.1	4		0	3
Bozoisky Russian wildrye	0.7	1.0	0.1	0.1	4	5	0	3
Yellow sweetclover	0.7			0.1	2			N/A
Ladak alfalfa								
Nordan crested wheatgrass	1.3				4			

[1] Plants/ft²
[2] rated on a 1-9 scale (1=best, 9= worst)

Jeff's Flat was one of a handful of high precipitation planting sites that favored the fine fescues over introduced wheatgrasses and wildryes. Covar sheep fescue and Durar hard fescue started with low plant densities but by the 2007 evaluation had densities of 1.5 and 2.0 plants/ft² respectively. Conversely Ephraim crested wheatgrass, P-27 Siberian wheatgrass, Vinall Russian wildrye and Bozoisky Russian wildrye all started with excellent initial establishment but reduced in density as the years progressed. Nordan crested wheatgrass was recorded in 1989 but did not

show up on future evaluation sheets, thus the blank cells for the 1999-2007 seasons do not necessarily indicate a lack of plants.

Higher precipitation at Jeff's Flat also facilitated spread by rhizomatous species. Both smooth brome accessions began with low plant densities but showed dramatic ability to spread by the 2003 evaluation. The fine fescues again appeared difficult to differentiate. The ability of Covar sheep fescue to spread was rated excellent in 1999 but no spread in 2003. Durar received a 7 for spread in 2003 and a 1 in 2007.

Bradbury Flat

The Bradbury Flat demonstration planting site is located 3 miles southeast of Challis (44.420310, -114.1530353). Pre-existing vegetation on the Bradbury site included Indian ricegrass, bottlebrush squirreltail, Nevada bluegrass, Sandberg bluegrass, needle-and-thread, shadscale, budsage, rubber rabbitbrush, Wyoming big sagebrush, winterfat, Nuttall's saltbush, and prickly pear cactus. The site receives 7 to 9 inches precipitation annually. The site sits at 5,400 ft elevation on the Whiteknob soil series consisting of deep, well drained soils formed in mixed alluvium.

Bradbury Flat demonstration planting site, 2007.

The Bradbury Flat demonstration planting trial incorporated a more complex experimental design than the other sites and is in essence two separate planting trials. The project design included a 1980 spring and fall (dormant) planting of selected plant materials. For the most part the accessions were the same in both seedings. Three seedbed preparation techniques were used: 1) disked to smooth the soil surface, 2) chiseled 4 to 6 inches deep and then disked, and, 3) chiseled 8 to 10 inches and then disked. The different techniques were conducted parallel to each other. Three rows, 45 feet long of each species were drilled perpendicular and across the seedbed preparation techniques. These treatments were not specified in evaluation sheets. No distinction is made in the results section on seedbed preparation methods, only species.

Little difference in establishment was recorded between spring and fall seeded plots. Crested and Siberian wheatgrasses established well from both seeding dates. Secar Snake River wheatgrass had a very good stand from the fall seeding and no recorded stand the first year in the spring seeding. However by 1992, the fall and spring seedings showed equally good stands. Both Russian wildrye accessions (planted only in the fall seeding) showed no stand during the 1989 evaluation, but developed into excellent stands over time.

Plant densities reflect the stand ratings. AB-447 crested wheatgrass (spring and fall seeded), spring seeded Secar Snake River wheatgrass, and fall seeded winterfat accessions had excellent densities over 1.0 plants/ft². At the time of the 2013 final evaluation the best densities were recorded for spring seeded Ephraim crested wheatgrass, spring seeded winterfat, spring seeded Sodar streambank wheatgrass and fall seeded Russian wildrye accessions.

Bradbury Flat stand rating	Fall Seeding							Spring Seeding					
	1989[1]	1992[1]	1995[1]	1999[1]	2003[2]	2013[2]		1989[1]	1992[1]	1995[1]	1999[1]	2003[2]	2013[2]
Ephraim crested wheatgrass	5	8	4	4	50		Ephraim crested wheatgrass	5	3	3	2	70	70
P-27 Siberian wheatgrass	4	8	5	4	60		P-27 Siberian wheatgrass	5	4	3	3	65	20
Sodar streambank wheatgrass		6	4	5	80		Sodar streambank wheatgrass	5	6	5	4	65	20
Nezpar Indian ricegrass	8	9					Nezpar Indian ricegrass		9	9			
Luna pubescent wheatgrass							Luna pubescent wheatgrass	7					
AB-447 crested wheatgrass	5	4	3	3	65		AB-447 crested wheatgrass	3	7	2	3	60	30
Goldar bluebunch wheatgrass							Goldar bluebunch wheatgrass	7	9		9		
Magnar basin wildrye							Magnar basin wildrye						
Topar pubescent wheatgrass							Topar pubescent wheatgrass	2					
Secar Snake River wheatgrass	3	2	4	4	50		Secar Snake River wheatgrass		2	3	3	60	
Appar blue flax							Appar blue flax						
Firecracker penstemon							Firecracker penstemon						
Bandera Rocky Mt. Penstemon							Bandera Rocky Mt. penstemon						
Palmer’s penstemon							Palmer’s penstemon						
Alpine penstemon							Alpine penstemon						
Hatch Winterfat	2	4	4	3	1	50	AB-555 aster						
AB-764 Winterfat	3	4	3	3	20	50	AB-677 aster						
Blackeyed susan							Hatch winterfat						50
AB-922 fourwing saltbush	6	5	5.5		3	2	764 winterfat						50
AB-942 fourwing saltbush	6	5	7		2	2	Blackeyed Susan						
Delar small burnet							AB-922 fourwing saltbush		7			50	
Immigrant forage kochia	5	3	5	7	3	5	AB-942 fourwing saltbush		9			50	
Bozoisky Russian wildrye		2	3	2	70	60	Delar small burnet						
Vinall Russian wildrye		3	3.5	3	70	30	Immigrant forage kochia					1	
Lodorm green needlegrass		8					Ladak alfalfa		4	8	7	1	
Blair smooth brome		8					Buckwheat						
Paiute orchardgrass							Arrowleaf balsamroot						

[1] rated on a 1-9 scale (1=best, 9= worst)

[2] rated as percent cover using line intercept method

Bradbury Flat plant density[1]	Fall Seeding						Spring Seeding				
	1989	1995	1999	2003	2013		1989	1995	1999	2003	2013
Ephraim crested wheatgrass	0.3	0.5	1.5	0.5		Ephraim crested wheatgrass	1.0	0.5	1.5	1.0	1.0
P-27 Siberian wheatgrass	0.3	0.3	1.5	0.75		P-27 Siberian wheatgrass	1.0	0.4	1.5	0.5	0.2
Sodar streambank wheatgrass		0.8	2.0	1.25		Sodar streambank wheatgrass		0.3	2.0	1.5	1.0
Nezpar Indian ricegrass						Nezpar Indian ricegrass		0.1			
Luna pubescent wheatgrass						Luna pubescent wheatgrass	1.0				
AB-447 crested wheatgrass	1.3	0.6	1.5	0.5		AB-447 crested wheatgrass	12.0	0.6	1.5	0.5	0.4
Goldar bluebunch wheatgrass						Goldar bluebunch wheatgrass	1.0		0.5		
Magnar basin wildrye						Magnar basin wildrye					
Topar pubescent wheatgrass						Topar pubescent wheatgrass					
Secar Snake River wheatgrass	0.6	0.5	1.0	0.25		Secar Snake River wheatgrass	4.0	0.5	0.5	0.25	
Appar blue flax						Appar blue flax					
Firecracker penstemon						Firecracker penstemon					
Bandera Rocky Mt. Penstemon						Bandera Rocky Mt. penstemon					
Palmer's penstemon						Palmer's penstemon					
Alpine penstemon						Alpine penstemon					
Hatch Winterfat	1.1	1.0	4.0	0.1	0.7	AB-555 aster					
AB-764 Winterfat	1.1	1.0	4.0	0.15	0.7	AB-677 aster					
Blackeyed susan						Hatch winterfat				0.5	0.7
AB-922 fourwing saltbush	0.2	0.3		0.1	0.1	764 winterfat				0.5	0.7
AB-942 fourwing saltbush	0.2	0.2		0.1	0.1	Blackeyed Susan					
Delar small burnet						922 fourwing saltbush				0.1	
Immigrant forage kochia	0.2	0.3	0.5	0.1	0.1	942 fourwing saltbush				0.1	
Bozoisky Russian wildrye		1.0	3.0	0.5	0.8	Delar small burnet					
Vinall Russian wildrye		1.7	3.0	0.7	0.8	Immigrant forage kochia					
Lodorm green needlegrass						Ladak alfalfa		0.1	0.5		
Blair smooth brome						Buckwheat					
Paiute orchardgrass						Arrowleaf balsamroot					

[1] Plants/ft^2

Bradbury Flat ability to spread[1]	Fall Seeding					Spring Seeding			
	1995	1999	2003	2013		1995	1999	2003	2013
Ephraim crested wheatgrass	4	3	5		Ephraim crested wheatgrass	4	3		2
P-27 Siberian wheatgrass	4	3	5		P-27 Siberian wheatgrass	3	3		2
Sodar streambank wheatgrass	3	2	1		Sodar streambank wheatgrass	3	2	1	9
Nezpar Indian ricegrass					Nezpar Indian ricegrass	7			
Luna pubescent wheatgrass					Luna pubescent wheatgrass				
AB-447 crested wheatgrass	5	3	5		AB-447 crested wheatgrass	3	3		2
Goldar bluebunch wheatgrass					Goldar bluebunch wheatgrass		9		
Magnar basin wildrye					Magnar basin wildrye				
Topar pubescent wheatgrass					Topar pubescent wheatgrass				
Secar Snake River wheatgrass	5	4			Secar Snake River wheatgrass	5	3		
Appar blue flax					Appar blue flax				
Firecracker penstemon					Firecracker penstemon				
Bandera Rocky Mt. Penstemon					Bandera Rocky Mt. penstemon				
Palmer’s penstemon					Palmer’s penstemon				
Alpine penstemon					Alpine penstemon				
Hatch Winterfat	7	7	0	2	AB-555 aster				
AB-764 Winterfat	7	7	9	2	AB-677 aster				
Blackeyed susan					Hatch winterfat			1	2
AB-922 fourwing saltbush	5		3	6	764 winterfat			1	2
AB-942 fourwing saltbush	6		0	6	Blackeyed Susan				
Delar small burnet					AB-922 fourwing saltbush			5	
Immigrant forage kochia	4	3		5	AB-942 fourwing saltbush			5	
Bozoisky Russian wildrye	4	4		2	Delar small burnet				
Vinall Russian wildrye	4	3		2	Immigrant forage kochia				
Lodorm green needlegrass					Ladak alfalfa	6	6		
Blair smooth brome					Buckwheat				
Paiute orchardgrass					Arrowleaf balsamroot				

[1] rated on a 1-9 scale (1=best, 9= worst)

Ability to spread was not rated during the 1989 or 1992 evaluations. In 2013, spring seeded Ephraim crested wheatgrass appeared to be spreading via seed into the adjacent plots and beyond. The 2003 evaluation of winterfat and fourwing saltbush are noteworthy in that the reviewer felt one accession of each was able to spread and the other wasn't. In 2013, the two accessions of each shrub were rated identically due to the inability to separate them. At that time, the winterfat had spread more than 30 feet from the original plots. The ability to spread ratings for the spring seeded plots were similar to the fall seeded plots. Crested wheatgrass, Siberian wheatgrass and winterfat all showed high rates of spread.

Gooseberry Creek or Sheep Creek

The Gooseberry Creek demonstration planting site is located approximately 15 miles southeast of Challis (44.281772, -113.970237) at 7,300 ft elevation on Zeelnot gravelly loam soil. The site receives 12 to 16 inches mean annual precipitation. The native plant community is dominated by mountain big sagebrush, Idaho fescue and bluebunch wheatgrass.

Gooseberry Creek stand rating

	1989[1]	1992[1]	2003[2]	2007[2]	2013[2]
Nordan crested wheatgrass	1	6	5	60	50
Bozoisky Russian wildrye	3	4	10	5	
Vinall Russian wildrye	5	6	10	3	
Magnar basin wildrye	9				
Sherman big bluegrass	1	3	95	95	50
Greenar intermediate wheatgrass	8	4	2	2	
P-27 Siberian wheatgrass	1	8	0.5		
Ephraim crested wheatgrass	8	7	3	2	
Paiute orchardgrass					
Appar blue flax	5				1
Cedar Palmer's penstemon	9				
Bandera Rocky Mt. penstemon	8	8			
Durar hard fescue	5	3	85	90	90
Covar sheep fescue	3	3	80	90	80
Manchar smooth brome	3	3	50	50	20
Baylor smooth brome	7	2	20	40	20
Lutana cicer milkvetch		7			
Delar small burnet					
Fairway crested wheatgrass	1	4	5		
RS-2 quackgrass x bluebunch	7				1
RS-1 quackgrass x bluebunch	5				5
BC-70 synthetic alfalfa	7	5			1
GP-52 synthetic alfalfa	5	3			1

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

The Gooseberry Creek site averaged slightly greater precipitation than some of the lower valley sites and thus had better initial establishment of a wide variety of accessions. Over time, the fine fescues, Sherman big bluegrass, and Nordan crested wheatgrass showed the best long term persistence. The fescues in adjacent plots had spread and likely intermingled. There is also an interesting increase in Nordan between 2003 (5%) and 2007 (60%).

Gooseberry Creek demonstration planting site, 2007.

Gooseberry Creek plant density and spread	Density[1]				Spread[2]			
	1989	2003	2007	2013	1989	2003	2007	2013
Nordan crested wheatgrass	3.0	0.1	0.6	0.4	5	0	NA	3
Bozoisky Russian wildrye	1.6	0.2	0.1		4	0	NA	
Vinall Russian wildrye	1.2	0.3	0.1		5	0	NA	
Magnar basin wildrye	0.1				9			
Sherman big bluegrass	1.5	1.5	3.0	0.5	5	3	NA	5
Greenar intermediate wheatgrass	0.5	0.5	0.1		5	5		
P-27 Siberian wheatgrass	1.8	0.01			9	0		
Ephraim crested wheatgrass	0.9	0.1	0.1		7	0	NA	
Paiute orchardgrass					0			
Appar blue flax	1.5				3	3		
Cedar Palmer's penstemon	0.1				9			
Bandera Rocky Mt. penstemon	0.2				9			
Durar hard fescue	0.6	2.0	3.0	1.5	7	5	3	2
Covar sheep fescue	1.3	2.0	3.0	1.0	4	5	3	2
Manchar smooth brome		0.5	0.5	0.5	3	2	3	1
Baylor smooth brome		2.5	0.3	0.5	7	3	3	1
Lutana cicer milkvetch								
Delar small burnet								
Fairway crested wheatgrass		0.1			7	0		
RS-2 quackgrass x bluebunch	0.1				7			0
RS-1 quackgrass x bluebunch	0.2			0.5	5			5
BC-70 synthetic alfalfa				0.1	7			3
GP-52 synthetic alfalfa	0.1			0.1	7			3

[1] Plants/ft²

[2] rated on a 1-9 scale (1=best, 9= worst)

Nordan crested wheatgrass had an excellent density early in the trial (3.0 plants/ft²) but thinned to 0.4 plants/ft² by 2013. Several other accessions also started well and declined or disappeared. Durar hard fescue and Covar sheep fescue maintained high stand densities and percent cover throughout the trial.

The enclosure and surrounding areas are dominated with a fine bunch fescue assumed to be either the native Idaho fescue or sheep fescue. In 2013, it was impossible to measure the spread of the fescue accessions because we could not tell from which direction the plants had come. Sherman big bluegrass had a good stand and had spread approximately 6 ft outside of the plot. Appar blue flax was not observed within its plot but volunteers could be found as much as 15 ft away from the original planting. Smooth brome had spread approximately 60 feet from the original plots into low lying areas.

Round Valley

The Round Valley demonstration planting site is located at an arid site which receives about 6 to 9 inches mean annual precipitation and supports a shadscale and sand dropseed plant community. The site is approximately 2 miles east of Challis (44.487872, -114.124357) at an elevation of 5,200 ft on Snowslide very gravelly loam soil.

Fifteen of 24 accessions were established at the time of the 1985 evaluation. In 2013, however, only 5 accessions, Immigrant forage kochia, P-27 Siberian wheatgrass, Nordan crested wheatgrass and both Russian wildrye accessions, had persisted. Much of the site at the time of the 2013 evaluation was dominated by P-27 Siberian wheatgrass. Presumably this was the result of a seeding outside of the Round Valley enclosure.

Round Valley demonstration planting site, 2007.

Round Valley stand rating							
	1985[1]	1992[1]	1995[1]	1999[1]	2003[2]	2007[2]	2013[2]
GP-52 Synthetic alfalfa	6	9					
BC-79 Synthetic alfalfa	3						
RS-1 bluebunch x quackgrass		9		9	1		
RS-2 bluebunch x quackgrass		8		8	1		
Fairway crested wheatgrass	7	9		9			
Immigrant forage kochia		7	7	7	2	1	1
Scarlet globemallow		9			1		
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax	2						
Paiute orchardgrass	9						
Ephraim crested wheatgrass	5	8	3	7	70	35	
P-27 Siberian wheatgrass	6	3	3	3	70	70	70
Goldar bluebunch wheatgrass	4		8				
Secar Snake River wheatgrass	3	5	7	8			
Barton western wheatgrass							
Topar pubescent wheatgrass	7						
Whitmar beardless wheatgrass	7						
Nezpar Indian ricegrass	8				1		
Magnar basin wildrye	7		7				
Vinall Russian wildrye		2	2	2	30	75	40
Bozoisky Russian wildrye	7	1	1	1	75	90	80
Yellow sweetclover							
Nordan crested wheatgrass	6	1	2	1	60	65	1

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

Plant densities in general decreased over time for all species and accessions with the exception of P-27 Siberian wheatgrass and the two Russian wildrye accessions which maintained at nearly 1 plant/ft² over the course of the study. Nordan crested wheatgrass interestingly peaked at 2 plants/ft² in 1999 then steadily declined to only 0.01 plants/ft² in 2013, likely being replaced by the more drought tolerant accessions of Siberian wheatgrass and Russian wildrye.

Round Valley. Original drill rows are clearly visible in some accessions.

Round Valley plant density[1]						
	1989	1995	1999	2003	2007	2013
GP-52 Synthetic alfalfa	0.1					
BC-79 Synthetic alfalfa	0.2					
RS-1 bluebunch x quackgrass	0.4		0.5	0.01		
RS-2 bluebunch x quackgrass			0.5	0.01		
Fairway crested wheatgrass			0.5			
Immigrant forage kochia		1.0	0.5	0.1	0.1	0.01
Scarlet globemallow				0.1		
Bandera Rocky Mt. penstemon						
Cedar Palmer's penstemon						
Appar blue flax						
Paiute orchardgrass						
Ephraim crested wheatgrass	0.7	0.75	0.5	1.0	0.5	
P-27 Siberian wheatgrass	0.7	1.0	1.5	1.0	0.75	0.7
Goldar bluebunch wheatgrass	0.3	0.25				
Secar Snake River wheatgrass	1.0	0.05	0.5			
Barton western wheatgrass						
Topar pubescent wheatgrass	1.2					
Whitmar beardless wheatgrass	0.8					
Nezpar Indian ricegrass						
Magnar basin wildrye		0.1				
Vinall Russian wildrye	0.1	0.8	1.0	0.5	1.0	0.5
Bozoisky Russian wildrye	0.6	1.25	3.0	1.5	1.5	1.0
Yellow sweetclover						
Nordan crested wheatgrass	1.0	0.9	2.0	1.0	0.6	0.01

[1] Plants/ft²

Due to the use of P-27 Siberian wheatgrass outside the enclosure it was difficult to measure the spread of P-27 Siberian wheatgrass from the original plots. After 30 years, the rows of Bozoisky Russian wildrye were still easy to locate and showed little encroachment from weeds. Russian wildrye had spread approximately 12 ft beyond the original plots by 2013. Immigrant forage kochia had spread approximately 7 ft beyond the original plots by the final evaluation despite very low density within the plots.

Round Valley ability to spread[1]						
	1989	1995	1999	2003	2007	2013
GP-52 Synthetic alfalfa						
BC-79 Synthetic alfalfa						
RS-1 bluebunch x quackgrass			9			
RS-2 bluebunch x quackgrass			8			
Fairway crested wheatgrass			8			
Immigrant forage kochia		5	5	3	3	3
Scarlet globemallow						
Bandera Rocky Mt. penstemon						
Cedar Palmer's penstemon						
Appar blue flax						
Paiute orchardgrass						
Ephraim crested wheatgrass		3	7		NA	
P-27 Siberian wheatgrass		3	2		NA	3
Goldar bluebunch wheatgrass		5				
Secar Snake River wheatgrass			9			
Barton western wheatgrass						
Topar pubescent wheatgrass						
Whitmar beardless wheatgrass						
Nezpar Indian ricegrass						
Magnar basin wildrye		7				
Vinall Russian wildrye		3	5		NA	4
Bozoisky Russian wildrye		3	7		NA	4
Yellow sweetclover						
Nordan crested wheatgrass		2	3		NA	

[1] rated on a 1-9 scale (1=best, 9= worst)

Conclusions

In general, introduced species such as crested wheatgrass, Siberian wheatgrass, Russian wildrye and forage kochia showed good to excellent establishment and persistence at sites with lower average precipitation (6-11 in). However at the Bradbury Flat site, native accessions Sodar streambank wheatgrass and two accessions of winterfat also performed well. The two higher precipitation sites (12-16 in), Jeff's Flat and Gooseberry Creek, favored long-term establishment of fine fescues over all other species. Crested wheatgrass, Russian wildrye and Whitmar beardless wheatgrass were the top long-term performers at Centennial Flat, which is intermediate in precipitation (8-12 in).

The ability of Russian wildrye plants to exclude new plants from establishing between the rows is worth noting. Russian wildrye has been found to be an effective species for green stripping (fuel breaks) due to its ability to remain green throughout a longer portion of the growing season than other species, and for its ability to halt the spread of invasive annual grasses that create flash-fuel for wildfires. This study has shown that Russian wildrye can maintain clean between-row spaces with little encroachment from high risk species for over 30 years.

Many species and accessions tested in the trial either failed to establish, or established but did not persist. The low precipitation sites were especially difficult. Forbs had poor establishment at most locations. At Centennial Flat the only forbs to establish and persist to 2013 were alfalfa, Lutana cicer milkvetch and scarlet globemallow. Alfalfa and yellow sweetclover established and persisted at low densities at Jeff's Flat until the 2007 evaluation. At Gooseberry Creek, Appar blue flax and both accessions of alfalfa had managed to maintain at very low levels (1% stand) in 2013. No forbs persisted at Round Valley or the Spud Alluvial site through 2013.

Based on these findings, introduced species are safe recommendations for range seedings in the Challis, Idaho area on sites receiving less than 12 inches mean annual precipitation. There is however some risk of introduced species spreading under exceptional precipitation periods. On low precipitation sites where native plant communities are desirable, streambank wheatgrass and winterfat are viable options. On higher precipitation sites, many additional native species should be considered.

Rangeland grasses are susceptible to reduction in plant vigor due to old plant residue (litter) buildup in the crowns in the absence of grazing or other disturbance. Without periodic mechanical harvest or proper grazing management, plant litter increases over time and shades the photosynthetically active plant material, reducing ability of the plant to capture sunlight necessary for growth. Stands should be periodically grazed, mowed, burned or otherwise managed to break down old plant residue or litter to help maintain plant health. See Idaho Plant Materials Technical Notes 10 and 11 for more information on range management.

Several new plant cultivars (varieties) that have potential for use in the Challis region have been released since the beginning of this trial. Bozoisky II Russian wildrye was selected for improved seedling vigor (emergence from deeper planting depth), seed yield, vegetative vigor, total dry matter production, and response to drought. Bozoisky II Russian wildrye also has a much broader genetic base than other Russian wildrye cultivars and was extensively evaluated on rangeland sites in the western United States. Vavilov Siberian wheatgrass was released for its significantly improved seedling vigor compared to P-27; and Vavilov II Siberian wheatgrass' improved ability to resist wear and trampling. Because Vavilov and Vavilov II Siberian wheatgrass are tremendous improvements in seedling vigor and trampling resistance, P-27 Siberian wheatgrass was discontinued in 2010. Anatone bluebunch wheatgrass, a recent release of bluebunch wheatgrass has improved seedling vigor allowing it to establish at lower precipitation areas than Goldar bluebunch wheatgrass or Whitmar beardless wheatgrass. Additional new and improved plant releases that should be considered for use in the Challis area include Bannock thickspike wheatgrass, High Plains Sandberg bluegrass, Discovery Snake River wheatgrass, and selections of bottlebrush squirreltail.

Seeding Rate Evaluation for Low Precipitation Sites

Study Number: IDPMC-T-1401
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Plant Materials Center
Aberdeen, Idaho

In extreme arid sites, standard seeding rates produce satisfactory stand densities only in exceptional water years. Anecdotal evidence suggests initial stands in average or below average moisture conditions may be improved with increased seeding rates. The aim of this study is to evaluate establishment and long-term stand densities using the standard seeding rate and a 2X rate.

The Skull Valley Off-Center Test Site (approximately 1.5 acres) is located about 1 mile east of the Ensign North Ranch headquarters in the foothills of the Stansbury Mountains. The soil at the test site is Hiko Peak gravelly, loam soil series and historically supported a Wyoming big sage/bluebunch wheatgrass plant community. The typical soil profile is a very deep (>60 inch), well-drained gravelly loam. The site receives an average of 8 to 10 inches of precipitation annually. Elevation at the site is approximately 4600 feet.

Materials and Methods

The seedbed was prepared with chemical treatments of 16 oz. 2, 4-D and 64 oz. glyphosate per acre applied on May 26, 2011; November 3, 2011; May 9, 2012; and April 19, 2013. No additional seed bed preparation was conducted. The trial was planted no-till fashion on November 20, 2013 with a modified Tye Drill with a width of 80 inches (8 spouts at 10" spacing).

Eleven species were selected for the trial based on potential adaptation to the local site conditions. The trial included native and introduced grasses, as well as the native desert shrub, fourwing saltbush. Species and varieties are listed in table 1.

Table 1. Species and seeding data.

Species	Variety	Seed rate (Lb/ac)
Bluebunch wheatgrass	Anatone	8
Streambank wheatgrass	Sodar	8
Thickspike wheatgrass	Bannock	8
Snake River wheatgrass	E-64	8
Big bluegrass	Sherman	2
Bottlebrush squirreltail	Rattlesnake	6
Indian ricegrass	Nezpar	8
Crested wheatgrass	Hycrest II	5
Russian wildrye	Bozoisky II	6
Siberian wheatgrass	Vavilov II	6
Fourwing saltbush	Snake River Plains	0.25

Seeding depths were based on recommendations found in Ogle et al. (2007). Species were seeded at a target rate of 20 to 30 pure live seeds (PLS) per ft² for large seeded species (<500,000

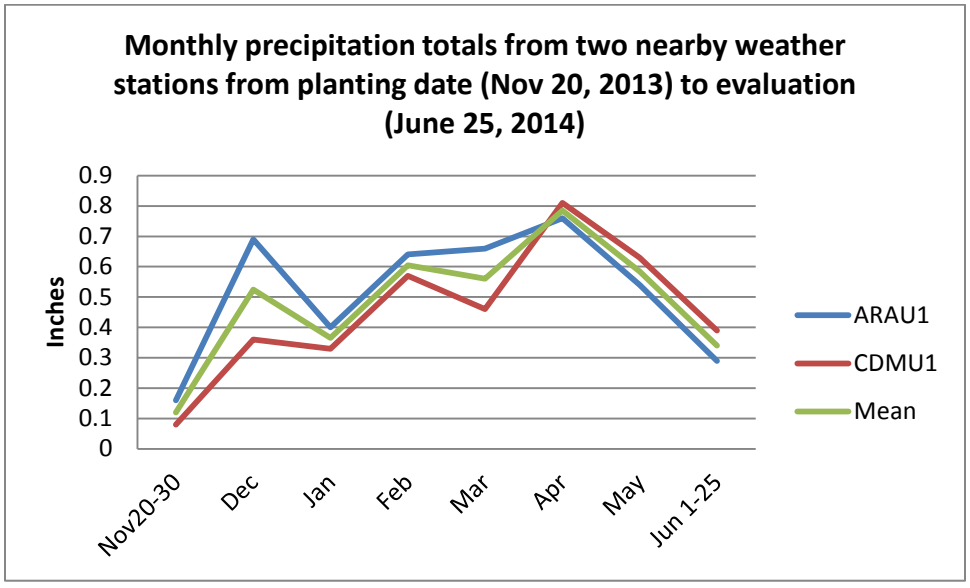
seeds per pound) and 40 to 50 PLS/ft² for smaller seeded species (>500,000 seeds/lb). All seed was mixed with rice hulls as an inert carrier to ensure better seed flow according to St. John et al (2005).

The design consisted of single plots, one drill width (7 ft) wide and 130 ft long. Standard rate and 2x rate plots for each species were laid adjacent to one another for easy visual comparisons. The plots were evaluated for initial establishment on June 25, 2014 using a frequency grid as described by Vogel and Masters (2001). The grid measured approximately 40 x 41 inches, having four 10-inch columns (to incorporate 1 drill row per column) and five rows, totaling 20 cells. The grid was placed ten times within the plot giving a total of 200 evaluated cells. Counts were made of the cells that contained at least one plant. An estimated number of plants/m² was determined for each grid placement, and the ten grids per plot were used as quasi-replications and averaged.

Data were analyzed using the Statistix 8 Analytical software and subjected to an analysis of variance with a significance level of $p<0.05$. If significance was detected, means were separated using a Least Significant Difference test for pairwise comparisons.

Weather

The two closest weather stations to the Skull Valley site are the Aragonite (ARAU1) and Cedar Mountain (CDMU1) stations. Aragonite is located 16 miles WNW of the site at 40.5983, -113.0217 degrees and 5,030' elevation. The Cedar Mountain station is approximately 15 miles S of the site at 40.3008, -112.7767 and 4,650' elevation. Because of the differences in precipitation observed between the two stations, monthly precipitation totals were taken from both sites. All weather data were obtained from MesoWest (2014).



Results and Discussion

Snake River Plains fourwing saltbush failed to establish. All other species established to at least a minimal degree (Table 2). Two species, thickspike wheatgrass and Siberian wheatgrass, had

greater establishment densities from the 1x rate than the 2x rate, though differences were not statistically significant. Of the remaining eight species, seven showed improved establishment with the 2x seed rate; however, a statistically significant difference was only observed with streambank wheatgrass where the 2x rate of streambank wheatgrass resulted in nearly three times greater plant density than the standard rate.

Table 2.			
	1X	2X	
	--------Plants/m^2--------		p
Russian wildrye	14.6	15.9	0.46
Crested wheatgrass	9.6	12.4	0.10
Thickspike wheatgrass	9.4	8.9	0.85
Snake River wheatgrass	8.7	9.9	0.46
Siberian wheatgrass	7.5	6.3	0.54
Bluebunch wheatgrass	7.4	8.6	0.51
Streambank wheatgrass	3.7	9.9	0.004
Bottlebrush squirreltail	3.3	5.8	0.07
Indian ricegrass	0.7	0.8	0.80
Big bluegrass	0.1	0.2	0.59
Fourwing saltbush	0	0	NA

Recurring rains in the spring of the establishment year benefitted plant germination and growth early in the season. However, at the time of the evaluation, significant damage from grasshoppers was visible. These early data indicate that doubling the seeding rate does not consistently result in significantly greater establishment. Therefore the additional cost for the extra seed may not be justified by the results. Plots will be evaluated again in 2015 to observe long term persistence and changes in plant densities over time.

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United States Department of Agriculture

NRCS Natural Resources Conservation Service

2013
Aberdeen Plant Materials Center
Progress Report of Activities
January 2014

P.O. Box 296, Aberdeen, ID 83210, Tel: 208-397-4133, Fax: 208-397-3104, Web site: Plant-Materials.nrcs.usda.gov

Aberdeen Plant Materials Center Home Farm

Who We Are

The mission of the USDA NRCS Plant Materials Program is to develop and transfer effective state-of-the art plant science technology to meet customer and resource needs. The Aberdeen Plant Materials Center (PMC) was established in 1939 to evaluate and select plant materials and techniques for establishment and management of plants for use in resource conservation activities in the Western United States.

There are 27 PMCs nationwide, each serving a specific geographic and ecological area. The Aberdeen PMC serves portions of the Intermountain West including southern Idaho, western Utah, northern Nevada, western Wyoming and eastern Oregon.

Program Emphasis

The activities of the Aberdeen PMC are guided by a Long-Range Plan (2011-2020). The priority work areas are:

- Range and forest lands in poor ecological condition
- Wildlife habitat in poor ecological condition
- Riparian and wetland degradation
- Plant releases, seed and plant production
- Technology transfer and education

This report highlights many of the major activities at the PMC during 2013. For more detailed information, contact the PMC.

Technology Development

Pollinator Plantings

Commercially produced wildflower seed mixes are commonly available, and broadly used for attracting pollinators and adding beauty to small gardens and landscapes. These mixtures are popular with landowners because they are pre-mixed and eliminate the guess work of designing custom mixtures. They also eliminate the need to search for and purchase individual species from multiple vendors to create a seed mix.

One of the wildflower mixes planted in 2013. Several native and introduced species can be seen.

Despite these advantages, suitability of many of the species in the mixes to pollinator plantings for CRP or other NRCS programs is largely unknown. Many species are from North America outside of the Intermountain West; still others are of Eurasian or African origin. These mixtures may contain plant species that can become invasive or the mix may contain plant species that are attractive to humans but provide little forage to pollinators.

We planted six commercially available wildflower seed mixes designed for use in western North America into non-replicated plots to determine which species are well adapted to conditions in the PMC service area and contribute to

pollinator foraging. The plots established well and initial evaluations have been conducted.

In 2011, the PMC established 5 acres of pollinator habitat at the Fish and Game farm for display and to research management requirements involved in pollinator friendly plantings. We observed fair establishment of most of the forb species planted, but there was also significant weed pressure. In 2012 the field provided excellent pollinator forage with all planted species present. In 2013 the planting showed an increase in the presence of invasive weeds. The lack of herbicides available for use in pollinator plantings to control broadleaf weeds is a major concern. The planting will be evaluated again next season to follow trends in species composition.

Blue flax, sainfoin, yarrow and small burnet can be seen in this photo of the PMC pollinator planting in 2012.

Prickly lettuce dominates the pollinator planting in mid-summer, 2013.

Willow Cutting Storage

In 2012 The PMC started a study evaluating storage longevity of native willows to determine the maximum length of storage time before cutting survival and growth start to decline. We also looked at ways to extend cutting viability by decreasing moisture loss in the cuttings during storage. Our results indicate that cuttings stored under refrigerated conditions will retain good vigor for at least four months. Increasing humidity and maintaining cutting moisture levels by bagging the cuttings in plastic extends vigor with no loss of survival for up to 6 months. Bagging the cuttings also appears to stimulate root and shoot growth compared to non-bagged and fresh cuttings.

Soil Health

The PMC is working closely with Marlon Winger, Idaho State Agronomist, to evaluate cover crop species suitable for use in Idaho farming systems. Cover crops can prevent wind erosion and help improve soil health. In 2013 the PMC installed a multi-species trial to generate data for updating WEPS (Wind Erosion Prediction System). Current data in WEPS uses small grains as the standard for cover crops, but our trial indicates that alternate species and cocktail mixtures provide significantly greater cover values and increased soil protection.

A "cocktail" (multi-species) cover crop mixture of mustards, legumes and small grains provides excellent cover and soil protection and promotes increased soil health.

Breeder, Foundation, and Cooperative Seed Production

The Aberdeen PMC produces the highest quality conservation seed available, and is responsible for the production of Breeder and Foundation seed of 18 plant releases. In 2013 the PMC had seed production fields of Anatone Select and 'Goldar' bluebunch wheatgrass, 'Regar' meadow brome, 'Appar' blue flax, 'Vavilov II' Siberian wheatgrass, and Maple Grove Lewis flax. The PMC shipped 7,870 pounds of seed to commercial seed growers in 2013. Seed growers should contact the University of Idaho Foundation Seed program or the Utah Crop Improvement Association to request Foundation or early generation Certified seed.

The PMC has been working with Yellowstone National Park since 2009 to produce seed for restoration in the Park. In 2013 we produced seed of Sandberg bluegrass and bluebunch wheatgrass. The grasses are being used to restore lands within the Park that had previously been in production agriculture many years ago.

The PMC is similarly working with Grand Teton National Park to increase seed of source collections from the Park to be used for restoration projects. The PMC is currently growing Idaho fescue for the Park for restoring lands that were previously in production agriculture.

In 2011 the PMC entered into an agreement with the Idaho Army National Guard to produce globemallow seed for revegetating army training grounds in southern Idaho. Five hundred feet of weed barrier fabric was seeded in the fall of 2011 and spring 2012. Seed harvests have taken place in 2012 and 2013.

Globemallow plants grown in weed barrier fabric for the Idaho Army National Guard.

Plant Testing

Native Forbs

The PMC is increasing early generation seed of three native forb species; hoary tansyaster (*Machaeranthera canescens*), Douglas' dustymaiden (*Chaenactis douglasii*) and Wyeth buckwheat (*Eriogonum heracleoides*). All of these forbs will be useful in sage grouse and pollinator plantings as well as rangeland restoration plantings. Once enough seed is produced, these accessions will be named and officially released for commercial seed production. Hoary tansyaster is scheduled for release later this year. Seed should hopefully be commercially available within 2 to 3 years.

The PMC borrowed a flail-vac seed harvester from the Forest Service Lucky Peak Nursery in 2013 to test its performance in harvesting hoary tansyaster. We were very impressed with its ability to harvest the seed. Special thanks go to the Lucky Peak Nursery folks for lending the machine to us for the 2013 seed harvest!

Harvesting hoary tansyaster with a Flail Vac. Once released, this seed will be allocated to commercial seed growers for production and sale.

In the spring of 2010, the PMC installed a common garden study of Nevada bluegrass with an assembly of 34 accessions from Idaho, Utah, Montana and Nevada. The study resulted in a promising accession of Nevada bluegrass which compares favorably to 'Opportunity' Nevada bluegrass. In 2013, we planted this accession in an advanced evaluation planting with Opportunity to gather additional detailed information on seed and production attributes.

Maple Grove Lewis flax. 37 accessions of Lewis flax are being evaluated to identify populations with better vigor and seed production traits.

The PMC initiated a cooperative project with the USDA-ARS Forage and Range Lab, the USDA Rocky Mountain Research Station (RMRS) Shrub Science Lab and the Utah Division of Wildlife Resources (UTDWR), with the goal of identifying an accession of Lewis flax with improved seedling vigor and seed production capabilities that may perform better than Maple Grove Selected Class Germplasm. Thirty-seven accessions were collected and propagated in the PMC greenhouse and transplanted to common garden plantings at Logan and Fountain Green,

Utah for evaluation. Establishment was excellent and evaluations are underway by ARS, RMRS and UTDWR personnel.

Forage kochia

Rangeland wildfires are an ever growing problem in the Intermountain West. The PMC recently installed a study to demonstrate and evaluate accessions of forage kochia (*Bassia prostrata*) in an alternate row seeding with Hycrest II crested wheatgrass in a simulated green stripping or fire break planting. 'Snowstorm' forage kochia was released in 2012 by the USDA Agricultural Research Service in Logan, Utah based on improved stature (taller), productivity, and nutritional content compared to 'Immigrant'. Five accessions including Snowstorm and Immigrant were planted in replicated plots in May, 2012 at the PMC Fish and Game Farm. Evaluations are being made measuring plant vigor, density and height.

'Snowstorm' forage kochia.

Off-Center Testing

In November, 2010 the PMC planted a new off-center trial on the Curlew National Grassland in Southeastern Idaho in cooperation with the USDA Forest Service. The trial includes 63 accessions of native and introduced grasses, forbs, and shrubs adapted to the 12 to 16 inch precipitation zone in Southern Idaho and Northern Utah. Above average precipitation in 2011 resulted in excellent initial establishment of most species in the planting, but the dry 2012 growing season was a struggle for some plants. This site is a valuable resource for Conservation District cooperators, NRCS field staff, Forest Service, BLM and other land managers to get a firsthand look at the plant releases available for conservation seedings on the eastern Idaho Plateaus. Contact the PMC for further information.

Fish Creek bottlebrush squirreltail at the Curlew Off-Center Test site.

In the fall of 2013 the PMC planted a seeding rate study at an off-center site at Skull Valley, Utah. The trial will evaluate the use of higher seeding rates in extreme arid (less than 8" precipitation) conditions. Twelve native and introduced species were planted at the standard rate and a 2X rate in a side-by-side comparison. Evaluations will begin in 2014.

Technology Transfer - New Publications

A number of new or revised publications were completed during the past year – a few are mentioned below:

Technical Notes

- Technical Note 2C. Plant Materials for Pollinators and other Beneficial Insects in Eastern Utah and Western Colorado
- Technical Note 52. Threatened, Endangered and Candidate Plant Species of Utah
- Technical Note 51. Threatened, Endangered and Candidate Plant Species of Idaho

Plant Guides

New or revised Plant Guides were completed in 2013 for the following: Columbia needlegrass, bigflower Agoseris, Las Vegas buckwheat, mountain goldenbanner, western aster, showy goldeneye, limestone hawksbeard, Siberian wheatgrass, small burnet, Indian ricegrass, Palmer's penstemon, thickleaf penstemon, Rydberg's penstemon, thickspike wheatgrass and streambank wheatgrass.

Website

All Aberdeen PMC publications can be downloaded from the following web-sites:

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

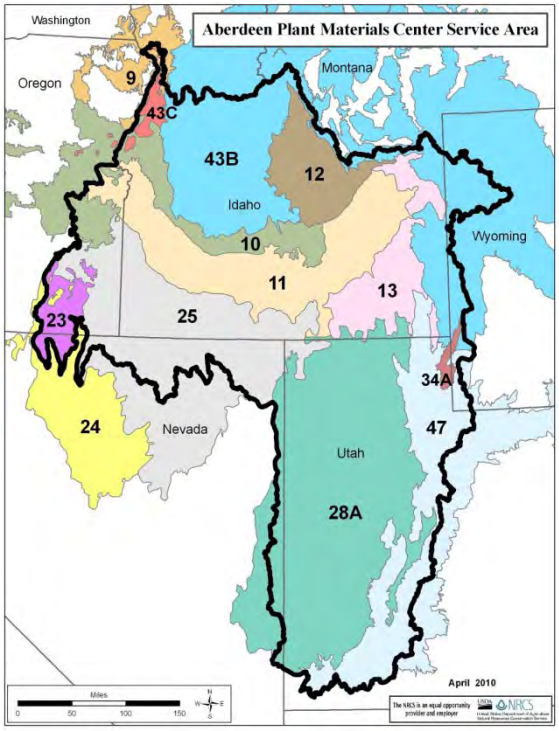
USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

ABERDEEN PLANT MATERIALS CENTER

INTERMOUNTAIN PLANT NOTES

A newsletter to inform you about activities at the Aberdeen Plant Materials Center

The Aberdeen Plant Materials Center (PMC) was established in 1939 to develop plant materials and techniques for establishment and management of plants for use in resource conservation activities in the Western United States. There are 27 Plant Materials Centers nationwide, each serving specific geographic and ecological areas. The Aberdeen PMC service area covers 83 million acres of the Intermountain West encompassing southern Idaho, western Utah and parts of northern Nevada, western Wyoming and eastern Oregon.



PMC service area map with overlay of Major Land Resource Areas (MLRAs).

In March, the NRCS National Plant Materials Program announced a new Plant Materials Center Improvement Effort. It was determined that in order to address budget challenges, PMC operations would be stratified into different tiers for contributing to agency priorities. Nine PMCs, including Aberdeen, will be designated Tier A centers with a staff of 4-5 Full Time Employees (FTEs). The remaining PMCs will be Tier B PMCs with 2-3 FTEs.

PMCs have also been assigned areas of focus to insure that the limited staff and resources are utilized to their fullest efficacy. Aberdeen's primary focus will be improving habitat for at-risk wildlife species such as sage-grouse. The second study area will be grazing land health to improve range and pasture productivity and increase plant species diversity.

We look forward to implementing the new Improvement Effort and continuing our efforts to conserve the natural resources in the Intermountain West.

Foundation/Early Generation Certified Seed Production

A major responsibility of the PMC is the production of Foundation and early generation Certified Seed of the plant releases made by the Center. The releases currently in production are: Anatone and 'Goldar' bluebunch wheatgrass, 'Regar' meadow brome, 'Appar' blue flax, Maple Grove Lewis flax, 'Vavilov II' Siberian wheatgrass, Richfield select firecracker penstemon, 'Delar' small burnet and 'Bannock' thickspike wheatgrass. Seed growers may contact the University of Idaho Foundation Seed Program or the Utah Crop Improvement Association to request Foundation or early generation Certified seed.

Display Plantings

Pollinator Display

In May of 2011, the PMC planted 5 acres of pollinator habitat at the PMC Fish and Game Farm. The planting contains a mixture of forbs chosen to provide a variety of flower shapes and colors throughout the growing season. The whole planting is irrigated to simulate a 14 to 16 inch

precipitation area. The display is being evaluated to develop management strategies for use in pollinator and wildlife friendly plantings. It is also a good visual tool for NRCS field office staff and other land managers.

Curlew National Grassland

In the fall of 2010, PMC staff planted a multi-species off-center evaluation on the USDA-Forest Service, Curlew National Grassland located 30 miles south of American Falls, Idaho in cooperation with the Caribou/Targhee National Forest. The trial includes over 60 accessions of primarily native grasses, forbs and shrubs adapted for use in MLRA 13 Eastern Idaho Plateaus (13 to 18 inch plus precipitation areas). The PMC is evaluating the plots for establishment and performance. For more information or to arrange a site visit, contact the PMC.

Plant Selection and Development

The PMC is in the early stages of seed production prior to the official release of Douglas' dustymaiden, hoary tansyaster and whorled buckwheat. The initial evaluations for these species were completed in 2010 and the best rated accessions were identified for seed increase and release. These native forbs are important food sources for pollinators and will benefit sage-grouse habitat restoration. These accessions will be officially released to growers when the PMC has bulked up enough seed to satisfy expected demands.

Soil Health

Soil Health and Cover Crop Tour

On June 12, we will be hosting a soil health and cover crop tour. Marlon Winger, NRCS Idaho State Agronomist will be speaking and showing demonstrations on how to improve soil health in conjunction with Idaho agriculture. In the afternoon we will be touring the new cover crop display planting to get a look at the many available species that can be used in our area. Presentations start at 9:00 am at the PMC office. Call Derek Tilley at 397-4133 for more information.

Cover Crop Display

In late April the PMC planted a cover crop display at the Home Farm that includes 40 species. The new display is arranged into blocks of cool season grasses, cool season broadleaf plants, legumes, warm season broadleaf plants and warm season grasses. When developing a cover crop seeding mixture, it is important to include as many functional groups as possible to increase diversity and fill above and below ground niches to support the greatest species richness of microorganisms. Contact the PMC for a map or to arrange a visit. We also plan to install an additional display of the same species this summer to observe how they overwinter.

Cover Crops for Wind Erosion Protection

Wind erosion is a major problem throughout the Aberdeen PMC service area. Wind erosion removes the most fertile part of the soil (organic matter, clay, and silt) and lowers soil productivity. Cover crops and crop residues reduce wind erosion by reducing the wind velocity at the soil surface and by increasing the size of soil aggregates. Last August, we installed a trial to evaluate the cover value of several cover crop species. Nine individual species were planted along with a cocktail mix composed of the same nine species.

Each of the functional groups examined filled a specific niche in providing soil protection. Mustards provided early dense cover in the fall and developed a protective coating of leaf tissue in the spring. Small grains like wheat and oat, with their vertical stature, added moderate amounts of cover but also added height in the fall and spring to reduce surface wind speed. Legumes, while limited in their fall cover value, added soil nitrogen for growth. Over wintering legumes such as hairy vetch also provided spring cover and a living root system which feeds the soil micro-fauna. The cocktail mix did not provide the best ranking of any of the three evaluated characters, but did offer a combination of traits not available from a single species.

Cocktail mix 30 days after planting.

Legume Winter Kill Evaluation

Cover crops have been shown to mediate soil erosion, increase water infiltration, improve soil biodiversity, and increase organic matter. Additionally, legumes in a symbiotic relationship with Rhizobium bacteria have the further benefit of fixing soil nitrogen into a form useable by other plants. To better ascertain which legume cover crops naturally winter kill and which overwinter and require termination in our region, the Aberdeen PMC installed a multi-species trial of several legumes suggested for use in Idaho. Nine commonly used legume cover crop species were planted last August including chickling vetch, sun hemp, chickpea, berseem clover, spring pea, cowpea, lentil crimson clover and hairy vetch.

All species with the exception of chickpea and berseem clover established good stands. At 70 days after planting (October 16) the sun hemp had already died from early frosts. On March 24, the following spring, only hairy vetch and crimson clover were still alive. Hairy vetch produced 3300 lbs/ac of above ground biomass and crimson clover produced 1500 lbs/ac of biomass.

Crimson clover plants showing frost damage in early March. By the end of the month, these plants had mostly recovered and were actively producing nitrogen.

Radish Bolting

One of the workhorse species for cover crop plantings is radish. Radishes provide excellent cover and produce a large taproot capable of penetrating hard soil pans. Typical plantings in August produce good above ground growth and root development before going dormant in the fall; however if planted too early in the season, the radish will simply bolt and put out flowers instead of developing a robust plant. This year we are evaluating five radish varieties to determine which may be amenable to earlier planting dates for use in full-season cover crop seedings. Small plots of each variety are being seeded each month and evaluated for root growth, above ground biomass and date of flowering.

This radish was planted late in the season and did not flower before the first frost.

Technology Development

Seeding rate studies

There is some old wisdom that says in lower precipitation areas you should plant fewer seeds than the standard rate. The reason being that there is less moisture to go around and every rain drop or snowflake should be allocated to fewer competitors. The other side to this debate says higher seeding rates means more chances for establishment and if a plant doesn't establish then competition really doesn't matter. To test these ideas we installed a seeding rate study at Skull Valley, Utah in a 6 to 8 inch precipitation area. The site was planted last year to 12 species at 1X and 2X the standard drill rates. A twin trial will be planted at Coffee Point northwest of Aberdeen this fall. We will be monitoring these plantings for the next few years to evaluate establishment and persistence and hopefully come to some conclusion regarding seeding rates for low precipitation areas.

Cooperative Seed and Plant Production Projects

IDARNG Globemallow

In 2011 the PMC installed a planting of

globemallow to produce seed for the Idaho Army National Guard for revegetating their rangeland training areas. Seed was harvested in 2012 and 2013 and will be harvested one last time this year.

Globemallow grown in weed barrier fabric.

Yellowstone and Grand Teton National Parks

The PMC is producing seed for the conversion of historical agricultural lands in Yellowstone National Park back to native rangeland. Seed production fields of Sandberg bluegrass, bluebunch wheatgrass and needle-and-thread were planted in 2009 and harvested for seed in 2010 -2012. New fields for bluebunch wheatgrass and Sandberg bluegrass were planted in 2013 and will be harvested this year. The PMC is also currently producing Idaho fescue seed for use in restoration projects in Grand Teton National Park. The PMC has worked with Grand Teton NP since 2006 to produce slender wheatgrass, Sandberg bluegrass, blue wildrye and mountain brome seed.

Public Information Activities

New, Revised or Updated PM Technical Notes

- TN-62 Challis, Idaho Demonstration Plantings Summary
- TN-63 Evaluation of Perennial Grasses Used in Cross Wind Trap Strips in Eastern Idaho
- TN-57 cutting Storage (update)
- Planning and Implementing a Seeding in Sage-Grouse Country (in review)
- What to do with Pivot Corners (in review)

Plant Guides

- Rydberg's Penstemon
- Thickleaf Penstemon
- Palmer's Penstemon
- Rocky Mountain Penstemon
- Plains Pricklypear Cactus
- Purple Three-awn
- Leafy Spurge
- Shadscale Saltbush
- Meadow Deathcamas
- Dahurian Wildrye

Presentations

- Fundamentals of Rangeland Seeding: Emphasis on Sage-Grouse Habitat & Sagebrush Ecosystems
- Developing Seed Mixes for Sage-Grouse Habitat Restoration
- Great Basin Native Plant Project
- Idaho Rare Plant Conference

Plant Materials Team and Contact Information

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TECHNICAL NOTE

USDA - Natural Resources Conservation Service
Boise, Idaho

TN Plant Materials NO. 57 **January 2014**
Revision

EFFECTS OF LONG-TERM REFRIGERATED STORAGE ON HARDWOOD WILLOW CUTTINGS

Derek Tilley, Agronomist, NRCS, Aberdeen, Idaho
Loren St. John, PMC Team Leader, NRCS, Aberdeen, Idaho

This technical note describes performance of dormant hardwood cutting of two native willow species under varying lengths of storage in dark refrigerated conditions. It also compares survival and growth with decreased moisture loss through the use of polyethylene bags. Non-bagged cuttings stored under refrigerated conditions retained good vigor for at least four months. Increasing humidity and maintaining cutting moisture levels by bagging the cuttings in polyethylene extended vigor with no loss of survival for up to 6 months. Bagging the cuttings also appears to stimulate root and shoot growth.

Effects of long-term refrigerated storage and bagging in polyethylene on hardwood willow cuttings

Study Number: IDPMC-T-1201-RI
Derek J. Tilley, PMC Agronomist
Loren St. John, PMC Team Leader
Natural Resources Conservation Service
Plant Materials Center
Aberdeen, Idaho

Planting healthy, vigorous cuttings is essential to successful establishment of riparian willow plantings for streambank erosion practices. Vigor of cuttings during the initial planting phase is critical to establishment and long-term survival of the cutting. Cuttings are often harvested dormant in late winter prior to the scheduled planting, but schedules frequently become preempted by unforeseen circumstances. Installation is then forced to wait until the completion of groundwork, construction, etc, or until conditions become favorable, or when funding for the planting is approved. Willow cuttings are commonly kept in long-term storage for weeks to months after their scheduled installation date, which raises the question, "how long can cuttings be kept in storage and still retain enough vigor to be successfully used in riparian restoration projects?"

Cutting survival under storage conditions is dependent on water loss and the prevention of infection (Behrens, 1988). Unfavorable conditions can 1) kill cuttings, or 2) reduce rooting potential (Behrens, 1988). Best storage conditions for dormant cuttings are those that cause no water stress and prevent the spread of fungal pathogens. The best means to achieve this is to lower the temperature and increase humidity (Behrens, 1988; Davis and Potter, 1985). If possible, relative humidity should be kept near 100% (Behrens, 1988; Scianna et al., 2005). An optimum temperature for cutting storage is approximately -4° C (24° F) (Behrens, 1988; Cram and Lindquist, 1982).

The majority of cutting storage research involves small diameter cuttings used for nursery stock production. Meeting ideal storage conditions is more feasible with small nursery cuttings than for larger cuttings (poles or posts) intended for riparian bioengineering projects. Many riparian restoration projects are limited in resources and cutting storage locations may include basements, root cellars, walk-in refrigerators or in plastic bags stored outside during winter months.

Storage of dormant, leafless hardwood cuttings during winter months is not problematic and is a well-established practice without any major problems (Behrens, 1988). Cuttings should maintain vigor in freezing conditions outside fairly well if protected from disease, wind, sunshine, or insects. Heeling-in cuttings as well as fall dormant planting have also proven successful as means of storage and establishment (Cram and Lindquist, 1982; Tilley and Hoag, 2009).

However, long term storage effects on hardwood cuttings for restoration in less than ideal conditions are less well understood. Problems arise when storage becomes prolonged and conditions need to be maintained artificially. This study conducted by the Aberdeen Plant Materials Center addresses long term refrigerated storage on larger diameter cuttings of two

willow species commonly used for riparian restoration projects in the Great Basin Region. It also compares the effects of storage in polyethylene versus cuttings stored in open conditions.

Materials and Methods

The test occurred over two seasons. During the first season we tested cuttings stored exposed (not bagged in polyethylene, hereafter referred to as the non-poly treatment) in a dark walk-in cooler. During the second season the cuttings were kept in large black polyethylene bags (hereafter poly treatment) tied shut to retain moisture. Dormant hardwood cuttings for the non-poly treatment were harvested on November 29-30, 2011. Cuttings used in the poly treatment were collected on November 26-28, 2012. Yellow willow (*Salix lutea*) was collected from a native stand at Quaking Aspen Spring at an elevation of 1,585 m (5200 ft) (42.2309642, -112.7885628). Coyote willow (*S. exigua*) was collected from a native stand on the Curlew National Grassland on Hwy 37, approximately 1 mi south of Twin Springs in Rock Creek at 1,554 m (5100 ft) (42.2423708, -112.7495098). All cuttings were trimmed to a length of 60 cm (24 in) with a basal diameter of 1.9 to 2.5 cm (0.75 to 1.0 in). Temperatures in the cooler ranged between from 1 to 2° C (34 to 39° F) with 77 to 82% relative humidity. Relative humidity inside the polyethylene bags was measured at 99%. The cuttings were stored for 60, 120, 180 and 240 days and a 0 day control treatment.

Four replications of 6 cuttings each were placed in 9.5 l (10 qt) galvanized buckets in a growth chamber kept at 22-23° C (71 to 74° F). The design was a randomized complete block with 4 buckets acting as 4 replications. The growth chamber was equipped with six, 34 watt white fluorescent bulbs, 3 on the door and 3 on the back panel with a 24 hr light period. Photosynthetically active radiation (PAR), measured using a Decagon AccuPAR LP-80 ceptometer®, measured 45 µmols/m²s. Relative humidity in the growth chamber was measured at 58%. The buckets were watered daily to maintain water depth at 23 cm (9 in). No soil medium was used in the experiment to facilitate root measurement.

Cuttings were evaluated after 32 days of growth chamber conditions for percent survival (visible active growth, root initials, or healthy green stem tissues) and for average shoot and root biomass. Biomass was measured after air drying for 14 days at 22° C (72° F).

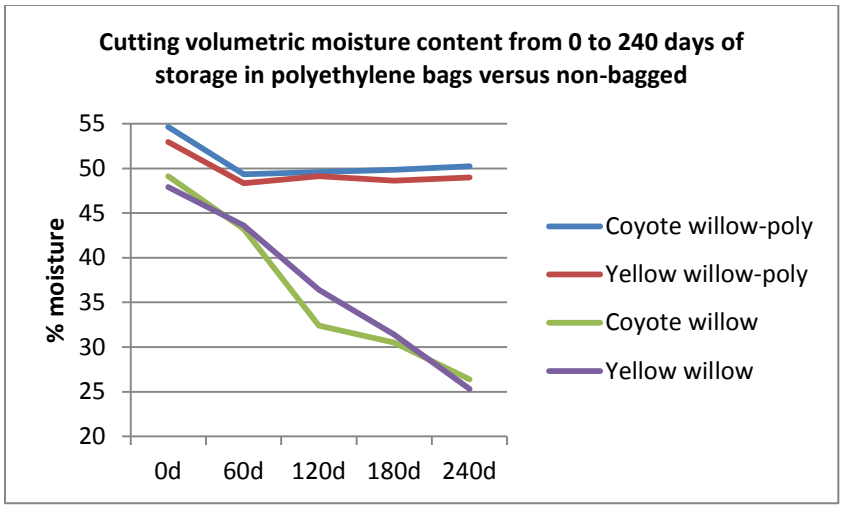
A second set of cuttings for each treatment was used to measure cutting volumetric moisture content. Four replications of one cutting per rep were used for each storage treatment. Fresh weights were measured after storage treatment conclusion, and dry weights were recorded after oven drying at 60° C (140 °F) for 10 days.

Comparisons of cutting survival and growth measurements were made using a one-way ANOVA. Significance was assessed at $\alpha=0.05$. Means were differentiated using a Least Significant Difference (LSD) test. Statistical analysis was conducted using Statistix 8 Analytical Software.

Results

Cutting volumetric moisture content

The 2011 harvested non-poly cuttings began the storage treatment with between 45 and 50% moisture content. The poly treatment cuttings began with slightly higher moisture ranging between 50 and 55%. Cutting moisture decreased steadily in the non-poly cuttings at a rate of approximately 0.1% per day. After 240 days water content ranged from 25 to 30% (figure 1). The cuttings stored in polyethylene lost a small amount of moisture between 0 and 60 days, then leveled off at approximately 50% for the remainder of the trial.



Cutting survival

Fresh cuttings of both species planted with no storage had 100% survival (table 1). Excellent survival was achieved with fresh cuttings and from cuttings bagged in polyethylene up to 180 days of storage but then declined significantly at the 240 day evaluation. Cuttings not bagged in polyethylene had excellent survival with up to 120 days of storage. At 180 days and beyond coyote and yellow willow survival decreased significantly for cuttings in the non-poly treatment.

Table 1. Cutting Survival

	Coyote willow	Yellow willow
0d	100 a[1]	100 a
0d poly	100 a	100 a
120d poly	100 a	100 a
180d poly	96 a-b	100 a
60d	92 a-b	92 a-b
60d poly	88 a-b	100 a
120d	79 a-b	96 a
240d poly	75 b	77 b-c
180d	17 c	58 c
240d	8 c	29 d

[1] Means followed by the same letter are not significantly different at P≤0.05 using LSD (least significant difference) test.

Root development

Root biomass of coyote willow was significantly greater in treatments with cuttings stored in polyethylene bags compared to non-bagged cuttings and the 0d control treatment (table 2). Root production of coyote willow cuttings stored in poly did not differ significantly between storage durations. Likewise, root weight of coyote willow cuttings not stored in poly did not differ significantly from one another.

Differences in root growth were detected between storage durations among yellow willow cuttings. Greatest root biomass was found with 180d poly treatment which differed significantly from the 240 and 60d poly treatments but not the 120d poly treatment. Root biomass among the non-poly treatments of yellow willow cuttings did not differ significantly from one another regardless of length of storage.

Table 2. Root biomass

	Coyote willow	Yellow willow
	----------(g)----------	
240d poly	0.76 a[1]	0.48 b-c
120d poly	0.67 a	0.57 a-b
60d poly	0.67 a	0.36 c-d
180d poly	0.58 a	0.72 a
0d	0.06 b	0.11 e-f
120d	0.04 b	0.07 f
180d	0.02 b	0.04 f
60d	0.01 b	0.28 d-e
0d poly	0.00 b	0.11 e-f
240d	0.00 b	0.00 f

[1] Means followed by the same letter are not significantly different at P≤0.05 using LSD (least significant difference) test.

Shoot development

Poly treatments all produced significantly more shoot growth in coyote willow than the non-poly treatments (table 3). Coyote willow stored in polyethylene also produced more shoot biomass than fresh cuttings of the 0d control treatment. Storage for 180d in poly had two times more shoot production than the next highest rated treatment.

Yellow willow cuttings showed significant difference in shoot production between the 0d poly and 0d non-poly treatment. This may be a reflection of different moisture levels at start of trial. Poly treatments produced significantly more growth of yellow willow shoots than all non-poly treatments but not the 0d control of the 2012 harvested cuttings. 120d poly had significantly greater shoot production than all other treatments, two times more shoot biomass than the next highest rated treatment.

Table 3. Shoot biomass

	Coyote willow	Yellow willow
	----------(g)----------	
180d poly	13.76 a[1]	6.60 b
120d poly	6.63 b	12.64 a
60d poly	4.95 b-c	6.93 b
240d poly	3.83 c	8.06 b
60d	0.45 d	2.64 c
0d	0.43 d	2.86 c
120d	0.40 d	1.31 c
180d	0.04 d	0.46 c
0d poly	0.00 d	6.22 b
240d	0.00 d	0.00 c

[1] Means followed by the same letter are not significantly different at P≤0.05 using LSD (least significant difference) test.

Discussion

Although cuttings for the two storage treatments (poly and non-poly) were harvested in different years, fresh cuttings from each treatment (0d poly and 0d non-poly) did not differ significantly from one another in the characters measured.

Mold and fungus development was visible in the polyethylene bagged cuttings at 60 days of storage and beyond. Black spots and a fuzzy white fungus were observed on cut tips and pruned branches. The presence of fungus however did not seem to inhibit survival or growth under shorter lengths of storage when compared to fresh cuttings. Only after 240 days of poly treatment did we observe a significant decrease in survival. We also observed fungus on the non-poly cuttings, but not to the degree of that on the cuttings stored under high relative humidity in the polyethylene.

Our results indicate that non-bagged cuttings stored under refrigerated conditions will retain good vigor for at least four months. Increasing humidity and maintaining cutting moisture levels by bagging the cuttings in polyethylene extends vigor with no loss of survival for up to 6 months. Bagging the cuttings also appears to stimulate root and shoot growth. 120 to 180 days of storage in polyethylene resulted in significantly greater shoot production than all other treatments including freshly harvested cuttings. This information may be useful for stream bank restoration or bioengineering where more root and shoot production is useful for bank protection.

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TECHNICAL NOTE

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CHALLIS, IDAHO DEMONSTRATION PLANTINGS SUMMARY: 1980 - 2013

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Round Valley demonstration site, Custer County, Idaho

This technical note provides 30+ years of data from six rangeland plantings in areas surrounding Challis, Idaho. The plantings were evaluated every 3- 4 years for plant establishment, stand, survival, plant density, plant vigor, resistance to insects, resistance to drought, ability to spread, height, competitive ability, plant production estimates and seed production. This report summarizes all available evaluations for stand, plant density and the species' estimated ability to spread.

Introduction

Six demonstration plantings were seeded in the Challis, Idaho NRCS Field Office service area in Custer County, Idaho between 1980 and 1982 as a part of the Challis Experimental Stewardship Program. The objective of these plantings was to determine and display species and cultivars (varieties) of grasses, forbs, legumes and shrubs adapted for use in rangeland rehabilitation and the improvement of wildlife habitat. Many agencies, including USDA NRCS (SCS), USDI BLM, USDA FS and Idaho Department of Lands contributed to the establishment of this project. Long term demonstration planting evaluations were the responsibility of USDA NRCS.

Climate

The average annual precipitation for Challis is 7.70 inches. However, the foothill areas receive more precipitation, as much as 20 inches or more at higher elevations to the north, west and south of Challis. The growing season is quite short in most of the area, from 50 to 100 days. During this growing period, about 30 to 40 percent of total annual precipitation typically falls at lower, warmer elevation sites. Most of this growing season precipitation occurs from mid-April to early-June with June through August being fairly dry. The heaviest 1-day precipitation amount during the period of record was 1.85 inches at Challis on July 10, 1983. The years between 1982 and 1984 were good precipitation years as total annual amounts were between 2 and 3.5 inches above average. This likely resulted in good initial establishment of many of the species at the demonstration plantings. Between the years of 1985 and 1989, precipitation was below average. 1988 in particular was a drought year with the area only receiving 4.77 inches of precipitation. In effect, the mid 1980s through the next 20 years were either average or drier than average for the area with the occasional occurrence of a slightly above average precipitation year.

Materials and Methods

Six fenced enclosure sites were seeded, Jeff's Flat, Round Valley, Bradbury Flat (two plantings), Centennial Flat, Gooseberry Creek and Spud Alluvial (figure 1). Each enclosure was divided into two areas with one half left with native vegetation and the other half scalped and prepared for seeding. All seedings were made in the scalped area. Drilled areas were worked with a spring tooth harrow for seedbed preparation. Grasses, legumes, and forbs were seeded in 3 rows, one foot apart, 30 feet long with a John Deere double disc drill with packer wheels. The shrubs were greenhouse grown transplants individually planted in 100 foot rows 5 feet apart with 3 foot within row spacing.

Figure 1. Map of Challis area demonstration plantings.

The plantings were evaluated every 3- 4 years by many NRCS employees. Plant characteristics evaluated and rated include establishment, stand, survival, plant density, plant vigor, resistance to insects, resistance to drought, ability to spread, height, competitive ability, plant production estimates and seed production. However evaluations were not consistent through the 30(+) years. This report summarizes all available evaluations for stand, plant density and the species' estimated ability to spread.

In some years, stand rating was rated on a 1-9 scale (1 being best and 9 being worst), while in other years it was rated on a percent cover basis. This report lists evaluations as they were conducted in the field and a valid comparison of species and accessions can be inferred.

The method of evaluating ability to spread varies from one evaluation to the next. In some cases a single rating is given. In other cases ability to spread was divided into spread by seed and vegetative spread (rhizomatous) and given separate ratings. In a few instances it seems that only vegetative spread is considered as all non-rhizomatous species were given a "non-applicable" rating. In this report we attempt to capture the intention of the evaluator. In instances where separate ratings for vegetative and seed spread were recorded, we provide here the average of those scores.

Several accessions being investigated in this study were formally released in later years following the establishment of these plantings. To avoid confusion, the current release names are given.

Many accessions in the six plantings either failed to establish or did not persist. Rather than filling the attached tables with zeros, the authors have chosen to leave cells blank in which there is no rating due to a failed stand. This should make the report easier to read.

Spud Alluvial

The Spud Alluvial demonstration site is located approximately 30 miles southwest of Challis (44.228549, -114.299698). This site lies at an elevation of 5570 ft and receives 7 to 11 inches mean annual precipitation. The soils at the location are Whiteknob gravelly loam with 2 to 8% slopes. The native plant community is dominated by Wyoming big sagebrush and bluebunch wheatgrass.

Records indicate that the ground was frozen and rocky at the time of seeding with the resulting seedbed being fair at best. Despite poor seeding conditions, 16 of 24 planted species established to some extent.

The Spud Alluvial demonstration planting area, July 2007.

Spud Alluvial stand rating							
	1989[1]	1992[1]	1995[1]	1999[1]	2003[2]	2007[2]	2013[2]
GP-52 synthetic alfalfa	5	8	3	7			
BC-79 synthetic alfalfa	4	8	7	7			
RS-1 bluebunch x quackgrass	8	7			85		
RS-2 bluebunch x quackgrass	7	5			85		
Fairway crested wheatgrass	2	2	1		85	87	30
Immigrant forage kochia	7	6	1		50	85	70
Scarlet globemallow	8	8					
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax							
Paiute orchardgrass							
Ephraim crested wheatgrass	6	7	3	5	75	15	30
Barton western wheatgrass		9			2		
Topar pubescent wheatgrass	7	9	9	9			
Whitmar beardless wheatgrass	5	4	2	1	70	35	2
P-27 Siberian wheatgrass	3	2	2	1	90	90	60
Goldar bluebunch wheatgrass	5	8	4	7	25	2	
Secar Snake River wheatgrass	3	3	3	3	80	50	15
Nezpar Indian ricegrass							
Magnar basin wildrye							
Vinall Russian wildrye	5	3	2	3	85	75	25
Bozoisky Select Russian wildrye	3	3	2	3	85	85	20
Yellow sweetclover				*	*		
Nordan crested wheatgrass	3	2	2	*	*	95	70

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method
* No record of evaluation

Mark Olson and Dan Ogle evaluating the Spud Alluvial demonstration site in 2007.

Spud Alluvial plant density[1]							
	1989	1992	1995	1999	2003	2007	2013
GP-52 synthetic alfalfa	0.4		0.4				
BC-79 synthetic alfalfa	0.4		0.1				
RS-1 bluebunch x quackgrass	0.1				1.5		
RS-2 bluebunch x quackgrass	0.3				1.5		
Fairway crested wheatgrass	1.1		2.0		1.5	0.7	0.4
Immigrant forage kochia	0.1		1.0	2.0	2.0	1.0	1.0
Scarlet globemallow	0.1						
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax							
Paiute orchardgrass							
Ephraim crested wheatgrass	0.5		1.0	2.0	1.0	0.2	0.4
Barton western wheatgrass					0.1		
Topar pubescent wheatgrass	0.4		0.1	1.0			
Whitmar beardless wheatgrass	0.5		1.0	1.0	1.0	0.3	
P-27 Siberian wheatgrass	1.0		1.5	1.0	1.5	1.25	0.8
Goldar bluebunch wheatgrass	0.5		0.4	7.0	0.3	0.1	
Secar Snake River wheatgrass	0.3		0.8	0.7	0.75	0.8	0.3
Nezpar Indian ricegrass							
Magnar basin wildrye							
Vinall Russian wildrye	0.3		1.0	1.5	1.0	0.8	0.5
Bozoisky Select Russian wildrye	0.3		0.9	0.5	0.75	1.0	0.3
Yellow sweetclover							
Nordan crested wheatgrass	1.0		1.5	*	*	1.5	0.7

[1] Plants/ft²

* No record of evaluation

Immigrant forage kochia, P-27 Siberian wheatgrass, Vinall Russian wildrye, and Nordan crested wheatgrass all had fair to good stands at the time of the 2013 evaluation. Ephraim and Fairway crested wheatgrass, Secar Snake River wheatgrass and Bozoisky Russian wildrye also had fair plant densities throughout much of the life of the planting. The 7.0 plants/ft² recorded for Goldar bluebunch wheatgrass in 1999 is most likely a mistake made while recording the data. There is a footnote on the evaluation sheet stating that only 5 plants remained in the entire plot. Dividing those 5 plants by the 90 ft² area of the plot comes to 0.06 plants/ft².

Spud Alluvial ability to spread[1]							
	1989	1992	1995	1999	2003	2007	2013
GP-52 synthetic alfalfa			5	7			
BC-79 synthetic alfalfa			7	7			
RS-1 bluebunch x quackgrass							
RS-2 bluebunch x quackgrass							
Fairway crested wheatgrass	4.5		3			5	5
Immigrant forage kochia	2		2	3	1	1	1
Scarlet globemallow							
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax							
Paiute orchardgrass							
Ephraim crested wheatgrass	4		4	5		7	5
Barton western wheatgrass					7		
Topar pubescent wheatgrass	6		7				
Whitmar beardless wheatgrass			4	7	4		
P-27 Siberian wheatgrass	3		3	6			5
Goldar bluebunch wheatgrass			6	9			
Secar Snake River wheatgrass			5	5			7
Nezpar Indian ricegrass							
Magnar basin wildrye							
Vinall Russian wildrye			4	5	7	5	7
Bozoisky Select Russian wildrye	7		4	7	7	3	7
Yellow sweetclover							
Nordan crested wheatgrass	5		3	*	*	2	3

[1] rated on a 1-9 scale (1=best, 9= worst)
* No record of evaluation

Numerous Immigrant forage kochia volunteers were observed in 2003. In 2007, Immigrant forage kochia was reported outside of the exclosure and by 2013 (30+ years), had spread 30-50 feet (approximately 1- 2 ft/year) from the original planting. In 2013, the Russian wildrye, rated with low ability to spread, had spread via seed approximately10 feet beyond the plots, but it was unclear which accession had moved. The site is dominated by crested and Siberian wheatgrasses both inside and outside the exclosure making it difficult to determine what has moved from which plots of those species.

Centennial Flat

The Centennial Flat demonstration planting site is located at 44.353729, -114.302423, approximately 10 miles southwest of Challis. The elevation of the site is approximately 6,100 ft elevation, and the soils are Venum-Cronks complex gravelly loam. The area receives an estimated 8 to 12 inches mean annual precipitation and is dominated by Wyoming big sagebrush and bluebunch wheatgrass.

No evaluation occurred in 2013. There was also no record of an evaluation of this site in 1999.

Centennial Flat demonstration planting site, 2007.

Centennial Flat stand rating

	1989[1]	1992[1]	1995[1]	2003[2]	2007[2]
GP-52 Synthetic alfalfa	7	4	2	10	10
BC-79 Synthetic alfalfa	5	4	2	3	15
RS-1 bluebunch x quackgrass		8		25	
RS-2 bluebunch x quackgrass		4		15	
Fairway crested wheatgrass	5	2		75	
Lutana cicer milkvetch	2	7	7		1
Canbar Canby's bluegrass		5			
Immigrant forage kochia					
Scarlet globemallow	9	3	9	1	3
Bandera Rocky Mt. penstemon					
Cedar Palmer's penstemon					
Appar blue flax	7	2	6		
Paiute orchardgrass	9				
Ephraim crested wheatgrass	2	3	1	85	70
Barton western wheatgrass		4		5	5
Topar pubescent wheatgrass	3	4	3	1	15
Whitmar beardless wheatgrass	6	5	7	25	65
P-27 Siberian wheatgrass	2	3		0	2
Goldar bluebunch wheatgrass	7	3	4	25	25
Secar Snake River wheatgrass	8	4	4	50	40
Nezpar Indian ricegrass					
Magnar basin wildrye					
Vinall Russian wildrye	6	4	3	60	60
Bozoisky Russian wildrye	5	4	2	45	40
Yellow sweetclover					
Ladak alfalfa	9	7	9	1	
Nordan crested wheatgrass	3	2	2	70	75

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

This site had the best diversity in establishment of the six plantings. Only Immigrant forage kochia, Bandera penstemon, Palmer's penstemon, Nezpar Indian ricegrass and Magnar basin wildrye failed to establish. Ephraim crested wheatgrass, Whitmar beardless wheatgrass, Vinall and Bozoisky Russian wildrye and Nordan crested wheatgrass all had high stand ratings from the 2007 evaluation. Most accessions maintained some level of a stand throughout the life of the planting, either with long-lived plants or by natural seed recruitment and spread.

Centennial Flat plant density and spread	**Density**[1]				**Spread**[2]			
	1989	1995	2003	2007	1989	1995	2003	2007
GP-52 Synthetic alfalfa	0.2	1	0.1	0.1	7	3	5	5
BC-79 Synthetic alfalfa	0.3	1	0.05	0.2	7	3	5	4
RS-1 bluebunch x quackgrass			0.5					
RS-2 bluebunch x quackgrass			0.25					
Fairway crested wheatgrass	0.5		1.0		5		7	
Lutana cicer milkvetch	0.1	0.2		0.1	7	3		7
Canbar Canby's bluegrass								
Immigrant forage kochia								
Scarlet globemallow	0.7	0.1	0.1	0.1	9	7		6
Bandera Rocky Mt. penstemon								
Cedar Palmer's penstemon								
Appar blue flax	0.2	0.5			5	5	6	
Paiute orchardgrass								
Ephraim crested wheatgrass	1.3	1.6	1.25	0.8	3	1		5
Barton western wheatgrass	0		0.25	0.1			7	4
Topar pubescent wheatgrass	1.4	1.0	0.1	0.3	1	3		4
Whitmar beardless wheatgrass	0.1	0.1	0.25	1.0	4	5	5	3
P-27 Siberian wheatgrass	0.9	1.5	0	0.1	2	5		9
Goldar bluebunch wheatgrass	0.2	0.5	0.5	0.5	4	3	5	5
Secar Snake River wheatgrass	0.1	0.3	0.75	0.5	4	5	5	5
Nezpar Indian ricegrass								
Magnar basin wildrye								
Vinall Russian wildrye	0.6	0.5	0.75	0.7	3	5		7
Bozoisky Russian wildrye	0.4	0.5	0.25	0.3	2	5		5
Yellow sweetclover								
Ladak alfalfa		0.5	0.1				6	
Nordan crested wheatgrass	0.8	1.0	0.75	1.0	2	5	6	7

[1] Plants/ft²
[2] rated on a 1-9 scale (1=best, 9= worst)

Good densities were achieved by several accessions at the Centennial Flat site. Most of these (Ephraim crested wheatgrass, Goldar bluebunch wheatgrass, Secar Snake River wheatgrass, Vinall Russian wildrye and Nordan crested wheatgrass) established well and maintained vigorous stands. Whitmar beardless wheatgrass had poor initial plant densities but increased over time to rival Nordan crested wheatgrass at the 2007 evaluation.

Jeff's Flat

The Jeff's Flat demonstration planting is located approximately 6 miles northwest of Challis (44.542114, -114.341991) at an elevation of 6,600 ft. The soils at the site are Nielsen-Gaciba association gravelly loam soils. Average annual precipitation ranges from 12 to 16 inches, supporting a bluebunch wheatgrass, Idaho fescue and mountain big sagebrush plant community.

The Jeff's Flat site could not be visited in 2013 due to wildfires. There were also no records of an evaluation for 1995 due to road maintenance issues.

Jeff's Flat demonstration planting area, 2007.

Jeff's Flat stand rating

	1989[1]	1992[1]	1999[1]	2003[2]	2007[2]
GP-52 Synthetic alfalfa	7	4	9	2.5	5
BC-79 Synthetic alfalfa	7	4	9	2.5	3
RS-1 bluebunch x quackgrass	8	5			
RS-2 bluebunch x quackgrass	8	6			
Fairway crested wheatgrass	1	2			
Delar small burnet					
Lutana cicer milkvetch	7	8	9		
Manchar smooth brome		8	1	50	25
Baylor smooth brome	7	6		50	10
Covar sheep fescue	5	2	1	45	75
Durar hard fescue	7	3	5	75	90
Bandera Rocky Mountain penstemon					
Cedar Palmer's penstemon					
Appar blue flax		5			
Whitmar beardless wheatgrass	3	3			
Paiute orchardgrass					
Ephraim crested wheatgrass	2	4	7	25	10
P-27 Siberian wheatgrass	1	3	9	40	20
Greenar intermediate wheatgrass	4	5	9	65	5
Sherman big bluegrass	5	6			
Magnar basin wildrye	5	8		5	5
Vinall Russian wildrye	2	3		3	8
Bozoisky Russian wildrye	3	3	5	5	8
Yellow sweetclover	2				5
Ladak alfalfa		4			
Nordan crested wheatgrass	3	3			

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

P-27 Siberian wheatgrass, Fairway crested wheatgrass, Ephraim crested wheatgrass, Vinall Russian wildrye and yellow sweetclover produced the best initial stands. Yellow sweetclover, a biennial, apparently disappeared for several seasons (very typical for the species) but had a modest stand in 2007. Over time the wheatgrasses and wildryes were surpassed by Covar sheep fescue and Durar hard fescue which had the top stand ratings in 2007. The adjacent plots of smooth brome appear to have been difficult to discern. In 1989, Manchar smooth brome was rated as having no established plants while Baylor smooth brome was rated as a 7. In the 1999 evaluation Manchar had obtained a 1 rating, while Baylor scored a 0. Separating the two cultivars from one another is nearly impossible and no conclusions of performance should be taken at an accession level, but as a generalization for the species.

Jeff's Flat plant density and spread	**Density**[1]				**Spread**[2]			
	1989	1999	2003	2007	1989	1999	2003	2007
GP-52 Synthetic alfalfa	0.1	1.0	1.0	0.1	7	4	7	N/A
BC-79 Synthetic alfalfa	0.1	1.0	1.0	0.1	7	4	7	N/A
RS-1 bluebunch x quackgrass								
RS-2 bluebunch x quackgrass								
Fairway crested wheatgrass	0.8				7			
Delar small burnet	0							
Lutana cicer milkvetch	0	1.0						
Manchar smooth brome	0	4.0	4.5	0.3		5	1	3
Baylor smooth brome	0.2		4.5	0.1	3		1	3
Covar sheep fescue	0.2	3.0	1.5	1.5		1	9	3
Durar hard fescue	0.2	1.0	3.0	2.0	3	7	7	1
Bandera Rocky Mountain penstemon								
Cedar Palmer's penstemon								
Appar blue flax								
Whitmar beardless wheatgrass	0.2				3			
Paiute orchardgrass								
Ephraim crested wheatgrass	1.5	1.0	0.5	0.1	2	2	0	N/A
P-27 Siberian wheatgrass	1.4	1.0	0.75	0.2	2	7	7	N/A
Greenar intermediate wheatgrass	0.2	1.0	4.0	0.1	3	9	1	3
Sherman big bluegrass	0.8				5			
Magnar basin wildrye	0.2		0.1	0.1	5		0	N/A
Vinall Russian wildrye	0.8		0.1	0.1	4		0	3
Bozoisky Russian wildrye	0.7	1.0	0.1	0.1	4	5	0	3
Yellow sweetclover	0.7			0.1	2			N/A
Ladak alfalfa								
Nordan crested wheatgrass	1.3				4			

[1] Plants/ft²
[2] rated on a 1-9 scale (1=best, 9= worst)

Jeff's Flat was one of a handful of high precipitation planting sites that favored the fine fescues over introduced wheatgrasses and wildryes. Covar sheep fescue and Durar hard fescue started with low plant densities but by the 2007 evaluation had densities of 1.5 and 2.0 plants/ft² respectively. Conversely Ephraim crested wheatgrass, P-27 Siberian wheatgrass, Vinall Russian wildrye and Bozoisky Russian wildrye all started with excellent initial establishment but reduced in density as the years progressed. Nordan crested wheatgrass was recorded in 1989 but did not

show up on future evaluation sheets, thus the blank cells for the 1999-2007 seasons do not necessarily indicate a lack of plants.

Higher precipitation at Jeff's Flat also facilitated spread by rhizomatous species. Both smooth brome accessions began with low plant densities but showed dramatic ability to spread by the 2003 evaluation. The fine fescues again appeared difficult to differentiate. The ability of Covar sheep fescue to spread was rated excellent in 1999 but no spread in 2003. Durar received a 7 for spread in 2003 and a 1 in 2007.

Bradbury Flat

The Bradbury Flat demonstration planting site is located 3 miles southeast of Challis (44.420310, -114.1530353). Pre-existing vegetation on the Bradbury site included Indian ricegrass, bottlebrush squirreltail, Nevada bluegrass, Sandberg bluegrass, needle-and-thread, shadscale, budsage, rubber rabbitbrush, Wyoming big sagebrush, winterfat, Nuttall's saltbush, and prickly pear cactus. The site receives 7 to 9 inches precipitation annually. The site sits at 5,400 ft elevation on the Whiteknob soil series consisting of deep, well drained soils formed in mixed alluvium.

Bradbury Flat demonstration planting site, 2007.

The Bradbury Flat demonstration planting trial incorporated a more complex experimental design than the other sites and is in essence two separate planting trials. The project design included a 1980 spring and fall (dormant) planting of selected plant materials. For the most part the accessions were the same in both seedings. Three seedbed preparation techniques were used: 1) disked to smooth the soil surface, 2) chiseled 4 to 6 inches deep and then disked, and, 3) chiseled 8 to 10 inches and then disked. The different techniques were conducted parallel to each other. Three rows, 45 feet long of each species were drilled perpendicular and across the seedbed preparation techniques. These treatments were not specified in evaluation sheets. No distinction is made in the results section on seedbed preparation methods, only species.

Little difference in establishment was recorded between spring and fall seeded plots. Crested and Siberian wheatgrasses established well from both seeding dates. Secar Snake River wheatgrass had a very good stand from the fall seeding and no recorded stand the first year in the spring seeding. However by 1992, the fall and spring seedings showed equally good stands. Both Russian wildrye accessions (planted only in the fall seeding) showed no stand during the 1989 evaluation, but developed into excellent stands over time.

Plant densities reflect the stand ratings. AB-447 crested wheatgrass (spring and fall seeded), spring seeded Secar Snake River wheatgrass, and fall seeded winterfat accessions had excellent densities over 1.0 plants/ft^2. At the time of the 2013 final evaluation the best densities were recorded for spring seeded Ephraim crested wheatgrass, spring seeded winterfat, spring seeded Sodar streambank wheatgrass and fall seeded Russian wildrye accessions.

Bradbury Flat stand rating	Fall Seeding							Spring Seeding					
	1989[1]	1992[1]	1995[1]	1999[1]	2003[2]	2013[2]		1989[1]	1992[1]	1995[1]	1999[1]	2003[2]	2013[2]
Ephraim crested wheatgrass	5	8	4	4	50		Ephraim crested wheatgrass	5	3	3	2	70	70
P-27 Siberian wheatgrass	4	8	5	4	60		P-27 Siberian wheatgrass	5	4	3	3	65	20
Sodar streambank wheatgrass		6	4	5	80		Sodar streambank wheatgrass	5	6	5	4	65	20
Nezpar Indian ricegrass	8	9					Nezpar Indian ricegrass		9	9			
Luna pubescent wheatgrass							Luna pubescent wheatgrass	7					
AB-447 crested wheatgrass	5	4	3	3	65		AB-447 crested wheatgrass	3	7	2	3	60	30
Goldar bluebunch wheatgrass							Goldar bluebunch wheatgrass	7	9		9		
Magnar basin wildrye							Magnar basin wildrye						
Topar pubescent wheatgrass							Topar pubescent wheatgrass	2					
Secar Snake River wheatgrass	3	2	4	4	50		Secar Snake River wheatgrass		2	3	3	60	
Appar blue flax							Appar blue flax						
Firecracker penstemon							Firecracker penstemon						
Bandera Rocky Mt. Penstemon							Bandera Rocky Mt. penstemon						
Palmer’s penstemon							Palmer’s penstemon						
Alpine penstemon							Alpine penstemon						
Hatch Winterfat	2	4	4	3	1	50	AB-555 aster						
AB-764 Winterfat	3	4	3	3	20	50	AB-677 aster						
Blackeyed susan							Hatch winterfat						50
AB-922 fourwing saltbush	6	5	5.5		3	2	764 winterfat						50
AB-942 fourwing saltbush	6	5	7		2	2	Blackeyed Susan						
Delar small burnet							AB-922 fourwing saltbush		7			50	
Immigrant forage kochia	5	3	5	7	3	5	AB-942 fourwing saltbush		9			50	
Bozoisky Russian wildrye		2	3	2	70	60	Delar small burnet						
Vinall Russian wildrye		3	3.5	3	70	30	Immigrant forage kochia					1	
Lodorm green needlegrass		8					Ladak alfalfa		4	8	7	1	
Blair smooth brome		8					Buckwheat						
Paiute orchardgrass							Arrowleaf balsamroot						

[1] rated on a 1-9 scale (1=best, 9= worst)

[2] rated as percent cover using line intercept method

Bradbury Flat plant density[1]	Fall Seeding						Spring Seeding				
	1989	1995	1999	2003	2013		1989	1995	1999	2003	2013
Ephraim crested wheatgrass	0.3	0.5	1.5	0.5		Ephraim crested wheatgrass	1.0	0.5	1.5	1.0	1.0
P-27 Siberian wheatgrass	0.3	0.3	1.5	0.75		P-27 Siberian wheatgrass	1.0	0.4	1.5	0.5	0.2
Sodar streambank wheatgrass		0.8	2.0	1.25		Sodar streambank wheatgrass		0.3	2.0	1.5	1.0
Nezpar Indian ricegrass						Nezpar Indian ricegrass		0.1			
Luna pubescent wheatgrass						Luna pubescent wheatgrass	1.0				
AB-447 crested wheatgrass	1.3	0.6	1.5	0.5		AB-447 crested wheatgrass	12.0	0.6	1.5	0.5	0.4
Goldar bluebunch wheatgrass						Goldar bluebunch wheatgrass	1.0		0.5		
Magnar basin wildrye						Magnar basin wildrye					
Topar pubescent wheatgrass						Topar pubescent wheatgrass					
Secar Snake River wheatgrass	0.6	0.5	1.0	0.25		Secar Snake River wheatgrass	4.0	0.5	0.5	0.25	
Appar blue flax						Appar blue flax					
Firecracker penstemon						Firecracker penstemon					
Bandera Rocky Mt. Penstemon						Bandera Rocky Mt. penstemon					
Palmer's penstemon						Palmer's penstemon					
Alpine penstemon						Alpine penstemon					
Hatch Winterfat	1.1	1.0	4.0	0.1	0.7	AB-555 aster					
AB-764 Winterfat	1.1	1.0	4.0	0.15	0.7	AB-677 aster					
Blackeyed susan						Hatch winterfat				0.5	0.7
AB-922 fourwing saltbush	0.2	0.3		0.1	0.1	764 winterfat				0.5	0.7
AB-942 fourwing saltbush	0.2	0.2		0.1	0.1	Blackeyed Susan					
Delar small burnet						922 fourwing saltbush				0.1	
Immigrant forage kochia	0.2	0.3	0.5	0.1	0.1	942 fourwing saltbush				0.1	
Bozoisky Russian wildrye		1.0	3.0	0.5	0.8	Delar small burnet					
Vinall Russian wildrye		1.7	3.0	0.7	0.8	Immigrant forage kochia					
Lodorm green needlegrass						Ladak alfalfa		0.1	0.5		
Blair smooth brome						Buckwheat					
Paiute orchardgrass						Arrowleaf balsamroot					

[1] Plants/ft^2

Bradbury Flat ability to spread[1]	Fall Seeding					Spring Seeding			
	1995	1999	2003	2013		1995	1999	2003	2013
Ephraim crested wheatgrass	4	3	5		Ephraim crested wheatgrass	4	3		2
P-27 Siberian wheatgrass	4	3	5		P-27 Siberian wheatgrass	3	3		2
Sodar streambank wheatgrass	3	2	1		Sodar streambank wheatgrass	3	2	1	9
Nezpar Indian ricegrass					Nezpar Indian ricegrass	7			
Luna pubescent wheatgrass					Luna pubescent wheatgrass				
AB-447 crested wheatgrass	5	3	5		AB-447 crested wheatgrass	3	3		2
Goldar bluebunch wheatgrass					Goldar bluebunch wheatgrass		9		
Magnar basin wildrye					Magnar basin wildrye				
Topar pubescent wheatgrass					Topar pubescent wheatgrass				
Secar Snake River wheatgrass	5	4			Secar Snake River wheatgrass	5	3		
Appar blue flax					Appar blue flax				
Firecracker penstemon					Firecracker penstemon				
Bandera Rocky Mt. Penstemon					Bandera Rocky Mt. penstemon				
Palmer’s penstemon					Palmer’s penstemon				
Alpine penstemon					Alpine penstemon				
Hatch Winterfat	7	7	0	2	AB-555 aster				
AB-764 Winterfat	7	7	9	2	AB-677 aster				
Blackeyed susan					Hatch winterfat			1	2
AB-922 fourwing saltbush	5		3	6	764 winterfat			1	2
AB-942 fourwing saltbush	6		0	6	Blackeyed Susan				
Delar small burnet					AB-922 fourwing saltbush			5	
Immigrant forage kochia	4	3		5	AB-942 fourwing saltbush			5	
Bozoisky Russian wildrye	4	4		2	Delar small burnet				
Vinall Russian wildrye	4	3		2	Immigrant forage kochia				
Lodorm green needlegrass					Ladak alfalfa	6	6		
Blair smooth brome					Buckwheat				
Paiute orchardgrass					Arrowleaf balsamroot				

[1] rated on a 1-9 scale (1=best, 9= worst)

Ability to spread was not rated during the 1989 or 1992 evaluations. In 2013, spring seeded Ephraim crested wheatgrass appeared to be spreading via seed into the adjacent plots and beyond. The 2003 evaluation of winterfat and fourwing saltbush are noteworthy in that the reviewer felt one accession of each was able to spread and the other wasn't. In 2013, the two accessions of each shrub were rated identically due to the inability to separate them. At that time, the winterfat had spread more than 30 feet from the original plots. The ability to spread ratings for the spring seeded plots were similar to the fall seeded plots. Crested wheatgrass, Siberian wheatgrass and winterfat all showed high rates of spread.

Gooseberry Creek or Sheep Creek

The Gooseberry Creek demonstration planting site is located approximately 15 miles southeast of Challis (44.281772, -113.970237) at 7,300 ft elevation on Zeelnot gravelly loam soil. The site receives 12 to 16 inches mean annual precipitation. The native plant community is dominated by mountain big sagebrush, Idaho fescue and bluebunch wheatgrass.

Gooseberry Creek stand rating

	1989[1]	1992[1]	2003[2]	2007[2]	2013[2]
Nordan crested wheatgrass	1	6	5	60	50
Bozoisky Russian wildrye	3	4	10	5	
Vinall Russian wildrye	5	6	10	3	
Magnar basin wildrye	9				
Sherman big bluegrass	1	3	95	95	50
Greenar intermediate wheatgrass	8	4	2	2	
P-27 Siberian wheatgrass	1	8	0.5		
Ephraim crested wheatgrass	8	7	3	2	
Paiute orchardgrass					
Appar blue flax	5				1
Cedar Palmer's penstemon	9				
Bandera Rocky Mt. penstemon	8	8			
Durar hard fescue	5	3	85	90	90
Covar sheep fescue	3	3	80	90	80
Manchar smooth brome	3	3	50	50	20
Baylor smooth brome	7	2	20	40	20
Lutana cicer milkvetch		7			
Delar small burnet					
Fairway crested wheatgrass	1	4	5		
RS-2 quackgrass x bluebunch	7				1
RS-1 quackgrass x bluebunch	5				5
BC-70 synthetic alfalfa	7	5			1
GP-52 synthetic alfalfa	5	3			1

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

The Gooseberry Creek site averaged slightly greater precipitation than some of the lower valley sites and thus had better initial establishment of a wide variety of accessions. Over time, the fine fescues, Sherman big bluegrass, and Nordan crested wheatgrass showed the best long term persistence. The fescues in adjacent plots had spread and likely intermingled. There is also an interesting increase in Nordan between 2003 (5%) and 2007 (60%).

Gooseberry Creek demonstration planting site, 2007.

Gooseberry Creek plant density and spread	Density[1]				Spread[2]			
	1989	2003	2007	2013	1989	2003	2007	2013
Nordan crested wheatgrass	3.0	0.1	0.6	0.4	5	0	NA	3
Bozoisky Russian wildrye	1.6	0.2	0.1		4	0	NA	
Vinall Russian wildrye	1.2	0.3	0.1		5	0	NA	
Magnar basin wildrye	0.1				9			
Sherman big bluegrass	1.5	1.5	3.0	0.5	5	3	NA	5
Greenar intermediate wheatgrass	0.5	0.5	0.1		5	5		
P-27 Siberian wheatgrass	1.8	0.01			9	0		
Ephraim crested wheatgrass	0.9	0.1	0.1		7	0	NA	
Paiute orchardgrass					0			
Appar blue flax	1.5				3	3		
Cedar Palmer's penstemon	0.1				9			
Bandera Rocky Mt. penstemon	0.2				9			
Durar hard fescue	0.6	2.0	3.0	1.5	7	5	3	2
Covar sheep fescue	1.3	2.0	3.0	1.0	4	5	3	2
Manchar smooth brome		0.5	0.5	0.5	3	2	3	1
Baylor smooth brome		2.5	0.3	0.5	7	3	3	1
Lutana cicer milkvetch								
Delar small burnet								
Fairway crested wheatgrass		0.1			7	0		
RS-2 quackgrass x bluebunch	0.1				7			0
RS-1 quackgrass x bluebunch	0.2			0.5	5			5
BC-70 synthetic alfalfa				0.1	7			3
GP-52 synthetic alfalfa	0.1			0.1	7			3

[1] Plants/ft²

[2] rated on a 1-9 scale (1=best, 9= worst)

Nordan crested wheatgrass had an excellent density early in the trial (3.0 plants/ft²) but thinned to 0.4 plants/ft² by 2013. Several other accessions also started well and declined or disappeared. Durar hard fescue and Covar sheep fescue maintained high stand densities and percent cover throughout the trial.

The enclosure and surrounding areas are dominated with a fine bunch fescue assumed to be either the native Idaho fescue or sheep fescue. In 2013, it was impossible to measure the spread of the fescue accessions because we could not tell from which direction the plants had come. Sherman big bluegrass had a good stand and had spread approximately 6 ft outside of the plot. Appar blue flax was not observed within its plot but volunteers could be found as much as 15 ft away from the original planting. Smooth brome had spread approximately 60 feet from the original plots into low lying areas.

Round Valley

The Round Valley demonstration planting site is located at an arid site which receives about 6 to 9 inches mean annual precipitation and supports a shadscale and sand dropseed plant community. The site is approximately 2 miles east of Challis (44.487872, -114.124357) at an elevation of 5,200 ft on Snowslide very gravelly loam soil.

Fifteen of 24 accessions were established at the time of the 1985 evaluation. In 2013, however, only 5 accessions, Immigrant forage kochia, P-27 Siberian wheatgrass, Nordan crested wheatgrass and both Russian wildrye accessions, had persisted. Much of the site at the time of the 2013 evaluation was dominated by P-27 Siberian wheatgrass. Presumably this was the result of a seeding outside of the Round Valley enclosure.

Round Valley demonstration planting site, 2007.

Round Valley stand rating							
	1985[1]	1992[1]	1995[1]	1999[1]	2003[2]	2007[2]	2013[2]
GP-52 Synthetic alfalfa	6	9					
BC-79 Synthetic alfalfa	3						
RS-1 bluebunch x quackgrass		9		9	1		
RS-2 bluebunch x quackgrass		8		8	1		
Fairway crested wheatgrass	7	9		9			
Immigrant forage kochia		7	7	7	2	1	1
Scarlet globemallow		9			1		
Bandera Rocky Mt. penstemon							
Cedar Palmer's penstemon							
Appar blue flax	2						
Paiute orchardgrass	9						
Ephraim crested wheatgrass	5	8	3	7	70	35	
P-27 Siberian wheatgrass	6	3	3	3	70	70	70
Goldar bluebunch wheatgrass	4		8				
Secar Snake River wheatgrass	3	5	7	8			
Barton western wheatgrass							
Topar pubescent wheatgrass	7						
Whitmar beardless wheatgrass	7						
Nezpar Indian ricegrass	8				1		
Magnar basin wildrye	7		7				
Vinall Russian wildrye		2	2	2	30	75	40
Bozoisky Russian wildrye	7	1	1	1	75	90	80
Yellow sweetclover							
Nordan crested wheatgrass	6	1	2	1	60	65	1

[1] rated on a 1-9 scale (1=best, 9= worst)
[2] rated as percent cover using line intercept method

Plant densities in general decreased over time for all species and accessions with the exception of P-27 Siberian wheatgrass and the two Russian wildrye accessions which maintained at nearly 1 plant/ft² over the course of the study. Nordan crested wheatgrass interestingly peaked at 2 plants/ft² in 1999 then steadily declined to only 0.01 plants/ft² in 2013, likely being replaced by the more drought tolerant accessions of Siberian wheatgrass and Russian wildrye.

Round Valley. Original drill rows are clearly visible in some accessions.

Round Valley plant density[1]						
	1989	1995	1999	2003	2007	2013
GP-52 Synthetic alfalfa	0.1					
BC-79 Synthetic alfalfa	0.2					
RS-1 bluebunch x quackgrass	0.4		0.5	0.01		
RS-2 bluebunch x quackgrass			0.5	0.01		
Fairway crested wheatgrass			0.5			
Immigrant forage kochia		1.0	0.5	0.1	0.1	0.01
Scarlet globemallow				0.1		
Bandera Rocky Mt. penstemon						
Cedar Palmer's penstemon						
Appar blue flax						
Paiute orchardgrass						
Ephraim crested wheatgrass	0.7	0.75	0.5	1.0	0.5	
P-27 Siberian wheatgrass	0.7	1.0	1.5	1.0	0.75	0.7
Goldar bluebunch wheatgrass	0.3	0.25				
Secar Snake River wheatgrass	1.0	0.05	0.5			
Barton western wheatgrass						
Topar pubescent wheatgrass	1.2					
Whitmar beardless wheatgrass	0.8					
Nezpar Indian ricegrass						
Magnar basin wildrye		0.1				
Vinall Russian wildrye	0.1	0.8	1.0	0.5	1.0	0.5
Bozoisky Russian wildrye	0.6	1.25	3.0	1.5	1.5	1.0
Yellow sweetclover						
Nordan crested wheatgrass	1.0	0.9	2.0	1.0	0.6	0.01

[1] Plants/ft²

Due to the use of P-27 Siberian wheatgrass outside the enclosure it was difficult to measure the spread of P-27 Siberian wheatgrass from the original plots. After 30 years, the rows of Bozoisky Russian wildrye were still easy to locate and showed little encroachment from weeds. Russian wildrye had spread approximately 12 ft beyond the original plots by 2013. Immigrant forage kochia had spread approximately 7 ft beyond the original plots by the final evaluation despite very low density within the plots.

Round Valley ability to spread[1]						
	1989	1995	1999	2003	2007	2013
GP-52 Synthetic alfalfa						
BC-79 Synthetic alfalfa						
RS-1 bluebunch x quackgrass			9			
RS-2 bluebunch x quackgrass			8			
Fairway crested wheatgrass			8			
Immigrant forage kochia		5	5	3	3	3
Scarlet globemallow						
Bandera Rocky Mt. penstemon						
Cedar Palmer's penstemon						
Appar blue flax						
Paiute orchardgrass						
Ephraim crested wheatgrass		3	7		NA	
P-27 Siberian wheatgrass		3	2		NA	3
Goldar bluebunch wheatgrass		5				
Secar Snake River wheatgrass			9			
Barton western wheatgrass						
Topar pubescent wheatgrass						
Whitmar beardless wheatgrass						
Nezpar Indian ricegrass						
Magnar basin wildrye		7				
Vinall Russian wildrye		3	5		NA	4
Bozoisky Russian wildrye		3	7		NA	4
Yellow sweetclover						
Nordan crested wheatgrass		2	3		NA	

[1] rated on a 1-9 scale (1=best, 9= worst)

Conclusions

In general, introduced species such as crested wheatgrass, Siberian wheatgrass, Russian wildrye and forage kochia showed good to excellent establishment and persistence at sites with lower average precipitation (6-11 in). However at the Bradbury Flat site, native accessions Sodar streambank wheatgrass and two accessions of winterfat also performed well. The two higher precipitation sites (12-16 in), Jeff's Flat and Gooseberry Creek, favored long-term establishment of fine fescues over all other species. Crested wheatgrass, Russian wildrye and Whitmar beardless wheatgrass were the top long-term performers at Centennial Flat, which is intermediate in precipitation (8-12 in).

The ability of Russian wildrye plants to exclude new plants from establishing between the rows is worth noting. Russian wildrye has been found to be an effective species for green stripping (fuel breaks) due to its ability to remain green throughout a longer portion of the growing season than other species, and for its ability to halt the spread of invasive annual grasses that create flash-fuel for wildfires. This study has shown that Russian wildrye can maintain clean between-row spaces with little encroachment from high risk species for over 30 years.

Many species and accessions tested in the trial either failed to establish, or established but did not persist. The low precipitation sites were especially difficult. Forbs had poor establishment at most locations. At Centennial Flat the only forbs to establish and persist to 2013 were alfalfa,

Lutana cicer milkvetch and scarlet globemallow. Alfalfa and yellow sweetclover established and persisted at low densities at Jeff's Flat until the 2007 evaluation. At Gooseberry Creek, Appar blue flax and both accessions of alfalfa had managed to maintain at very low levels (1% stand) in 2013. No forbs persisted at Round Valley or the Spud Alluvial site through 2013.

Based on these findings, introduced species are safe recommendations for range seedings in the Challis, Idaho area on sites receiving less than 12 inches mean annual precipitation. There is however some risk of introduced species spreading under exceptional precipitation periods. On low precipitation sites where native plant communities are desirable, streambank wheatgrass and winterfat are viable options. On higher precipitation sites, many additional native species should be considered.

Rangeland grasses are susceptible to reduction in plant vigor due to old plant residue (litter) buildup in the crowns in the absence of grazing or other disturbance. Without periodic mechanical harvest or proper grazing management, plant litter increases over time and shades the photosynthetically active plant material, reducing ability of the plant to capture sunlight necessary for growth. Stands should be periodically grazed, mowed, burned or otherwise managed to break down old plant residue or litter to help maintain plant health. See Idaho Plant Materials Technical Notes 10 and 11 for more information on range management.

Several new plant cultivars (varieties) that have potential for use in the Challis region have been released since the beginning of this trial. Bozoisky II Russian wildrye was selected for improved seedling vigor (emergence from deeper planting depth), seed yield, vegetative vigor, total dry matter production, and response to drought. Bozoisky II Russian wildrye also has a much broader genetic base than other Russian wildrye cultivars and was extensively evaluated on rangeland sites in the western United States. Vavilov Siberian wheatgrass was released for its significantly improved seedling vigor compared to P-27; and Vavilov II Siberian wheatgrass' improved ability to resist wear and trampling. Because Vavilov and Vavilov II Siberian wheatgrass are tremendous improvements in seedling vigor and trampling resistance, P-27 Siberian wheatgrass was discontinued in 2010. Anatone bluebunch wheatgrass, a recent release of bluebunch wheatgrass has improved seedling vigor allowing it to establish at lower precipitation areas than Goldar bluebunch wheatgrass or Whitmar beardless wheatgrass. Additional new and improved plant releases that should be considered for use in the Challis area include Bannock thickspike wheatgrass, High Plains Sandberg bluegrass, Discovery Snake River wheatgrass, and selections of bottlebrush squirreltail.

TECHNICAL NOTE

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

TN PLANT MATERIALS NO. 63 **JANUARY 2014**

EVALUATION OF PERENNIAL GRASSES USED IN CROSS WIND TRAP STRIPS IN EASTERN IDAHO

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Rush Intermediate wheatgrass cross wind trap strip

Evaluation of Perennial Grasses use in Cross Wind Trap Strips in Eastern Idaho

INTRODUCTION

Wind erosion on cropland can be a serious problem in some areas of eastern Idaho (Figure 1). Transportation of loose, erosive soils on cropland can damage or reduce soil quality and crop productivity. Other negative impacts include degraded water quantity and quality, air quality, and soil biological activity. Cross wind trap strips (Conservation Practice Standard 603) are strips of herbaceous cover resistant to wind erosion established in one or more strips across the prevailing wind direction. Cross wind trap strips can trap windborne sediment and reduce damage caused by erosion. They can also catch other pollutants such as nutrients and pesticides and prevent them from reaching water bodies or other sensitive areas.

This technical note summarizes the evaluation of a cross wind trap strip field planting of seven perennial grass varieties and highlights the benefits as well as management issues of cross wind trap strips.

Carl Ball of Hamer Farms in Hamer, Idaho has used Cross Wind traps strips under sprinkler irrigation for a number of years. He has used tall wheatgrass and basin wildrye in cross wind trap strips to control wind erosion on potato – small grain rotations. The strips are effective in keeping soil on the field for about two years before soil buildup in the cross wind trap strips causes the grasses to become buried and start to thin out. Typically he will maintain the cross wind trap strips for as many as five years.

Figure 1. Example of soil-buried fence row

Cross wind trap strips are established at Hamer Farms at the same time potatoes are planted. This allows for the grasses to establish and the cross wind trap strips to begin to function in the fall after potato harvest when very little residue is left on the field. The cross wind trap strips are planted in 12 foot strips approximately 180 feet apart. The cropping distance between the cross wind trap strips works well for planting and harvesting potatoes and also is acceptable for pesticide application. The cross wind trap strips do add extra work for field activities as far as application of pesticides, harvesting and tillage activities, while working around the cross wind trap strips. With the advent of global positioning systems (GPS) field marking for the cross wind trap strips is much simpler. With prevailing winds from the southwest, the approximate unsheltered distance between strips is 255 feet if strips are planted in a north-south orientation.

Although cross wind traps strips are affective in keeping wind-borne soil on the field, they periodically must be removed to redistribute soil and level the field. Depending on how high the soil drifts are in the cross wind trap strip, disks or road graders are used to break down the drifts and redistribute the soil (Figure 2).

A costly issue for Hamer Farms was infestation of a grain crop with ergot that was probably introduced into one of his fields from infected tall wheatgrass used in a cross wind trap strip. Ergot is a fungus that grows on the florets of rye and related grasses. Ergot produces alkaloids that can cause circulation and neurological problems in humans and other mammals. If ergot is found in a grain crop, it can prevent the sale of the grain. The grain that was infected with ergot had to be cleaned several additional times to remove the ergot before it could be sold.

Other issues with cross wind trap strips include spread of the grass into the cropping area, weed control within the grass strips, and spray drift from treating potatoes with herbicides to control grassy weeds. Gaps in the cross wind trap strips can also occur if grasses do not establish. Irrigation of crops can also affect establishment and growth of the grass if too much water is applied to negatively affect grass growth.

Figure 2. Faint remnant of grass strip hump in field

In 2009, Hamer Farms contacted J. Howard Johnson, NRCS District Conservationist in the Rigby, Idaho Field Office to discuss the possibility of evaluating other grasses that could be used in cross wind trap strips. A field planting was planned and installed with technical assistance and grass seed provided by the NRCS Plant Materials Program.

BACKGROUND INFORMATION ON FIELD PLANTING

The field used for the study is under center pivot sprinkler irrigation with a wheat – potato crop rotation in MLRA 11(Snake River Plains). The soils are classified as Corassy Butte Loamy Sand, 2-4 percent slope with a southwest aspect at 4800 feet elevation. Soil pH is 6.6-8.4 and the soils are highly erodible by wind. The purpose of the field planting was to evaluate the performance of tall grass species in cross wind trap strips with special emphasis on finding grass species that have the best ability to regrow up through drifting sand.

FIELD PLANTING PLANNING AND INSTALLATION

A planting plan was developed and submitted to the Idaho/Utah Plant Materials Specialist who provided additional input to the plan and then contacted plant materials centers to provide seed of 'Rush' and 'Manifest' intermediate wheatgrass, 'Bozoisky' and 'Mankota' Russian wildrye, 'Luna' pubescent wheatgrass and 'Alkar' and 'Largo' tall wheatgrass. Ten strips were marked out in the field approximately 180 feet apart running north and south and the seed was planted with a 12 foot wide Brillion drill with six inch row spacing in June 2009 into a clean, firm seedbed. Figure 3 is an aerial photograph of the field and shows the layout of the cross wind trap strips. The seeding rate was approximately ten pounds PLS/ac for all strips. The strips were irrigated along with the crops growing in the field.

EVALUATION

The field planting was evaluated on September 24, 2010 (near the end of the second growing season of the cross wind trap strips). The data is summarized as follows:

Variety	Stand	Density ($Plt/ft^{2)}$	Vigor	Height (inches)	Plant injury	Weed infestation	Yield (Tons/ac)	Erosion control
Rush	Excellent	4	Excellent	68	None	None	5	Excellent
Manifest	Fair	4	Fair	50	Drifting	None	2	Fair
Luna	Excellent	4	Excellent	53	Drifting	None	3	Good
Bozoisky	Excellent	6	Fair	20	Irrigation	Light	1	Poor
Mankota	Excellent	6	Fair	20	Irrigation	Light	1	Poor
Alkar	Good	5	Excellent	68	None	Light	4	Good
Largo	Excellent	3	Excellent	72	Drifting	None	5	Excellent

Rush intermediate wheatgrass produced an excellent stand and was rated excellent for use in cross wind trap strips (cover photograph). Manifest intermediate wheatgrass (Figure 4) produced good stands but was not as vigorous. Heavy sand drifting also affected the Manifest stand and ergot was present in the seed heads (Figure 5). Bozoisky (Figure 6) and Mankota Russian wildrye produced very thick, short stands and were not very well suited for cross wind trap strips. Russian wildrye has a very vigorous root system and crowding it into tight row spacing will inhibit its growth. Irrigation of the field crops may have been excessive for this species also. Alkar (Figure 7) and Largo (Figure 8) tall wheatgrass also had excellent height and density but sand drifting was beginning to affect the plants. Luna pubescent wheatgrass (Figure 9) had good

height and stand density for erosion control but the stand was spotty, also had ergot, and was being affected by sand drifting. The cross wind trap strips were removed in the spring of 2013.

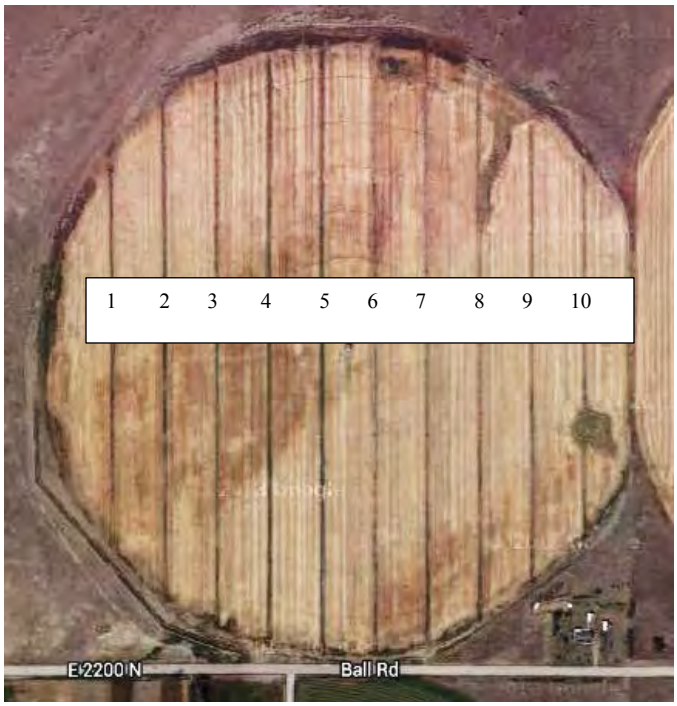

Figure 3. Cross Wind Trap Field Planting, Hamer Farms

Row Number	Grass Variety
1 and 2	Rush intermediate wheatgrass
3	Bozoisky Russian wildrye
4	Mankota Russian wildrye
5	Alkar tall wheatgrass
6	Largo tall wheatgrass
7 and 8	Manifest intermediate wheatgrass
9 and 10	Luna pubescent wheatgrass

CONCLUSIONS

Based on the evaluation of this field planting, Rush intermediate wheatgrass and Largo tall wheatgrass provided the best erosion control followed by Alkar tall wheatgrass and Luna pubescent wheatgrass. Manifest intermediate wheatgrass had only fair erosion control. Intermediate and pubescent wheatgrass are mildly rhizomatous and sod-forming and will spread more readily into the cropping area. The Russian wildrye varieties Bozoisky and Mankota are not well suited for cross wind trap strips because the bulk of plant growth is basal and they only had fair vigor, likely due to excessive irrigation for the species. Tall wheatgrass and Russian wildrye are bunch grasses which are less likely to creep into the cropping area. The only other tall perennial grass that could be used in cross wind trap strips in eastern Idaho is basin wildrye but it is highly susceptible to ergot.

Cross wind traps strips can be used in the NRCS Wind Erosion Prediction System (WEPS) to adjust for un-sheltered distance. Greater un-sheltered distance results in predicted higher rates of

wind erosion and conversely, smaller un-sheltered distance results in predicted lower rates of wind erosion. Cross wind trap strips are an effective conservation practice to keep blowing soil on a field but are not a permanent solution to control wind erosion and have management issues that must fit into a farming operation.

Figure 4 Manifest intermediate wheatgrass

Figure 5 Manifest intermediate wheatgrass with ergot

Figure 6 Bozoisky Russian wildrye

Figure 7 Alkar tall wheatgrass

Figure 8 Largo tall wheatgrass

Figure 9 Luna pubescent wheatgrass

TECHNICAL NOTE

USDA - Natural Resources Conservation Service
Boise, Idaho – Bridger, Montana – Portland, Oregon – Spokane, Washington

Plant Materials Technical Note No. 65 **June 2014**

Planning and Implementing a Seeding in Sage-Grouse Country

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This Technical Note is based on a webinar created by the Western Plant Materials Consortium for the NRCS and partner staff working on sage-grouse conservation. It is intended to provide information for planners and practitioners to make the best decisions possible when restoring or rehabilitating sagebrush ecosystems, while acknowledging the real-world compromises that are often encountered.

Introduction

The sagebrush steppe represents one of the largest ecosystems in North America. Significant efforts are underway across the west to conserve and restore sagebrush steppe, especially to reverse long-term declines in habitat quantity and quality for obligate wildlife species like sage-grouse. Restoration actions often involve seeding desired plant species to achieve resource objectives. However, seeding in arid rangeland settings like the sagebrush steppe can be a daunting task because of challenges with site limitations, species selection/availability, costs and risks. Conservationists need to be equipped with the best available information throughout the seeding process to set expectations appropriately and increase the likelihood of success wherever possible.

Planning should follow the old carpentry adage, "measure twice, cut once", or in other words, make sure the project is well thought out and all contingencies well planned before executing the seeding. It is not uncommon for planners to want to select species and procure seeds prematurely, but as will be described, species selection depends on many factors, not the least of which is commercial availability and cost. Considering information about the landscape context and site conditions will be necessary to improve the likelihood of achieving desired outcomes.

Time restraints, limited capability for adequate field preparation and weed control, and the availability and cost of native seed, hinder our abilities to rehabilitate sagebrush steppe. Invasive annuals like cheatgrass have significantly altered the environment, making traditional restoration approaches insufficient. Achieving optimal habitat from a heavily degraded site often requires multiple intermediate steps over several years. This Technical Note conveys key considerations, tools and resources to help practitioners plan and implement seedings, in light of these real world constraints, to maximize the likelihood of seeding success.

I. Planning

Landscape context is a primary consideration when planning seedings to benefit wildlife species like sage-grouse. We often spend a lot of time measuring and managing for habitat conditions at the site scale since that's where we work. However, we first need to pick our heads up and look around to understand the type of landscape the project site is set in.

Sage-grouse are considered a "landscape species" which means they require vast areas, often multiple watersheds in size, to fulfill their life history requirements. A prerequisite to supporting healthy sage-grouse populations is having large and intact areas supporting sagebrush rangelands instead of other land uses/cover types (e.g., cropland, annual grasslands, and juniper woodlands). As a general rule, birds do best in landscapes where >2/3 of the area is in sagebrush rangeland but have trouble persisting with <1/3 of the landscape in sagebrush communities.

This is relevant to seeding decisions because significant investments can be made in restoration of a really high quality patch, but if it's set in a fragmented landscape, it may not generate the desired outcomes for grouse. Planners should utilize available spatial data and local wildlife agency expertise to gauge the relative likelihood that site-scale restoration efforts will meet

project goals and objectives. If an evaluation of the landscape context reveals site level restoration would be beneficial, the next step is to begin to understand the ecology of the site.

Think about the ideal sagebrush ecosystem. What do you see? Most of us probably envision a sagebrush stand that's not too dense, with abundant forbs and grasses. But the sagebrush ecosystem is incredibly diverse and occurs across broad environmental gradients (Figure 1). Figuring out where the site you're working with falls along this gradient is pivotal to understanding the inherent site potential, limitations and risks.

Figure 1. The idealized vision of a sagebrush ecosystem.

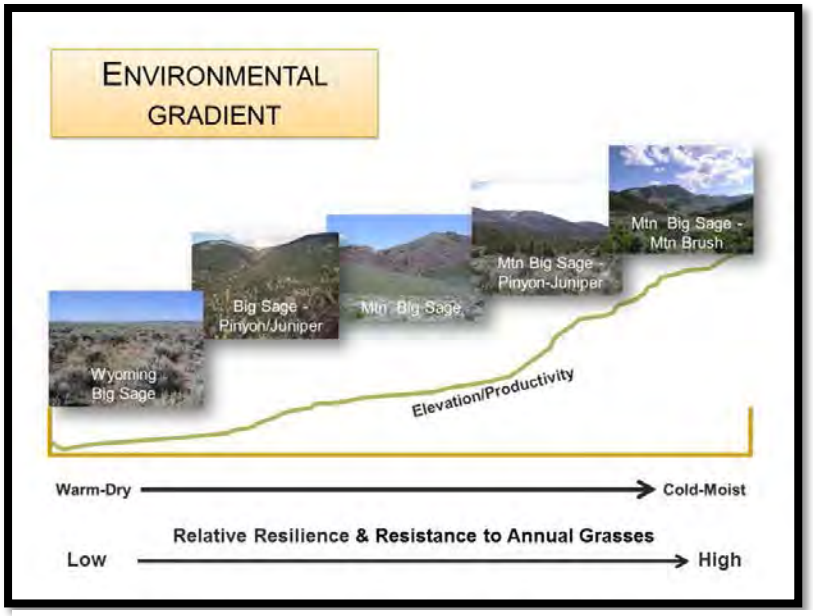

Figure 2. Sagebrush ecosystems are diverse and occur over a broad environmental gradient (modified from Chambers and others, In Press). Restoration risks and options vary considerably across ecosystem types.

Along this gradient, many defined ecological sites exist (Figure 2). An ecological site is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation. Ecological Site Descriptions (ESDs) provide a wealth of information about the site needed to make informed restoration decisions.

Once we know the type of site we're dealing with, we can gain a better understanding of vegetation dynamics through the state-and-transition model (STM). State-and-transition models are important conceptual tools that provide information on possible plant community states and phases, expected response to disturbances, and what pathways for recovery exist. Figure 3 shows one generic STM example with four possible states: reference, invaded, annual, and seeded states. Within each state are plant community phases that can shift back and forth. Each has its own

risks, recovery potential, and ability to support sage-grouse. Determining which state best characterizes your site will help you determine the appropriate role of seeding.

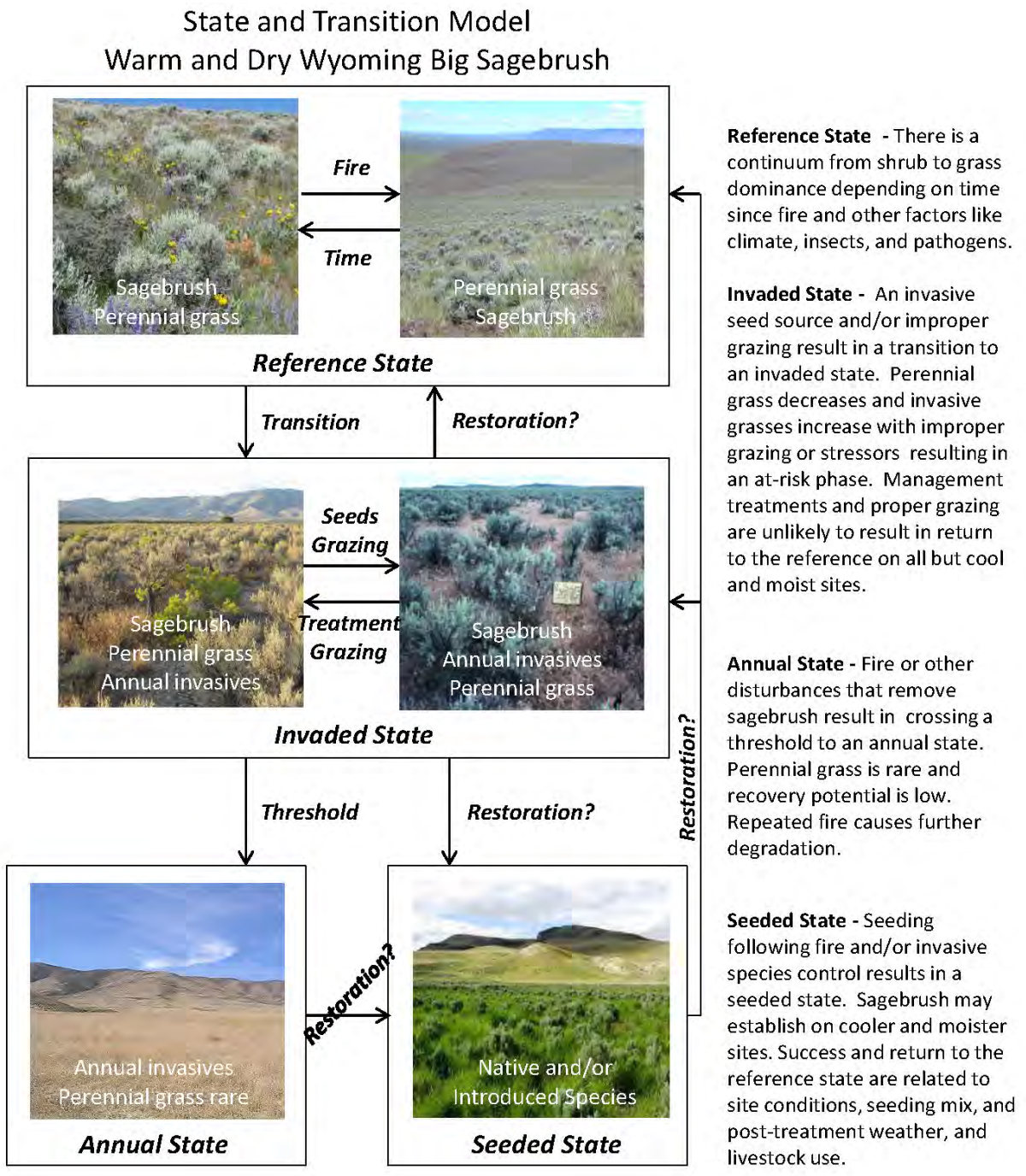

Figure 3. A generalized state and transition model that illustrates vegetation dynamics and restoration pathways for the warm and dry Wyoming big sagebrush ecological type (Chambers and others, In Press).

One of the first questions to be answered when looking at a site that needs vegetative improvement is: *"what is the best approach: re-seeding or better managing what exists on the*

site?" Seeding can be a risky proposition and may not be the best answer. For example, it might be preferable to manage the site to allow natural recovery to occur, especially if adequate amounts of desired species are present (e.g., desired species >25% of the total vegetative composition). (See Table 1).

In the Intermountain West, a large portion of non-irrigated plantings fail for one reason or another, with sites receiving fewer than 10 inches annual precipitation having the highest failure rates. A recent study examining 101 post-wildfire seedings in sagebrush steppe found that restoration actions did not increase the probability of burned areas meeting sage-grouse habitat guidelines, and that sage-grouse were found to be unlikely to use many burned areas within 20 years of fire regardless of treatment (Arkle and others 2014). Furthermore, seed and site preparation costs are high, which make multiple interventions unpalatable even when they may be needed.

It's important to keep in mind there are circumstances when seeding is not the best conservation solution, and can actually make an existing problem worse if the seeding fails! Plantings using complicated seed mixes occurring in areas of low annual precipitation, and sites with a heavy weed infestation are particularly prone to failure, thus requiring extra care. Inter-seeding into existing vegetation is seldom successful, which makes habitat enhancement projects especially difficult.

Regardless of your decision, planting or managing, it is important to spend adequate time evaluating landscape and site-scale information to determine the best course of action.

Table 1. To seed or not to seed? Ask yourself…

- Where is the site along the elevational /temperature/moisture gradient? Higher elevation, cooler and moister sagebrush sites often do not require re-seeding after disturbance.
- What is the current composition of desired plants? If desired species represent less than 25% of the existing on-site plants, then consider re-seeding
- What is the risk of invasive species? If current pressure from cheatgrass or other invasives is high, seeding desired perennials may be needed to stabilize the site.

Site and Resource Inventory

Once the decision has been made that seeding is warranted, it can be easy to get ahead of oneself in planning a seeding and to jump to species selection. Selecting the right plant species, deciding if the planting should consist of all native species, all introduced species, or a combination of both, and which cultivars or selections should be specified, will all be influenced by the site conditions as well as planting goals. A good site inventory is the first step towards a successful project.

Climate

Once it is determined that simply managing the site will not provide the desired results and that a new planting is needed, one of the first tasks is to complete a site inventory (Figure 1). This information will help you select the right plants, prepare the site properly and plant at the best time. One of the first things you should obtain is basic climate data. You want the most localized

information possible. You will want to know growing season length as determined by average first and last frost free dates. This helps identify which plants will be used as well as when you will be doing the seeding. You will want to note the monthly average high and low temperatures which again effects which plants are selected and when they are planted. And, most importantly, determine the total amount of precipitation received each year as well as its seasonal distribution.

Figure 4. A post-burn site in Hailey, Idaho. Before attempting any seeding, planners should properly understand the climatic and soil properties of the site. Photo by Derek Tilley, NRCS.

Soils

Understanding the soil properties can help you select the correct plants as well as find out if the site has characteristics that could impact planting installation or survivability of the seedlings. Soil chemistry including salinity and pH are important in determining well adapted species. Determine the site's predominant soil texture and the general lay of the land, as this greatly influences which species should be grown. Is your land on a slope (i.e., it drains well) or is it at the bottom (where water puddles)? A soil with a high clay content will tend to retain water. Sandy, gravelly and rocky soils will tend to drain quickly. If the site has low water holding capacity, is sandy or gravelly, the plants will become drought stressed fairly easily, and drought tolerant species should be selected. Species that have good tolerance for wet conditions should be selected for poorly drained sites.

Specific plant species characteristics and adaptations should be matched to soil and climatic conditions, as well as intended use of the planting.

Weeds

Proper control of weeds cannot be understated, as planting failure resulting from weed competition is common. It is crucial to understand the weeds present at a site, their abundance or density and the likelihood of an underground seed bank.

Cheatgrass and medusahead wildrye are perhaps the most common and most problematic weeds in sage-grouse habitat restoration (Figure 5). Both are winter annuals, germinating considerably earlier than most native species. This gives the weeds a significant tactical advantage in

Figure 5. Introduced annuals like cheatgrass compete against seeded species for moisture and nutrients. Weeds need to be controlled for seedings to be successful. Photo by Cassondra Skinner @ USDA-NRCS PLANTS Database

the fight for spring moisture and available soil nutrients.

Obtaining adequate weed control takes time and effort. In some cases two years of tillage and/or chemical fallow is necessary to significantly reduce long term competition. In the planning phase it is important to consider how much will be required to control the current competition as well as weed seed bank implications. One should also consider the possible secondary effects of weed control such as residual herbicide activity and increased erosion. Post seeding herbicide treatment options are limited, especially where forbs and shrubs are planted. University Extension weed control specialists are an excellent resource for herbicide questions.

Equipment

Once the soil properties and plant competition levels of a site are understood you can determine what type of equipment is needed for site preparation and planting. Drill seeding is far more effective at establishing grasses than broadcast seeding methods and is strongly recommended when feasible. Aerial seeding is often used for large areas of land, but the resulting seed-to-soil contact is poor and establishment rates may be significantly reduced.

Availability and cost of the necessary equipment are often a major factor, and conservationists are forced to use the best option at hand. A lack of availability of certain equipment may also limit your species options and may make seeding a particular site very difficult if not impossible. Consult with your state Plant Materials support staff to explore options.

Species Selection

In addition to many climatic and environmental considerations when selecting plants, there are numerous plant characteristics that need to be taken into account. These might include the species' competitive ability with weeds and other vegetation, their longevity or lifespan, i.e., are they annuals, short lived perennials, or long lived perennials, and are there distinctive growth habits of the species (bunch grass or sod-forming)?

Table 2. Native or Introduced?

Native
- (+) Well adapted to environmental extremes
- (+) Function well as part of native plant community
- (-) May not compete well with introduced weeds
- (-) May be difficult or slow to establish, especially where noxious weeds are prevalent

Introduced
- (+) Well adapted to environmental extremes
- (+) May compete well with introduced weeds
- (+) Typically easy/quick to establish
- (-) May form monocultures with limited diversity
- (-) Concerns about spreading into non-target areas

When properly applied, both native and introduced plant species serve a function in resource conservation. One of the major factors determining whether a seeding succeeds or fails is the weather during the first year of establishment. Natural weather patterns allow for recruitment from native stands only periodically. In low precipitation years the seed is preserved in the soil seed bank waiting for the right conditions in which to germinate. However, cheatgrass and other annual weeds can germinate and thrive under droughty conditions and create a landscape in which native species compete very poorly. Although not preferred for sage-grouse habitat, introduced perennial species can be useful in quickly stabilizing sites at risk of invasive species conversion and help prepare a site for future improvements.

Table 2 gives some of the pros and cons associated with the two types of conservation plants. The appropriate choice depends on many factors, but the most important are: what is the planner's objective and what is the environment into which the planting is going to be made? If the site is heavily infested with cheatgrass, especially at lower precipitation zones, use of introduced species capable of competing with the cheatgrass may be a better option than currently available native plant cultivars. Converting a site from cheatgrass directly to a diverse native community is highly unlikely.

Intermediate steps such as the establishment of introduced perennial species to restore ecosystem function may be required before a native species mix can be successfully introduced. There may be times when both may be appropriate to use, for instance, using natives in island type plantings, while seeding the open heavily weed infested areas with competitive introduced species.

Site Preparation

Site preparation is a critical and often overlooked step in the restoration process. How it is approached depends on variables such as topography, project scope, site disturbance considerations, likelihood of weed invasion, and of course, cost. Site preparation for most sage-grouse habitat projects, given their typically large scale, will generally fall into the first category, involving litter removal or dispersal, followed by chemical weed control and then dormant fall seeding.

On smaller, more intensively managed landscapes, conventional agronomic site preparation such as disking or even plowing may be possible. Use of seed drills (planters) may also be feasible if the site is level and accessible. Site preparation measures such as these will improve seed to soil contact and may improve stand establishment, although the cost may be relatively high.

Typical Protocols for Preparing a Seedbed Currently in Perennial Vegetation

1) Shred or burn existing litter		1) Plow 1st spring
2) Apply herbicides 1st spring, again in fall if green-up occurs		2) Disk 1st fall
		3) Disk 2nd spring
3) Apply herbicides 2nd spring, again in fall if green-up occurs	OR	4) Disk 2nd fall and mechanically prepare final seedbed
4) Plant new seed mixture as a dormant planting		5) Plant new seed mixture as a dormant planting

It is important to remember that these are starting recommendations. Each site is different and may require variations to this starter recommendation. The bottom-line message is that competition needs to be controlled and the seedbed must be in the best condition possible to facilitate seed germination and establishment.

Weed Control

The presence of weeds (especially noxious weeds) will also determine the methods used to prepare a good seedbed and to have a successful seeding (Figure 6). For successful establishment, seeding fields with significant weed populations must be delayed until weeds are controlled. Refer to the Pacific Northwest Weed Management Handbook and Montana-Utah-Wyoming Weed Management handbooks for information on herbicides that can be used for weed control during seedbed preparation and establishment.

Figure 6. When feasible, herbicide treatments can be an effective means of controlling weeds or eliminating competition from established introduced perennials. Photo by Loren St. John, NRCS.

Other sources of information include extension specialists, county weed control supervisors and chemical dealers. Guidelines for Integrated Pest Management are available in the electronic Field Office Technical Guide (EFOTG) section IV, Practice Standards. Always read and follow label instructions when applying herbicides.

II. Common Scenarios

To illustrate the variety of conditions encountered in Intermountain Western rangelands, we highlight four scenarios and discuss possible treatment options. Keep in mind though, all sites are unique and should be approached with an open mind.

Figure 7. N-sulate floating row cover is laid over small islands seeded to forbs and shrubs. Photo from UDWR.

Scenario 1: Low precipitation/ mostly native grasses/ poor cover/ few forbs

In this scenario the site is in a low precipitation area receiving less than 12 inches precipitation annually. The cover is predominantly native species but could use an increased forb component as well as increased sagebrush cover.

In general, sites like this are probably best left alone to allow nature to take its course. Any ground disturbance like tillage or herbicide treatments to prepare for a seeding has the potential to allow undesirable weeds to establish. If the ground has already been disturbed by wildfire, this

site would be a good candidate for a diverse native seed mix. Interseeding (planting directly into existing cover), though tempting, has been proven to be largely ineffective and is not recommended. It may be possible to clear isolated areas for the establishment of small pockets or islands of forbs and shrubs using seed or nursery developed materials. In the picture, forb islands are being covered with a floating row cover commonly used in vegetable production to improve soil moisture by reducing evaporation (Figure 7).

Scenario 2: Low precipitation/ introduced perennials or annual weeds dominate

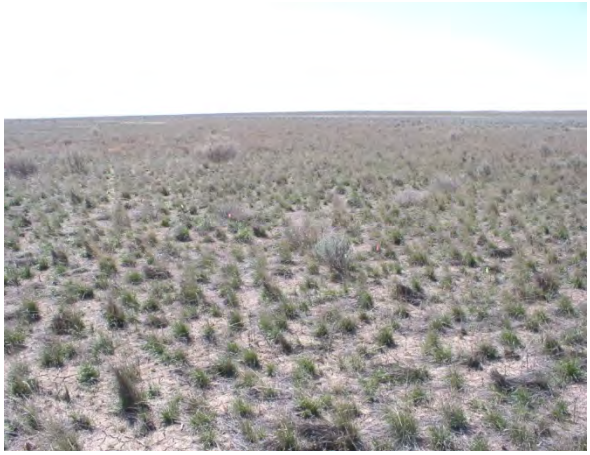

Figure 8. Scenario 2, a low precipitation site dominated by introduced perennials. Sites like these typically require a significant amount of preparation before a native seeding mixture can be successful. Photo by Derek Tilley, NRCS.

The second site is also a low precipitation area but is dominated by introduced species (Figure 5). A post-fire seeding of natives on a site like this without further site preparation is likely to fail. Introduced perennials like crested wheatgrass and intermediate wheatgrass are extremely competitive and are not typically reduced significantly from a single fire event. Additionally new seedlings from introduced perennials as well as cheatgrass and other annuals are more vigorous and can out-compete the majority of our available natives. Multiple site preparation treatments of tillage or chemical fallow are required to kill the existing stand and reduce the seed bank to a degree where natives will establish and persist. If site preparation treatments are not an option, consider improving ecosystem function by seeding a more diverse mixture of introduced species.

Scenario 3: Higher precipitation/ strong native plant community

The third site may be a location that receives 14 or more inches mean annual precipitation. There is a strong native plant community mostly consisting of perennial grasses. If there is little threat from weeds, then patience may be the best option. The site is likely recovering from a burn in the recent past and could be naturally moving towards the desired plant community. Again, forb or shrub islands and mother plants may be an option to hasten the process. If this is a post-fire seeding then a diverse native mix is recommended.

Scenario 4: Higher precipitation/ high weed pressure

The final site is a higher precipitation area but has a well-established community of invasive weeds. The most important thing to do here is control the weed population. A post-fire seeding may be initially successful, but the weeds will return if not properly treated. If the site is dominated by broadleaf weeds such as knapweed or yellow star thistle, it may be advisable to establish perennial grasses to allow for subsequent treatments of selective broadleaf herbicides. A more diverse native species mixture can be introduced at a later time when conditions are more favorable.

III. Developing Seed Mixes

Often the greatest technical challenge for planners and land managers when developing a seeding mix is choosing the species, determining their relative percentages in the seeding mixture, and then making the appropriate seeding rate calculations. In the following section we show how to develop a site specific seed mixture that is adapted to the local conditions and approximates the reference state plant community.

What Do I Need to Figure Out?

The answer depends on how much information is available, the complexity of the seeding mixture, the need for specialized carriers and equipment, the species selected, and the severity of the site disturbance. In almost all cases, planners will need to know how much seed (number or weight of live seeds) to apply per unit area. Adjustments will need to be made based on Pure Live Seed versus bulk seed, the quality of the seed lot used, if the seeding is broadcast sown versus drilled, if the site is a critical area planting or not, and if seed carriers are needed**.**

Since most seedings in sage-grouse country will involve relatively large acreages of rangeland, we show how to develop a mix for a broadcast seeding as well as a drill seeded mix. Both "good" sites, as well as "critical" or highly disturbed sites will be addressed. It is important to note that most seeding rate recommendations are based on "good" sites and the use of specialized planters; therefore, seeding rates must be adjusted accordingly when they are broadcast or the site is considered highly disturbed.

Which Species and Relative Amounts in the Mix? – Begin with Ecological Site Descriptions (ESDs)

Without experience, choosing the plant species to use and determining their relative percentages in a seed mix can be pretty intimidating. For sage-grouse habitat restoration in rangeland, an excellent starting place is the Ecological Site Description or ESD. These inventories provide a wealth of important information regarding site conditions and the types of plant species you might expect growing there.

The plant species are organized by life form (grasses, forbs, and woody plants), and their estimated anticipated annual production in the plant community. Although a relatively crude extrapolation, this information can be used to estimate the relative percentages to include in a mix, although availability and cost will certainly influence the final composition of the seed mix.

In this example from MLRA 25 in southwestern Idaho, grasses make up approximately 55% of the annual production on the site, while forbs account for approximately 15% and shrubs make up the final 30%.

Site name: **LOAMY 10-13 ARTRW8/PSSPS**
/ Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata
(/ Wyoming big sagebrush / bluebunch wheatgrass)
Site type: Rangeland
Site ID: R025XY019ID
Major land resource area (MLRA): 025-Owyhee High Plateau

	Annual Production (lbs per ac)	
1 -Grass/Grasslike	220	600
2 -Forb	55	170
3 -Shrub	125	330

The species composition tables provide additional production estimates of the dominant species in the plant community. The table below shows the composition of the grass and grasslike species at the site (Table 3). We would certainly want to include a substantial percentage of bluebunch wheatgrass in a seed mixture. We might also want to include a small portion of some of the other grasses concentrating primarily on the bunch grasses. If a particular species is not commercially available, choose species which are functionally or structurally similar. The same steps should be followed to decide on forb and shrub composition in the seed mix.

Table 3. Annual production estimates of grass/grasslike plants at LOAMY 10-13 ARTRW8/PSSPS

		Annual Production (lbs per ac)	
Common name	Scientific name	Low	High
		220	600
Indian ricegrass	*Achnatherum hymenoides*	5	20
Thurber's needlegrass	*Achnatherum thurberianum*	10	30
bottlebrush squirreltail	*Elymus elymoides*	10	30
thickspike wheatgrass	*Elymus lanceolatus*	1	15
Nevada bluegrass	*Poa nevadensis (syn)*	1	10
Sandberg bluegrass	*Poa secunda*	10	30
bluebunch wheatgrass	*Pseudoroegneria spicata* ssp. *spicata*	160	440

The final seeding mixture will reflect what is commercially available and within project budget. The NRCS Plant Materials Program has numerous well-adapted selections and can help planners decide which selection, if any, is best suited for the site and for enhancing or restoring sage-grouse habitat.

Forbs for sage-grouse habitat are particularly challenging as there are many fewer selections of native forbs available on the commercial market than grasses, and they are often very expensive. Many native forbs utilized by sage-grouse are poor seed producers or do not lend themselves to

mechanized seed production. There are currently no cultivars or tested plant materials available for any of the forbs or shrubs from this example ESD (Table 4). Wildland collected seed may be available, but it is likely to be expensive and its performance is unknown. Choosing related or similarly functioning species is often a real world compromise when selecting forbs for the seed mix.

Table 4. Annual production estimates of forbs at LOAMY 10-13 ARTRW8/PSSPS

		Annual Production (lbs per ac)	
Common name	Scientific name	Low	High
		55	170
pussytoes	*Antennaria*	1	5
aster	*Aster*	5	15
milkvetch	*Astragalus*	1	10
Hooker's balsamroot	*Balsamorhiza hookeri*	0	10
arrowleaf balsamroot	*Balsamorhiza sagittata*	10	30
tapertip hawksbeard	*Crepis acuminata*	10	20
larkspur, tall larkspur	*Delphinium*	1	5
erigenia	*Erigenia*	5	15
biscuitroot	*Lomatium*	1	5
lupine	*Lupinus*	5	15
Hoods phlox	*Phlox hoodii*	10	20
longleaf phlox	*Phlox longifolia*	10	20

As with forbs, shrubs are also less available and harder to establish than grasses. Success with shrub seeding is often much lower than grasses or even forbs, especially in low annual precipitation zones. Seeding or planting of seedlings in island plantings could be considered to establish woody plants in rangeland sites, although this too is far from guaranteed success.

Table 5. Annual production estimates of shrubs at LOAMY 10-13 ARTRW8/PSSPS

		Annual Production (lbs per ac)	
Common name	Scientific name	Low	High
		125	330
Wyoming big sagebrush	*Artemisia tridentata* ssp. *wyomingensis*	100	275
green rabbitbrush	*Chrysothamnus viscidiflorus*	10	30
buckwheat	*Eriogonum*	5	15

Sagebrush species and subspecies have narrow parameters of adaptation. Proper identification of species and subspecies is critical for the long-term restoration of sagebrush ecosystems. There is also increasing evidence supporting the importance of locality with regards to sagebrush establishment and persistence. Whenever possible, sagebrush seed should originate from the same Major Land Resource Area as the intended planting site. Additionally, sagebrush has small, relatively short-lived seed. It can easily be planted too deeply, and seems to establish better when properly broadcast than drilled.

Table 6. Possible sources for plant composition when ESD not available

- Major Land Resource Areas (MLRAs)
- Soil Survey information
- Habitat types
- Botanical surveys
- Study results
- Stand-alone publications
- Local experts

Ecological Site Description Not Available?

So what do you do if an ESD on your proposed project site is not available? There are many other sources of information that can be used to provide clues into site conditions and potentially adapted species (Table 6).

Remember, nothing is better than an on-site survey of the project site prior to seed mixture development. If the site has been recently disturbed, attempt to find undisturbed plant communities in close proximity or in a similar environment. An often overlooked resource is a local land manager, professional or private, that has knowledge of the site and climate in the restoration area. Such individuals provide invaluable plant community insight, and may save precious time and monetary resources when consulted early in the planning process.

Plant Materials Selections and Other Seed Sources for Sage-grouse Habitat Restoration
It's important to keep in mind that many native plant species may not be commercially available or are currently prohibitively expensive. To address these issues, the NRCS Plant Materials Program has developed a brochure titled, "*Improving Sage-grouse Habitat Through Revegetation and Rangeland Management*", providing lists of plant selections that may be used in seed mixes for enhancing or restoring sage-grouse habitat. This brochure lists plant selections from Plant Materials and other programs that should meet the functional requirements of each species and life form when attempting to establish a plant community capable of supporting sage-grouse habitat.

The Plant Materials Program has also developed some excellent resources regarding plant species characteristics and seeding installation. Visit your state NRCS Plant Materials Center website for these and other publications.

Plant Materials Tech Note 10 "Pasture and Range Seedings Planning-Installation-Evaluation and Management" provides information on planning, implementing and evaluating seeding projects.

Montana Plant Materials Tech Note 46 "Seeding Rates for Conservation Seedings" and Idaho Plant Materials Tech Note 24 "Conservation Plant Species for the Intermountain West" have detailed information on most conservation species.

Seed Mixture Considerations
Some general rules of thumb should be applied for developing seed mixtures. For dryland situations, choose 6 to 10 species including grasses, forbs and shrubs. Adding additional species generally increases cost but does little to increase overall diversity. Be mindful of compatibility issues. For example, will one species crowd out other species. You should also be aware of recommended seeding depths for each species. When using a seeding drill, deep seeded species and shallow seeded species should be planted separately, if possible. If separate seeding is not feasible, then the shallower depth should be used.

Extra consideration should be used when combining native and introduced species together. This practice is generally not recommended, as introduced species are very competitive and may out-compete native plants. However, introduced forbs such as alfalfa, blue flax and small burnet can be successfully established with native grasses.

When developing a seed mix one should consider the expected life span of the species. Some species have relatively short life spans, such as slender wheatgrass and, usually, should not make

up more than a fraction of the mix. These species are often fast at establishing and including them will help get a stand established while the slower and longer lived species develop.

Another thing to consider is whether or not the seed needs a pre-treatment. Many, if not most, native forbs require a cold stratification period in order to germinate. These species are typically planted in the fall rather than the spring to allow for natural stratification. Additionally, legume seed should be inoculated with the proper rhizobacteria prior to planting. Legume seed often has a hard seed coat which may need to be mechanically or chemically scarified to allow immediate germination. This is most often handled by the seed vendor and should be specified when purchasing the seed.

Example Seed Mix

Using the species composition from the ESD on page 10, one can determine relative percentages of grasses, forbs and shrubs at the site and develop a mixture approximating those proportions (Table 6). The information found in ID Tech Note-24, MT-46, Plant Guides and other sources can be used to select species not on the ESD suitable to the site, and guide decision making regarding cultivars or releases.

This sample mix includes a high percentage of bluebunch wheatgrass, a small component of Nevada bluegrass and Indian ricegrass, and a minimal amount of the sod forming grass, thickspike wheatgrass (Table 7). Also included is a low percentage of slender wheatgrass, a vigorous but short-lived perennial bunchgrass used to provide immediate cover and site stabilization. The forbs Lewis flax, yarrow and Palmer penstemon make up a relatively small amount of the overall mix reflecting the abundance of forbs in the ESD, as do the shrubs winterfat and Wyoming big sagebrush. Though the mix is not made of the exact species from the ESD, the species chosen are known to be commercially available and perform similar ecological functions to those in the reference state.

Table 7. Sample mix developed for LOAMY 10-13 ARTRW8/PSSPS

Species	Recommended Percentage in Mix
Bluebunch wheatgrass	40
Indian ricegrass	10
Nevada bluegrass	5
Thickspike wheatgrass	5
Slender wheatgrass	5
Lewis flax	5
Yarrow	5
Palmer penstemon	5
Winterfat	10
Wyoming big sagebrush	10

IV. Seed Quality: Not All Seed is the Same!

The quality of the seed of each lot in the mix is extremely important. When possible, always attempt to procure certified seed which has been inspected and is held to quality standards for germination, weeds, other crops and inert material. If certified seed is not available, make sure to request a full laboratory analysis (not just a seed tag) so that you know exactly which species of Other Crops and Weeds are in the sample. It will also be important to know how processed (how well cleaned) the seed is, as this characteristic will greatly influence mixing and seed flow through equipment. If you have questions about seed quality you can call a Plant Materials Center or seed certification office for advice. Montana Tech Note 67 is an excellent reference for this subject.

Seed Classes

It can be important in some cases to consider the different seed characteristics of each release class since the amount of testing, and therefore the anticipated performance, is reflected by the Release Class (Table 8). Source Identified seed has had no performance testing, but may have originated from a site nearer the intended seeding. Selected and Tested Class seed has undergone limited evaluations at a Plant Materials Center or similar facility and has documented performance. Cultivars have been tested extensively for multiple generations and in numerous locations; however, selection of certain traits may have narrowed the genetic diversity of the seed. Wildland and some common seed have virtually no performance pedigree, and are rarely certified, but may be the only materials available for use.

Table 8. Comparison of seed releases classes.

Source Identified	Selected/Tested Class	Cultivar
(-) No performance testing	(+) Some performance testing	(+) Performance known and tested in multiple environments
(-) Seed quality tests may be lacking	(+) Limited plant selection, so genetics little altered	(+) Usually establishes readily
(+) Seed can come from similar area or wildland collected from area to be planted with appropriate lead times	(+) Selection often grouping of better performing lines from within an ecological region	(+) Certified seed available
(-) Certified seed often not available	(+) Certified seed often available	(+) Seed relatively inexpensive
(-) Seed often expensive	(-) Level of testing not as thorough as cultivars	(-) Concerns by some that genetics have been narrowed which may affect performance and persistence

Certified seed

Certified seed insures the quality of the product and protects the buyer. It provides third party verification for seed collectors and growers. An independent certification agency verifies seed origin and generation, inspects production fields to verify isolation distances and control of weeds, and seed cleaning facilities are also inspected. If all the standards are met, then the seed lot can be tagged with Certification labels.

Certified seed is highly recommended for conservation seedings. Use of certified seed insures quality, which improves the chances of a successful planting. Some NRCS states actually require the use of Certified seed for cost-shared practices. Be sure to check your state standards.

Common seed

If you cannot obtain Certified seed, you may be able to purchase common class seed, but buyer beware. You may not be getting what you think you are or what you were willing to pay for. It may be a named variety but not grown under certification program or it may not have met certification requirements. Remember, you still must be provided a seed tag, and it is especially important to ask for a seed analysis report when the seed lot is not certified.

Figure 9. Seed purity and viability determine the quality and value of the seed. Photo by Derek Tilley, NRCS.

Pure Live Seed

All NRCS seeding recommendations are based on Pure Live Seed (PLS) rates. This value indicates the number of actual live seeds in a sample, and takes into account the viability of the seed lot, as well as the amount of other crop seeds, weed seeds, and inert (plant stems, broken seed, etc.) material (Figure 9). Percent PLS is calculated by multiplying the percent purity of the lot by the percent germination or viability of the lot. This information is found on some seed labels and on seed laboratory analyses. Bulk seed, on the other hand, includes live seeds plus all other seeds and inert material. You may need to calculate the bulk seed value when weighing or purchasing seed.

Purity is the actual amount of pure seed of the species in the lot. A higher purity percentage reflects a better quality of seed lot. Purity and inert matter will vary by species. Most commonly cultivated grasses should have purities approaching or exceeding 90 %. Some native grasses may only have purities of 50-60 % due to awns or long seed appendages. Forb and shrub seed is difficult to clean and may have very low purities; sagebrush for example is commonly sold with purities as low as 20%. This “trashiness” presents handling problems and may limit how the material can be planted. Seed that has a lot of trash in it (inert matter, other crop seed and damaged seed) can be difficult to run through a seed drill.

Viability

Seed calculations and procurement requests should always be conducted on a Pure Live Seed basis. Working with PLS means that we are always describing actual, live seeds placed on the ground. Live seeds are measured in different ways. “Germination” describes seeds that are likely to grow given favorable conditions in a certain amount of time, although some seed that does not germinate is often “alive”. “Total Viable Seed” describes all seed that will germinate, as well as other seeds that have hard seed coats and/or dormancy mechanisms that will not allow the germination until appropriate conditions are met. The tetrazolium, or TZ test, is used to identify if non-germinating seeds are alive or not, and provides an indication of how many seeds are

alive, even though some or all may not immediately germinate given favorable growing conditions.

High germination percentages suggest the seeds will germinate and grow given favorable conditions of temperature, moisture, etc. In contrast, seeds with a high percentage of hard or dormant seed will not germinate readily, and may need to be scarified or planted in the fall to overcome dormancy mechanisms.

As noted, NRCS conservation seedings should be based on Pure Live Seed (PLS). PLS is the percent purity times percent germination (or TZ) divided by 100 and is determined for each separate seed lot. For example, a seed lot with 99.5% purity is multiplied with 90 % germination and divided by 100. The resultant PLS is 89.56%.

- Germination
  - % normal seedlings likely under favorable conditions
- Total Viable Seed
  - % germination + % hard and/or dormant seed
  - Tetrazolium chloride test (TZ)
- % Purity + inert matter + weed seed + other crop seed = 100%
- PLS= % purity X % viable / 100

In general, most grasses should have germination rates above 80%. Be cautious buying grass seed with less than 60% germination, as it may have lower seedling vigor and thus poor establishment ability. In comparison, Source Identified class grasses, native forbs and shrubs often have lower germination rates.

Germination decreases with age, so older lots of seed should be avoided. Some species can lose viability rapidly. For example, winterfat and sagebrush are known to lose viability quickly after only two years of storage in typical conditions. The best way to avoid problems and insure the best quality of seed is to request a current germination or TZ test (within last 12 months).

Comparing Seed Cost

PLS is also a good tool to compare the relative value of a lot of seed. Bulk seed offers no consistency in terms of composition from lot to lot. Table 9 shows a simple comparison of two seed lots with different PLS values that both cost $1.00 per bulk pound. At first glance without doing the calculation you might not really notice much difference in seed quality. The % purity is not much different between Lot A and Lot B, but there is a huge difference in % germination, which translates into large differences in PLS. As a result,

Table 9. Comparison of the relative value of two lots of seed based on % PLS

	Lot A	**Lot B**
Purity (%)	99.5	93.0
Germination (%)	90.0	60.0
PLS (%)	89.56	55.8
$/lb PLS	**$1.12**	**$1.79**

lot A is a much better value per pound of Pure Live Seed.

Bulk seed

There are times when it may be necessary to know the bulk weight of seed, such as when weighing out prior to planting. In order to apply the recommended PLS rate during seeding, the bulk seeding rate needs to be determined from the PLS information on the seed tag. The recommended PLS seeding rate per acre is divided by the % PLS of the seed to determine the bulk seeding rate.

For example if Goldar bluebunch wheatgrass is being seeded at 8 pounds PLS/A and the PLS of the lot is 89.56%, then 8 pounds PLS divided by 0.8956 equals 8.9 pounds of bulk seed needed per acre.

It can be easy to get confused but all you need to remember is that the bulk seeding rate is **larger** than the recommended PLS seeding rate. If you mistakenly multiply the PLS seeding rate by the % PLS, the bulk rate will be smaller.

Seed Tags

The seed tag is an incredibly valuable piece of information. Everything listed on the tag is shown below (Table 10). This information includes the lot number, origin, and the name of the seller, should a problem arise. One key item missing on seed tags is which species make up the Other Crops and Weeds categories. You must request a laboratory analysis for that information.

Table 10. Items found on a seed tag

1) Variety and kind (Species and Common name)
2) Lot number
3) Origin
4) Net weight
5) Percent pure seed
6) Percent germination (and date of test)
7) Percent inert matter
8) Percent other crop seed
9) Percent weed seeds
10) Name of restricted noxious seed
11) **Prohibited noxious seeds are not allowed.**
12) Name and address of company responsible for analysis (seller)

Every state has a list of prohibited and restricted noxious weeds. It's not so important to know all the weeds on the noxious weed lists for your state, but it is important for the seed seller.

Table 11. Weed Seed Designations

- Prohibited Weeds:
  - No prohibited or restricted weed seed allowed in certified seed
- Restricted Weeds:
  - Allowed in "common seed"
    - Amount restricted up to limits established by law
    - Name and number of seeds per pound must be listed
- Common weeds:
  - Should not total more than 5% by weight
  - Obtain seed analysis report to view specific weeds

Prohibited noxious weeds are not allowed in either common or Certified seed. **Restricted** noxious weeds however are allowed in common seed but are restricted to certain limits allowed by law, while Certified seed may not contain any restricted noxious weed seed. Restricted weed species and number of seeds per pound must be listed on the tag. Common weeds should be no more than 5% by weight, but a standard tag won't specify what weeds these are (Table 11).

Seed grown in one state and purchased for use in another state must comply with the laws of both states. Even though each state has their own noxious weed list (and not all lists are the same from state to state), seed produced in Montana and shipped to Idaho must be free of the noxious weeds in Idaho as well as Montana. Basically it's the responsibility of the seed seller to make sure they are not importing weed seed to any state they ship to.

Seed Analysis Report

The seed analysis report is another valuable piece of paper. You should ask for a copy when you purchase seed. The seed seller is obligated by law to provide it upon request. Be wary of a seed vendor that won't provide the seed analysis report. You will be better off dealing with a company that does.

The seed analysis report has more detail than what can fit on a seed tag. It lists the crop seed by species (you may consider some "crops" weeds) and number per pound and weed seeds and their number per pound. It will also state whether or not the seed meets Certification standards. It is signed by the lab that did the test and is a valuable legal document if issues arise.

In the example, sender's information includes variety, kind, genus/species, lot number and class of seed (Figure 10). Purity analysis includes purity of the sample material, weed seed, crop seed, and inert matter. The viability section includes % germination, % dormant and the total viable seed. Other crop seeds are listed including weeds (blue mustard, shepherd's purse and dandelion) and other crops (penstemon and flax). The noxious weeds section states the lot is free of noxious weeds, and in the other determination section we see that a TZ test was conducted with resultant 69% viability.

Idaho State ..ed Lab
2240 Kellogg Lane
Boise, ID 83712
Laboratory Report of Analysis

..mpthorne
Governor
Patrick Takasugi
Director

MAY 2006 RECEIVED

USDA, NRCS
Plant Materials Center
P.O. Box 296
Aberdeen ID 83210-0296

Account No.	Date Received	Date Completed	Lab Number
6250	03/09/06	05/02/06	S06-3916

Sender's Information*

Variety	VNS
Kind	Muttongrass
Genus/Species	Poa fendleriana
Lot Number	PMC-05-12 G1
Class	Selected Class 5.75 lbs

*The information provided here is that of the sender and not of the laboratory.

Purity Analysis

Pure Seed Components In 2.1032 grams.		Purity
Muttongrass	*Poa fendleriana*	97.59%

Purity Grams Required	Weed Seed	0.00%
Noxious Grams Required	Crop Seed	0.00%
Grams Submitted	Inert Matter	2.41%

Viability Analysis

Germ Date	Germination %	Dormant %	Hard %	Total Viable
04/24/06	51	8	-N-	59

Other Crop Seeds

Mustard, blue	*Chorispora tenella*	90 per lb
Shepherd's purse	*Capsella bursa-pastoris*	45 per lb
Dandelion	*Taraxacum officinale*	22 per lb
Penstemon	*Penstemon sp.*	22 per lb
Flax, lewis	*Linum lewisii*	22 per lb

Noxious Weed Seeds: None Found
States: All States
In 20.1732 Grams.

Weed Seeds: None Found

Other Determinations
Muttongrass TZ test 69 %
The percent Dormancy was determined by Tetrazolium test on firm ungerminated seed following a Germination test according to AOSA Rules 4.2e and 4.9k.

Status: None. - ICIA will determine final class on all certified samples..

Remarks
All States Noxious examination excludes species declared undesireable grass seed by DE, MD, NJ, PA, VA and WV.
Field number: 20010
Inert Matter: Plant debris, sterile florets
Officially sampled by: ICIA
TESTED ACCORDING TO ISTA RULES AND PROCEDURES

Tests Requested All States Noxious, Germination, Purity, TZ test. No other tests requested.

Figure 10. Sample seed analysis report. This document provides information on seed purity, viability and detailed description of weed species found in the seed lot.

V. Calculations

In this section we cover the calculations commonly associated with developing a seed mixture. Careful attention to these calculations will ensure that the appropriate amount of seed of each species is planted for best chance of a good stand in an economically efficient manner.

Percentages of Each Species in the Seeding Mix (developed from ESD)

In this example, an experienced planner has suggested the relative percentages of each species in a mix (Table 12). These percentages can be multiplied by the full stand seeding rate to determine lbs PLS per acre of each component of the mix.

Table 12. Sample mix developed for LOAMY 10-13 ARTRW8/PSSPS

Species	Recommended Percentage in Mix
Bluebunch wheatgrass	40
Indian ricegrass	10
Nevada bluegrass	5
Thickspike wheatgrass	5
Slender wheatgrass	5
Lewis flax	5
Yarrow	5
Palmer penstemon	5
Winterfat	10
Wyoming big sagebrush	10

Determine Full Stand Seeding Rates (good site using a planter or drill)

The section of table below from ID TN-24 shows the recommended full stand seeding rate in PLS pounds per acre, when using a drill, on a non-critical area site, for several native grasses used in vegetative conservation practices in Montana (Table 13). The *full stand seeding rate* is the rate you would use if you were to seed a solid stand (100%) of a single species. It is based on a 12-inch, between-row spacing. In these cases, the rate is based on sowing 20 to 25 Pure Live Seeds per square foot. This number range is based on research results and observational experience on successful stand establishment in semi-arid environments, and also reflects the seed size of the individual species. On the table you can see that bluebunch wheatgrass is recommended at a full stand seeding rate of 8 lbs PLS per acre.

Table 13. Excerpt from ID Technical Note 24 showing tabular listing of seed information including the recommended full stand seeding rate (highlighted).

Grass seeding information				
Common Name	**Scientific name**	**Seeds/lb**	**Drill lb/ac**	**Seeding depth**
Wheatgrass, bluebunch	*Pseudoroegneria spicata*	139,000	8	1/4-1/2
Wheatgrass, crested	*Agropyron cristatum*	175,000	5	1/4-1/2
Wheatgrass, crested X	*Agropyron cristatum X*	165,000	5	1/4-1/2
Wheatgrass, crested	*Agropyron desertorum*	165,000	5	1/4-1/2
Wheatgrass, intermediate/pubescent	*Thinopyrum intermedium*	80,000	10	1/4-1/2
Wheatgrass, RS hybrid	*Elymus hoffmanii*	139,000	8	1/4-1/2
Wheatgrass, Siberian	*Agropyron fragile*	160,000	6	1/4-1/2
Wheatgrass, slender	*Elymus trachycaulus*	135,000	8	1/2-3/4

What If I Don't Have Full Stand Seeding Rate Information?

For many native species not commonly or historically used or available for conservation practices, it may be hard to find full stand seeding rates. In such cases, you can find and use the number of seeds per pound for that species, look up the target number of seeds per foot recommended for that size of seed, and work backwards to calculate the number of PLS pounds per acre to plant given our seeds per pound and target number of seeds.

Determine Seeding Rate for each Species in the Mixture

The next step in the equation is to calculate the seeding rate for each species in the mixture (Table 14). This is done simply by multiplying the full stand seeding rate times the desired percentage in the mix (in decimal format). For example bluebunch wheatgrass has a full stand seeding rate of 8 lbs/ac and is recommended to compose 40% of the total mixture. Multiplying 8 X 0.4 equals 3.2 lbs PLS per acre of bluebunch in the mix. The same calculation is done for each component.

Remember, these seeding rates are based on 12-inch between-row widths. We would need to makes adjustments to the PLS pounds per acre if row width increases above 12 inches. For example, at 24-inch row spacing, half as many linear feet are seeded than at 12-inch spacing. Thus the seed rate would need to be decreased by 50% to achieve the same number of seeds per foot of row.

Table 14. The desired percentage is multiplied by the full stand seeding rate to find the drill seeding rate for each component in the mix.

Species	Recommended Percentage in Mix	Drilled Full Stand Seeding Rate	Drilled Good Site Mix Seeding Rate
	%	*PLS lbs.*	*PLS lbs.*
Bluebunch wheatgrass	0.4	8	3.2
Nevada Sandberg bluegrass	0.05	2	0.1
Thickspike wheatgrass	0.05	8	0.4
Slender wheatgrass	0.1	8	0.8
Lewis flax	0.1	5	0.5
Yarrow	0.1	0.5	0.05
Winterfat	0.1	2	0.2
Wyoming big sagebrush	0.1	0.5	0.05
		Total:	**5.3**

Broadcast Seeded and Good Site

Seedling establishment tends to be lower when using broadcast seeding instead of using a planter or drill. To compensate for this decrease in seedling establishment, we increase the number of sown seeds by 1.5 to 2.0 times the standard drilled seeding rate (Table 15). In some instances, this increase in seeding rate is reduced (or not even needed) if there is a follow-up cultivation operation, such as rolling or packing after seeding. In the example below, the drilled seed rates are multiplied by two to provide the recommended broadcast seeding rate for each species in the mix.

Table 15. For sites being broadcast seeded, drill seed rates are multiplied by 2 to find the appropriate broadcast seeding rates.

Species	Recommended Percentage in Mix	Drilled Full Stand Seeding Rate	Drilled Good Site Mix Seeding Rate	Broadcast Good Site Mix Seeding Rate
	%	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*
Bluebunch wheatgrass	0.4	8	3.2	6.4
Nevada Sandberg bluegrass	0.05	2	0.1	0.2
Thickspike wheatgrass	0.05	8	0.4	0.8
Slender wheatgrass	0.1	8	0.8	1.6
Lewis flax	0.1	5	0.5	1.0
Yarrow	0.1	0.5	0.05	0.1
Winterfat	0.1	2	0.2	0.4
Wyoming big sagebrush	0.1	0.5	0.05	0.1
			Total:	**10.6**

Critical Area and Broadcast Seeded

Much as a broadcast seeding requires planting additional seed per unit area, so often does a critical area planting. What constitutes a 'critical area' depends on the site conditions and risks, but includes where rapid establishment is desired to prevent degradation, such as areas prone to severe erosion. The amount of additional seed recommended varies with the specific type of critical planting, standards and specifications by state, as well as other factors. A rate of 1.5 to 2 times the rate for broadcasting on a good site, and therefore 3 to 4 times the drill seeded rate on a critical area is not uncommon (Table 16). This example uses the 2 times the broadcast rate approach. You can see how much seed is required, and can anticipate the relatively high seed cost.

Table 16. For seedings in critical areas, the broadcast seed rate is doubled.

			Drilled	Broadcast	Broadcast
		Drilled	Good Site	Good Site	Critical Area
	Recommended	Full Stand	Mix	Mix	Mix
	Percentage	Seeding	Seeding	Seeding	Seeding
Species	in Mix	Rate	Rate	Rate	Rate
	%	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*
Bluebunch wheatgrass	0.4	8	3.2	6.4	12.8
Nevada Sandberg bluegrass	0.05	2	0.1	0.2	0.4
Thickspike wheatgrass	0.05	8	0.4	0.8	1.6
Slender wheatgrass	0.1	8	0.8	1.6	3.2
Lewis flax	0.1	5	0.5	1.0	2.0
Yarrow	0.1	0.5	0.05	0.1	0.2
Winterfat	0.1	2	0.2	0.4	0.8
Wyoming big sagebrush	0.1	0.5	0.05	0.1	0.2
			Total:		**21.2**

Calculating Bulk Seed per Acre

Remember, after we calculate how much pure live seed we want of each species, we'll need to convert that number to a bulk value because that is actually what we weigh out when mixing the various lots. The bulk weight is determined by dividing the PLS lbs/acre needed by the actual PLS % from the seed label or analysis to give us the bulk value (Table 17). The bulk value is always greater than the PLS value since it usually includes inert material and non-viable seeds.

In the example shown, the broadcast-critical area seed rate of each component is multiplied by the % PLS from the seed tag or seed analysis. For bluebunch wheatgrass 12.8 lb PLS/acre is divided by 0.9781 to obtain a bulk seeding rate of 13.09 lb/ac. If you were using a seed drill or seeding on a non-critical area site, you would divide those seed rates by the % PLS.

Table 17. PLS information from the seed tag is multiplied by the calculated seed rate to determine the amount of bulk seed needed per acre.

Species	Recommended Percentage in Mix	Drilled Full Stand Seeding Rate	Drilled Good Site Mix Seeding Rate	Broadcast Good Site Mix Seeding Rate	Broadcast Critical Area Mix Seeding Rate	Pure Live Seed	Bulk Seed Needed
	%	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*	*%*	*Lbs./A*
Bluebunch wheatgrass	0.4	8	3.2	6.4	12.8	.9781	13.09
Nevada Sandberg bluegrass	0.05	2	0.1	0.2	0.4	.9357	0.43
Thickspike wheatgrass	0.05	8	0.4	0.8	1.6	.9976	1.60
Slender wheatgrass	0.1	8	0.8	1.6	3.2	.9724	3.29
Lewis flax	0.1	5	0.5	1.0	2.0	.9258	2.16
Yarrow	0.1	0.5	0.05	0.1	0.2	.9921	0.20
Winterfat	0.1	2	0.2	0.4	0.8	.9167	0.87
Wyoming big sagebrush	0.1	0.5	0.05	0.1	0.2	.8993	0.22

Rice Hulls or Other Carriers

Additional seeding calculations are required when using carriers such as rice hulls (Figure 11). Rice hulls are a preferred carrier for seed mixes containing different sized seeds. Rice hulls prevent separation while planting and effectively keep the seed in the mix from settling or bridging in the seeding equipment. Many types of carriers are available but rice hulls are effective, relatively inexpensive, are compatible with conventional grain drills and are easy to calibrate. See Idaho Tech Note 7 for more information and for an online interactive rice hull calculator.

Figure 11. The Aberdeen PMC farm crew calibrates a rangeland drill. Photo by Derek Tilley.

Calibrating Seeding Equipment

Whatever seeding equipment is used, it will have to be calibrated to deliver the desired amounts of seed per acre. See Idaho Tech Note 7 for more information on how this is done.

VI. Installation and Beyond

In this final section we discuss some of the remaining considerations involved in rangeland seedings. We also look at potential impediments to success and reasons why plantings may fail.

Proper Seeding Dates

On light sandy to loamy soils, dormant fall planting is recommended. On heavy to medium textured soils that tend to form soil crusts over winter, early spring planting should be considered. In general, spring dryland plantings should be completed early in the spring as soon as equipment can get on the field to take advantage of spring moisture. Hopefully, seedings will have at least 30-45 days of adequate soil moisture to reach a 3-5 leaf stage. Dormant seedings may be completed any time after measured soil temperatures are below 40-45º F. Most states have seeding date specifications based on MLRA. Be sure to follow your state's specifications on seeding dates.

Seedbed Preparation

In the western United States, inspection of hundreds of plantings in the past 65 to 70 years have shown the most common cause of conservation seeding failures is from poor seedbed preparation. Seedbed deficiencies include soil looseness, dryness near the surface and excessive weed competition. The ideal seedbed is uniformly firm, has soil moisture near the surface, is free from competing vegetation and is well-packed underneath with small surface clods or a light mulch of residue to prevent erosion (Figure 12).

Figure 12. A firm seed bed (top) leaves a boot print approximately ½ inch deep, while a loose seed bed (bottom) leaves a much deeper print and needs additional firming with a packing implement. Photos by Derek Tilley, NRCS.

Some factors such as weather, disease/pest outbreaks are out of our control, but if we do everything in our power to provide as ideal a seedbed as possible, the chances of having a good stand establish increases and may compensate for the negative factors beyond our control.

Seeding Into Existing Stands

Many planners want "instant" results and try to interseed into existing plant communities. Numerous studies have shown interseeding into existing plant communities almost always fails due to competition for water and nutrients from existing vegetation. In addition, there may be allelopathic effects from living and decaying vegetation. Plantings where existing vegetation

can be completely killed with herbicides prior to the seeding are much more likely to succeed.

Seeding Equipment
The most successful seedings are those where competition is adequately reduced, either with chemical treatments or tillage. Tillage, however, is often unfeasible over large acreages or on rough terrain. It can also bring new weed seed to the soil surface, and can create a more favorable environment for cheatgrass germination. Rangeland drills eliminate the need for tillage and can be effective on level terrain that is largely free of rock, but no-till drills have some drawbacks. No-till seeders can produce poor seed to soil contact due to lack of seed bed preparation, and they can also be difficult to control seeding depth.

Broadcast seeders are those that randomly scatter seeds over the soil surface. This can be done from the ground or from the air. This is the cheapest and easiest method of seeding, but seed placement is not accurate and seeding rates need to be increased 50- 100%. To obtain adequate seed-to-soil contact, rolling the soil with a cultipacker, dragging a harrow, pulling a roller harrow with the tines up or running a drag over the soil surface after applying the seed is recommended.

Legume Inoculation
Legumes, in a symbiotic relationship with rhizobia bacteria, produce nodules that can fix nitrogen from the air and produce nitrogen needed for plant growth. It is critical that inoculant with the proper strain of rhizobia bacteria be used. Much of the seed being sold today is pre-inoculated. If the seed is not pre-inoculated or if seeding date is beyond the expiration date for the inoculant, the seed should be inoculated with a fresh culture prior to seeding.

Idaho Plant Materials Technical Note 26 “Legume Inoculation” provides information on the benefits and procedures to inoculate seed and also provides a list of manufacturers and distributors of inoculants.

Why Seedings Fail
Before establishing a conservation seeding, it is helpful to know why seedings fail. Losses occur over a long period, from the seeding itself, to early seedling establishment, to growth and development of seedlings into a mature stand. In reality very few of the seeds planted will survive to maturity. Many will die prior to germination from predation or desiccation. Many more may be lost at germination from a lack of soil moisture.

Even after emergence, many seedlings will die. Some of the more common reasons include poor soil conditions; too little water causes drought stress and mortality, especially to seedlings with small root systems. Too much water from poor drainage leaves the plants susceptible to fungal pathogens. Spring frosts can damage leaf tissues. Insects like weevils, grasshoppers, black grass bugs and aphids can attack the young seedlings. Finally, weeds and even other species seeded in the mixture can compete with the seedlings for light, nutrients and moisture.

Many of these factors are actually timing issues. For instance, sagebrush seedings need to be implemented either early enough to capture spring rains or planted fully dormant in the fall after any likelihood of warm temperatures to prevent premature germination and loss to freezing. Seed too late in the spring and you may miss spring moisture; seed too early in the fall and the seed

may germinate and you may lose seedlings to frost. As a result of these issues, dormant fall seedings are often the most practical and successful plantings.

Evaluating Planting Success

It is highly recommended that you read Idaho PMC Tech Notes 10 and 12, available from the Plant Materials website, as they provide good solid advice as well as how-to information relative to this subject. Inspect the planting as soon as possible after emergence; realizing identification of seedlings can be very difficult. Evaluating early may allow the planner to recommend a reseeding if the planting is an obvious failure. Early evaluation and decision making can capitalize on any residual soil moisture and salvage at least a part of the seedbed preparation cost.

However, care must be used in evaluating rangeland seedings since first year results can often be misleading. Planted seed will remain in the seed bank waiting for optimum conditions to germinate and the stand will improve over time. Additionally, good seedling establishment is often masked by heavy weed growth. Many such stands have been plowed up and reseeded when another year of deferment and observation could have allowed the seeded perennials to become fully established and eliminate the weeds through competition. With the exception of a complete seeding failure, it will be best in most cases to look at stand trends over time to determine if the establishment of desirable species is trending in the right direction given the climatic conditions since planting.

Replant or Natural Recruitment?

So you have determined your planting has a poor stand – not a total bust, but certainly not a success. Now you have to decide if the planting can be left as is and provide the desired cover and desired mix of species through natural recruitment, or do you reseed. This is never an easy decision. The rule of thumb is, "you should reseed unless natural succession is judged to result in at least fair condition range after 10 years."

If you do not reseed, some sites may persist in weeds indefinitely. Successional data indicates that abandoned cropland requires 25-30 years (if ever) to return to a fair condition on its own. In the Columbia Basin, Great Basin, and Snake River Plain, annual grasslands may persist indefinitely unless replaced with perennial species.

Conclusion

Unfortunately, limited time and available resources for adequate field preparation and weed control, and the availability and cost of native seed, hinder our current abilities to reliably restore sagebrush ecosystems and potentially sage-grouse habitat. We are often left with imperfect and unsatisfactory results that, while improve the overall condition of the site, may not meet conditions required by sage-grouse. This Technical Note is intended to provide the information for conservation planners and practitioners to make the best decisions possible to maximize the likelihood of success while acknowledging the real-world compromises and challenges that are often encountered.

Useful Websites
The following are useful websites where NRCS Technical Notes and plant information are located.

National Plant Materials Program:
http://www.nrcs.usda.gov/wps/portal/nrcs/main/plantmaterials/pmc/west/mtpmc/

Bridger Plant Materials Center (Montana NRCS):
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/mt/plantsanimals/?cid=nrcs144p2_057491

Aberdeen Plant Materials Center (Idaho NRCS):
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/id/technical/?cid=nrcs144p2_047764

IDAHO PMC Rice Hull Calculator:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/id/technical/?cid=nrcs144p2_047763

PLANTS Database:
http://plants.usda.gov/java/

Pacific Northwest Weed Management Handbook:
http://pnwhandbooks.org/weed/

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Ogle, D., St. John, l. Stannard, M., Cornwell, J, Holzworth, L. 2011. Technical Note 10: Pasture and Range Seedings – Planning, Installation, Evaluation, Management. USDA-NRCS. Boise, ID, Salt Lake City, UT, Spokane, WA. 35 p.

Ogle, D.O., St. John, L., Stannard, M. and L. Holzworth. 2012. Technical Note 24: Conservation Plant Species for the Intermountain West. USDA-NRCS. Boise, ID, Salt Lake City, UT, Spokane, WA. 57 p.

Scianna, J.D., Jacobs, J. and L. St. John. 2011. Technical Note 67: Seed Source Selection, Use of Certified Seed, and Appropriate Seed Release Class Improve Conservation Planting Success. USDA-NRCS. Bridger, MT. 18p.

St. John, L., Tilley, D., Ogle, D., Jacobs, J., Holzworth, L. and L. Wiesner. 2011. Technical Note No. 13: Principles of Seedbed Preparation for Conservation Seedings. USDA-NRCS. Boise, ID. 13p.

St. John, L., Tilley D., Scianna J., Jacobs, J. 2013. Technical Note 7: Mixing Seed with Rice Hulls. USDA-NRCS. Aberdeen, ID and Bridger, MT. 16p.

PALMER'S PENSTEMON

Penstemon palmeri A. Gray

Plant Symbol = PEPA8

Contributed by: USDA NRCS Idaho State Office and National Plant Data Center

Palmer's penstemon. John Hixson, Ladybird Johnson Wildflower Center.

Alternate Names

Common Alternate Names: Palmer's beardtongue, scented beardtongue, balloon flower
Scientific Alternate Names: *Penstemon palmeri* var. *palmeri*, *Penstemon palmeri* var. *macranthus*, *Penstemon palmeri* var. *eglandulosus*

Uses

Grazing/rangeland/wildlife: Palmer's penstemon produces succulent foliage during the spring and summer and is selectively used by small birds, big game and livestock. It also provides high quality forage during the winter (Stevens and Monsen, 1988).

Erosion control/reclamation: Palmer's penstemon provides good ground cover for controlling erosion and stabilizing disturbed and burned sites (Stevens and Monsen, 1988; Ogle, et. al., 2012). It has also been used for revegetation of mines and mine spoils.

Pollinators: Flowers of Palmer's penstemon attract bumblebees (*Bombus* sp.), carpenter bees (*Xylocopa* sp.) and digger bees (Anthophorini tribe) (Wilson, et. al., 2003).

Ornamental: Palmer's penstemon produces persistent foliage and abundant, aromatic flowers that are pleasing in ornamental settings.

Ethnobotany

The Kayenta Navajo prepared a poultice of the plant to apply to snakebite sores (Native American Ethnobotany Database).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Figwort Family (Scrophulariaceae). Palmer's penstemon is a short-lived (4-5 years), evergreen, native, perennial herb to slightly woody subshrub 50-140 cm tall with a thick crown and fibrous taproot that can reach to 1m deep. The plant is glabrous and glaucous with fleshy leaves. The leaves are opposite, dentate, 6-10 cm long and 1.5-3 cm wide with the upper ones smaller and sometimes triangular. Palmer's penstemon has long flowering stalks that are up to 140 cm tall. Flower clusters are 2-4 flowered and the flowers range from white to lavender pink color with prominent red-violet colored guidelines on the lower lip and inside the strongly inflated throat. Flowers of Palmer's penstemon give off a pleasant fragrance which is unique among penstemon species. The fruit is a many-seeded capsule. Cronquist, et. al. (1984) recognizes three botanical varieties and provides a key to distinguish them based on floral and leaf characteristics as well as geographic distribution.

Distribution: Palmer's penstemon is found in the western United States from Wyoming south to New Mexico and westward to California. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Palmer's penstemon is found in blackbrush, sagebrush, Joshua tree, pinyon-juniper and ponderosa pine communities where subsurface moisture is available for most of the growing season and elevation ranges from 2,600-8,200 feet above sea level (Cronquist et. al., 1984).

Adaptation
Palmer's penstemon is best adapted to well-drained, slightly acidic to slightly alkaline, coarse textured soils in areas receiving 10-16 inches annual precipitation and has excellent cold and drought tolerance (Ogle, et. al., 2012). Once established it can persist on sites receiving as little as 8 inches of annual precipitation (Stevens and Monsen, 1988). It has intermediate tolerance to salinity especially during periods of cool temperatures and lower light intensities (Zollinger, et. al., 2007). Palmer's penstemon is usually found in open areas but will tolerate semi-shaded conditions. It is not tolerant of fire, but is somewhat fire resistant due to leaves staying green with relatively high moisture content during wildfire season.

Establishment
Meyer and Kitchen (1992) observed cyclic seed dormancy in Palmer's penstemon. Chilling causes the seed population to diverge into spring-germinable and spring dormant fractions allowing the seed bank to persist from year to year. The general recommendation is to plant seed in the fall from 1/8 to no more than ¼ inch depth into a firm, weed-free seedbed. Good seed to soil contact is important for germination and establishment. The full seeding rate is 2 pounds Pure Live Seed (PLS) per acre (Ogle, et. al., 2012) and there are approximately 586,000 - 600,000 seeds per pound (Stevens and Monsen, 1988; USDA PLANTS database). When used as a component of a seed mix, adjust the seeding rate to the percent of mix desired. Stevens and Monsen (1988) recommend drilling Palmer's penstemon through a legume box on a drill or with a seed dilutent such as rice hulls because the seeds are small and may separate from other seeds in a mix. Vigorous seedlings appear in the spring, compete well, and usually are not eliminated by competition from other species (Monsen, et. al., 2004).

Mulching, irrigation and weed control benefit stand establishment. Some seed may not germinate until the second growing season. Plants begin growth early in the spring and flower blossoms appear in late spring and early summer. Flowering should not be expected until the second growing season.

Weed control will be required during establishment. Because penstemon is a broadleaf plant, the use of broadleaf type herbicides is not recommended. Mowing weeds when they are beginning to bloom will help reduce weed seed development.

Management
Palmer's penstemon should be used as a minor component of seed mixtures. Management strategies should be based on the key species in the established plant community. Grazing should be deferred on seeded lands for at least two growing seasons after seeding to allow for full stand establishment. Although Palmer's penstemon is short-lived, once established, it is self-perpetuating because of its abundant seed production and seed dormancy which allows it to establish readily when conditions are favorable for germination and survival (Monsen et. al., 2004).

Pests and Potential Problems
Information on pests and diseases of Palmer's penstemon is not well known. In general, penstemon is susceptible to soil-borne fusarium and rhizoctonia root rot which can be severe in poorly drained loam and clay textured soils. Stevens and Monsen (1988) mention that Palmer's penstemon irrigated seed production fields are subject to diseases associated with alfalfa and potatoes but do not specify those diseases. Colorado State University Extension (2013) has identified a penstemon weevil (*Hesperobarus ovulum,* precise species not yet identified) that has caused catastrophic damage to several species of penstemon (including Palmer's) seed production fields in southwestern Colorado. Penstemon weevil damage is difficult to control because even once damage is observed, no control methods are available. Weevils damage the plant by feeding in the taproot.

Environmental Concerns
Palmer's penstemon is a native plant species found in western North America and has no known negative impacts on wild or domestic animals. It is not considered a weedy or invasive species but can spread to adjoining vegetative communities under ideal conditions. It co-exists with other native species and adds biodiversity to plant communities.

Seed and Plant Production
There can be considerable variability in seed dormancy among collections of the same species of penstemon. A few methods can be used to overcome dormancy including the use of aged seed where after-ripening causes seed to lose dormancy, moist pre-chilling (stratification), and the use of plant hormones referred to as gibberellins (GAs). Kitchen and Meyer (1991) found one collection of Palmer's penstemon out of 3 collections tested that did not show dormancy. There were also significant differences in germination between different lengths of stratification periods. Treatment of Palmer's penstemon seed with GA_3 at a minimum concentration of 50 ppm resulted in complete germination. Abella (2009) evaluated emergence of 61 plant species where seed was subjected to liquid smoke treatments and found significant difference between non-treated seed and seed

exposed to a 10 % (vol/vol) aqueous smoke. Non-treated seed of Palmer's penstemon had 41% emergence vs. treated seed which had 81% emergence.

A standard method for propagating penstemon for transplants is to stratify the seed for 8-12 weeks in cold and moist conditions. Seed should be surface sown into plant containers and pressed into the soil surface and then containers stored under cool (36° F), dark conditions for 8-12 weeks. After stratification period, bring plants into greenhouse conditions and allow plants to grow for 8-12 weeks before transplanting in the field. Propagation of new plants from dividing older plants is also possible.

Fields for seed production can be established from direct seeding or from transplanting greenhouse grown containerized stock. Direct seeding should take place in late fall to allow for natural stratification of the seed. Palmer's penstemon should be seeded in 30-36 inch rows at a rate of 1.2 pounds PLS/ac (target 30 pure live seeds per linear foot of drill row) to allow for mechanical weed control (Cornforth, et. al., 2001). The use of weed barrier fabric is an alternative to allow closer spacing, reduce weeds and conserve soil moisture. Plant spacing of 18 inches provides for maximum growth and seed yield when using weed barrier fabric.

Seed normally ripens from mid-August to mid-September and is mature when seed capsules dry and become hard and dark in color. Seed will shatter once capsules have opened. Seed can be harvested by hand-stripping or with combine. Seed is separated from the capsule with use of a hammermill or barley debearder followed by fan cleaning. Seed yields average 100 pounds per acre (Stevens and Monsen, 1988). Storage of seed of up to 5 years has resulted in no significant loss in germination (Stevens and Jorgensen, 1994).

Cultivars, Improved, and Selected Materials (and area of origin)

'Cedar' Palmer's penstemon was released by Utah Division of Wildlife Resources and the Intermountain Research Station, Forest Service, and Soil Conservation Service, Department of Agriculture in 1985. The Agriculture Experiment Station of New Mexico State University, Colorado State University, University of Idaho, and Utah State University also participated in the release (Stevens and Monsen, 1988).

Cedar was originally collected in 1939 from a native stand near Cedar City, Utah in a mixed pinyon-juniper, big sagebrush plant community. Seed from the original site was compared with 17 other accessions at 20 locations in Utah and also in range plantings in Idaho, Montana, Wyoming, Nevada, Colorado, New Mexico, Arizona, and Oregon. Cedar was adapted to more sites, established better, was generally the most aggressive spreader, and produced as much or more forage than the other accessions tested. Certified seed is available and the Forest Service maintains Breeder seed.

Wildland collected Palmer's penstemon seed can also be obtained through commercial vendors (Native Seed Network).

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For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program Web site http://plant-materials.nrcs.usda.gov.

PLANTS is not responsible for the content or availability of other Web sites.

THICKLEAF PENSTEMON

Penstemon pachyphyllus A. Gray ex Rydb.

Plant Symbol = PEPA6

Contributed by: USDA NRCS Idaho State Office and National Plant Data Center

Thickleaf penstemon. W.D. Bransford, Ladybird Johnson Wildflower Center.

Alternate Names

Common Alternate Names: thickleaf beardtongue, elephant ear penstemon
Scientific Alternate Names: *Penstemon pachyphyllus* var. *pachyphyllus*, *Penstemon pachyphyllus* var. *congestus*

Uses

Grazing/rangeland: Thickleaf penstemon is eaten by wildlife and livestock (Monsen et. al., 2004). There is no published information on palatability and it is considered of incidental value as forage. It does provide diversity in the plant communities where it is found.

Erosion control/reclamation: Thickleaf penstemon provides excellent soil protection (Monsen et. al., 2004).

Pollinators: The large, purple colored flowers of thickleaf penstemon generally attract large bumblebees (*Bombus* sp.) (Kramer et. al., 2011).

Ethnobotany

The Havasupai Tribe of north central Arizona folded leaves of thickleaf penstemon lengthwise and placed them in their mouth to create a sound similar to a baby deer while hunting (Native American Ethnobotany Database).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Thickleaf penstemon, a member of the Figwort Family (Schrophulariaceae), is a short-lived perennial, native, herb growing 30-65 cm tall with well-developed basal leaves and a few, erect, simple stems arising from a thick crown. The leaves are fleshy, bluish-green in color and covered with wax. Leaves are opposite, and basal leaves are 5-10 cm long and 12-35 mm wide, oblanceolate to spatulate. Upper leaves are 2-5 cm long and 7-20 mm wide. Flower clusters are 2-5 flowered, tubular and blue to violet in color. The fruit is a capsule 9-13 mm long and seeds are 2-3 mm long. Cronquist et. al., (1984) recognizes two botanical varieties and provides a key to distinguish them based on floral characteristics as well as geographic distribution.

Distribution: Thickleaf penstemon is found in the western states of Wyoming, Colorado, New Mexico, Arizona, Nevada and Utah. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Thickleaf penstemon is found in salt desert shrub, sagebrush-grass, pinyon-juniper, mountain brush, and conifer plant communities (Monsen et. al., 2004).

Adaptation

Thickleaf penstemon specific information is limited. Penstemon species in general, prefer well-drained, infertile, disturbed soils. Thickleaf penstemon occurs on dry gravelly soils at elevations of 5,250-8,200 feet (Cronquist et. al., 1984). Annual precipitation requirements are estimated to be 10-16 inches for thickleaf penstemon to establish and persist.

Establishment
Monsen et. al., (2004) state that the planting process for thickleaf penstemon is similar to other penstemon species. The general recommendation is to plant seed in the fall from 1/8 to no more than ¼ inch depth into a firm, weed-free seedbed. Good seed to soil contact is important for germination and establishment. There are approximately 335,000 seeds per pound (Monsen et. al., 2004). To achieve a target seeding rate of 25 seeds per square foot, 3.25 pounds PLS (Pure Live Seed) /ac should be planted to achieve a full stand. When used as a component of a seed mix adjust the seeding rate to the percent of mix desired. Thickleaf penstemon should be drilled through a legume box or with a seed dilutent such as rice hulls because the seeds are small and may separate from other seeds in the mix.

Mulching, irrigation and weed control benefit stand establishment. Some seed may not germinate until the second growing season. Plants begin growth early in the spring and flower blossoms appear in the late spring and early summer. Flowering should not be expected until the second growing season.

Weed control will be required during establishment. Because penstemon is a broadleaf plant, the use of broadleaf type herbicides is not recommended. Mowing weeds when they are beginning to bloom will help reduce weed seed development.

Management
Thickleaf penstemon should be used as a minor component of seed mixtures. Management strategies should be based on the key species in the established plant community. Grazing should be deferred on seeded lands for at least two growing seasons after seeding to allow for full stand establishment. It is a short-lived plant, but with proper management, natural regeneration should maintain plants in the vegetative community.

Pests and Potential Problems
Information on pests and diseases of thickleaf penstemon is not well known. In general, penstemon is susceptible to soil-borne fusarium and rhizoctonia root rot which can be severe in poorly drained loam and clay textured soils. Grasshoppers and other insects may also damage plants.

Environmental Concerns
Thickleaf penstemon is a native plant species found in western North America and has no known negative impacts on wild or domestic animals. It is not considered a weedy or invasive species but can spread to adjoining vegetative communities under ideal conditions. It co-exists with other native species and adds biodiversity to plant communities.

Seed and Plant Production
There can be considerable variability in seed dormancy among collections of the same species of penstemon. A few methods can be used to overcome dormancy including the use of aged seed where after-ripening causes seed to lose dormancy, moist pre-chilling (stratification), and the use of plant hormones referred to as gibberellins (GAs). Kitchen and Meyer (1991) found germination of thickleaf penstemon to be negatively affected by chilling. There were also significant differences in germination between different lengths of stratification periods. Treatment of thickleaf penstemon seed with GA_3 at a minimum concentration of 50 ppm resulted in complete germination. Abella (2009) evaluated emergence of 61 plant species where seed was subjected to liquid smoke treatments and found significant difference between non-treated seed and seed exposed to a 10 % (vol/vol) aqueous smoke. Non-treated seed of thickleaf penstemon had 3% emergence vs. treated seed which had 30% emergence.

A standard method for propagating penstemon for transplants is to stratify the seed for 8-12 weeks in cold and moist conditions. Seed should be surface sown into plant containers, pressed into the soil surface with containers then stored under cool (36° F), dark conditions for 8-12 weeks. After the stratification period, bring plants into greenhouse conditions and allow plants to grow for 8-12 weeks before transplanting in the field. Propagation of new plants from division of older plants is also possible.

Fields for seed production can be established from direct seeding or from transplanting greenhouse grown containerized stock. Direct seeding should occur in late fall to allow for natural stratification of the seed. Thickleaf penstemon should be seeded in 30-36 inch rows at a rate of 1.0 pounds PLS/ac (target 30 pure live seeds per linear foot of drill row) to allow for mechanical weed control (Cornforth et. al., 2001). The use of weed barrier fabric is an alternative to allow closer spacing, reduce weeds and conserve soil moisture. Plant spacing of 18 inches provides for maximum growth and seed yield when using weed barrier fabric.

Seed normally ripens from mid-August to mid-September and is mature when seed capsules dry and become hard and dark in color. Seed will shatter once capsules have opened. Seed can be harvested by hand-stripping or with a combine. Seed is separated from the capsule with use of a hammermill or barley debearder followed by fan cleaning. Seed yields average 100 pounds per acre and seeds can be stored for up to 14 years without appreciable loss of viability (Stevens and Jorgensen, 1994).

Cultivars, Improved, and Selected Materials (and area of origin)
There are no cultivars, improved, or selected materials of thickleaf penstemon. Common wildland collected seed is available from commercial sources (Native Seed Network).

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Citation

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For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program Web site http://plant-materials.nrcs.usda.gov.

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USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

RYDBERG'S PENSTEMON

Penstemon rydbergii A. Nelson

Plant Symbol = PERY

Contributed by: USDA NRCS Idaho State Office and National Plant Data Center

Rydberg's penstemon. Sheri Hagwood, USDA-NRCS PLANTS Database.

Alternate Names

Common Alternate Names: meadow beardtongue, mountain meadow beardtongue

Scientific Alternate Names: *Penstemon rydbergii* var. *rydbergii*, *Penstemon rydbergii* var. *oreocharis*, *Penstemon rydbergii* var. *aggregatus*

Uses

Grazing/rangeland: Rydberg' penstemon is one of the more palatable species of penstemon and provides forage for wildlife, cattle and sheep (Forest Service, 1937; Bowns and Bagley,1986) and provides diversity in the plant communities where it is found.

Erosion control/reclamation: Penstemon species are used in seed mixes for erosion control and reclamation.

Pollinators: Rydberg's penstemon attracts hummingbirds, butterflies and insects (Pollinator Partnership, 2013).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Rydberg's penstemon, a member of the Figwort Family (Schrophulariaceae), is a semi-evergreen, perennial forb with a tap root, well-developed basal leaves and is 20-40 cm tall. The plant is mostly glabrous with pubescence sometimes restricted to lines on the stems below the junction with the leaves. The lower leaves are oblanceolate, entire, 4-7 cm long and 9-15 mm wide. The upper leaves are smaller, 2.5-6 cm long, 3-14 mm wide and are lanceolate. Flower clusters are dense with 2-7 flowers. The flower is 10-16 mm long and tubular. The limb of the flower is blue to blue-violet or purple in color and the tube is violet to blue purple colored and glabrous. The stamens are golden to yellow colored. The fruit is a capsule 5-10 mm long and seeds are 0.6-1 mm long. Cronquist et al., (1984) recognizes three botanical varieties and provides a key to distinguish them based on floral characteristics as well as geographic distribution.

Distribution: Rydberg's penstemon is found in the western United States from Montana south to New Mexico and westward to the Pacific Coast states of California, Oregon, and Washington. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Rydberg's penstemon grows on moderately moist to dry slopes, meadows and streambanks from valleys to sub alpine and alpine sites (Cronquist et. al.,

1984) in mountain brush, aspen, coniferous forests and open parklands (Monsen et. al., 2004).

Adaptation
Rydberg's penstemon is adapted to basic and acid soils (Monsen et. al., 2004) medium to fine textured soils in areas receiving 20-30 inches annual precipitation (USDA, NRCS, 2013), and 4,265-10,827 feet elevation (Cronquist et. al., 1984).

Establishment
Monsen et. al., (2004) state that the planting process for Rydberg's penstemon is similar to other penstemon species. The general recommendation is to plant seed in the fall from 1/8 to no more than ¼ inch depth into a firm, weed-free seedbed. Good seed to soil contact is important for germination and establishment. There are approximately 850,000 seeds per pound (Stevenson Intermountain Seed, 2013). To achieve a target seeding rate of 50 seeds per square foot, 2.5 pounds PLS (Pure Live Seed) /ac should be planted to achieve a full stand. When used as a component of a seed mix adjust the seeding rate to the percent of mix desired. Rydberg's penstemon should be drilled through a legume box or with a seed dilutent such as rice hulls because the seeds are small and may separate from other seeds in the mix.

Mulching, irrigation and weed control benefit stand establishment. Some seed may not germinate until the second growing season. Plants begin growth early in the spring and flower blossoms appear in the late spring and early summer. Flowering should not be expected until the second growing season.

Weed control will be required during establishment. Because penstemon is a broadleaf plant, the use of broadleaf type herbicides is not recommended. Mowing weeds when they are beginning to bloom will help reduce weed seed development.

Management
Rydberg's penstemon should be used as a minor component of seed mixtures. Management strategies should be based on the key species in the established plant community. Grazing should be deferred on seeded lands for at least two growing seasons after seeding to allow for full stand establishment. It is a short-lived plant, but with proper management, natural regeneration should maintain plants in the vegetative community.

Pests and Potential Problems
Information on pests and diseases of Rydberg's penstemon is not well known. In general, penstemon is susceptible to soil-borne fusarium and rhizoctonia root rot which can be severe in poorly drained loam and clay textured soils. Grasshoppers and other insects may also damage plants.

Environmental Concerns
Rydberg's penstemon is a native plant species found in western North America and has no known negative impacts on wild or domestic animals. It is not considered a weedy or invasive species but can spread to adjoining vegetative communities under ideal conditions. It co-exists with other native species and adds biodiversity to plant communities.

Seed and Plant Production
There can be considerable variability in seed dormancy among collections of the same species of penstemon. A few methods can be used to overcome dormancy including the use of aged seed where after-ripening causes seed to lose dormancy, and moist pre-chilling (stratification). However, there is no published information specific to the propagation of Rydberg's penstemon.

A standard method for propagating penstemon for transplants is to stratify the seed for 8-12 weeks in cold and moist conditions. Seed should be surface sown into plant containers, pressed into the soil surface with containers then stored under cool (36° F), dark conditions for 8-12 weeks. After the stratification period, bring plants into greenhouse conditions and allow plants to grow for 8-12 weeks before transplanting in the field. Propagation of new plants from division of older plants is also possible.

Fields for seed production can be established from direct seeding or from transplanting greenhouse grown containerized stock. Direct seeding should occur in late fall to allow for natural stratification of the seed. Rydberg's penstemon should be seeded in 30-36 inch rows at a rate of 0.85 pounds PLS/ac (target 50 pure live seeds per linear foot of drill row) to allow for mechanical weed control (Cornforth et. al., 2001). The use of weed barrier fabric is an alternative to allow closer spacing, reduce weeds and conserve soil moisture. Plant spacing of 18 inches provides for maximum growth and seed yield when using weed barrier fabric.

Seed normally ripens from mid-August to mid-September and is mature when seed capsules dry and become hard and dark in color. Seed will shatter once capsules have opened. Seed can be harvested by hand-stripping or with a combine. Seed is separated from the capsule with use of a hammermill or barley debearder followed by fan cleaning. Seed yields average 100 pounds per acre.

Cultivars, Improved, and Selected Materials (and area of origin)
There are no cultivars, improved, or selected materials of Rydberg's penstemon. Common wildland collected seed is available from commercial sources (Native Seed Network).

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Citation

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Plant Guide

PURPLE THREEAWN

Aristida purpurea Nutt.

Plant Symbol = ARPU9

Contributed by: USDA NRCS Idaho Plant Materials Program

Purple threeawn. Robert Soreng @ USDA-NRCS PLANTS Database.

Alternate Names

Common Alternate Names: wiregrass, red threeawn, dogtown grass, prairie threeawn

Scientific Alternate Names: A. longiseta

Uses

Forage value of purple threeawn depends largely on the other species growing in association in the region. In the Southwest, where forage is limited, purple threeawn is considered good spring forage while the plants remain green. In Arizona and New Mexico its abundance and fair palatability make purple threeawn a highly important source of forage. In northern areas where more palatable forage grasses are available, threeawn is considered weedy with little value (Stubendieck et al. 1994; USDA, 1937).

Purple threeawn is popular among horticulturalists for use in low water landscaping, especially in the Southwestern United States. Its reddish purple coloring and compact bunchgrass habit make it desirable. It spreads by seed readily however and can overwhelm landscape elements and become a nuisance. Seed also sticks to animal fur and human socks. Seed heads should be removed before maturity to prevent spread (Xeriscape Today 2010).

Purple threeawn provides some cover to small mammals and reptiles in sparsely vegetated desert areas. Native bees will make nests in the root structure.

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

This species has been separated in the past into several distinct species. However, the characteristics used to separate these taxa such as culm height, beak length and awn length are highly variable within populations and even on the same plant (Cronquist et al. 1977). The PLANTS Database currently recognizes a single species with five varieties: purple threeawn (*A. purpurea* var. *purpurea*), Fendler's threeawn (*A. p.* var. *fendleriana*), blue threeawn (*A. p.* var. *nealleyi*), Parish's threeawn (*A. p.* var. *parishii*), and Wright's threeawn (*A. p.* var. *wrightii*).

Purple threeawn is a short-lived native perennial warm season bunchgrass with densely tufted culms averaging 6 to 30 inches tall. The leaves are mostly basal with blades 1 to 10 inches long. The leaves are very narrow; less than 2 mm wide, and involute or rolled. The ligule is a membranous based ring of hairs 0.5 mm long. The inflorescence is a narrow panicle, 2 to 8 inches long with the lower branches ascending or spreading. The spikelets are reddish to purple colored. The floret bears a twisted awn column which divides into three awns 3/4 to 4 inches in length (Welsh et al. 2003).

Distribution:
Purple threeawn occurs in western North America from the west coast eastward to Minnesota, Illinois and Louisiana. There are also disjunct documented occurrences in Vermont, North Carolina and South Carolina. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Purple threeawn inhabits dry coarse or sandy soils in desert valleys and foothills. It grows in a variety of plant communities including: creosote bush, blackbrush, shadscale, greasewood, pinyon-juniper and ponderosa pine (Welsh et al. 2003). It is often found growing in association with sand dropseed, needleandthread, and bluebunch wheatgrass (Monsen et al. 2004).

Purple threeawn quickly invades roadsides, animal burrows and other areas where the soil is disturbed.

Adaptation
Purple threeawn is very drought tolerant and is generally adapted to sites receiving 6 inches or more annual precipitation. Plants are hardy to -10° F and suggested for use in USDA zone 6 (Mountain States Wholesale Nursery 2001).

Establishment
Warm to hot temperatures improve germination of purple threeawn. Evans and Tisdale (1972) recorded little germination before seeds were subjected to air temperatures of 104° F. Other studies show optimum germination between 50 and 86° F (Eddleman 1978).

Purple threeawn can be seeded alone or in mixtures with other native species (Monsen et al. 2004). Drill seeding to a depth of 1/2 to 1 inch is recommended. The full stand seeding rate of 4 lbs/ac Pure Live Seed (PLS) provides an average of 25 seeds/sq ft (Ogle et al., 2014).

De-awned seed can be drill seeded; however USDA-NRCS (2004) suggest that de-awning may reduce seed quality.

Management
Grazing should be deferred for two or more seasons to allow plants to establish (Ogle et al. 2011).

Purple threeawn increases under grazing because other more palatable bunchgrasses are favored by livestock.

Pests and Potential Problems
There are no pests or potential problems documented for this species.

Environmental Concerns
Purple threeawn is native to arid locations in western North America and poses no concern to native plant communities. However it spreads quickly into disturbed areas and can be considered invasive in certain situations. Its dominance may be indicative of poor grazing management, especially in the Northern Great Plains.

Once matured, the long awns on the seed head can become problematic. The awns and sharp seed can become lodged in the soft tissues of the mouth and nose developing into abscesses which are extremely painful. Animals will typically avoid eating threeawn when other more palatable forage is available. The awns may also decrease value of sheep wool.

Purple threeawn florets. Bruce Leander, Ladybird Johnson Wildflower Center.

Seeds and Plant Production
The USDA-NRCS Tucson Plant Materials Center (2004) recommends planting purple threeawn with 24 to 38 inch row spacing for seed production to allow for between row cultivation. Narrower row spacing can be used but seed yields and stand longevity may be reduced.

Seed is drilled in late summer to early fall into a firm, weed free seed bed. Fields are irrigated to prevent crusting and to aid stand establishment. After establishment fields are irrigated to field capacity in late fall. Established fields are irrigated if necessary in spring through the boot stage. Overhead irrigation should be avoided during flowering.

Seed is harvested in Tucson from May to July when seed is in the hard dough to mature stage. Some lodging may occur. Seed can be stripped for maximum yields. Direct combining or swathing and windrowing provide satisfactory results.

Awns are removed with a hammermill at moderate speed, and the seed is cleaned with air-screening. Weed seed can be removed using an indent or disc cleaner.

Cultivars, Improved, and Selected Materials (and area of origin)

Common seed of purple threeawn is available commercially.

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Citation

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For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program Web site http://plant-materials.nrcs.usda.gov.

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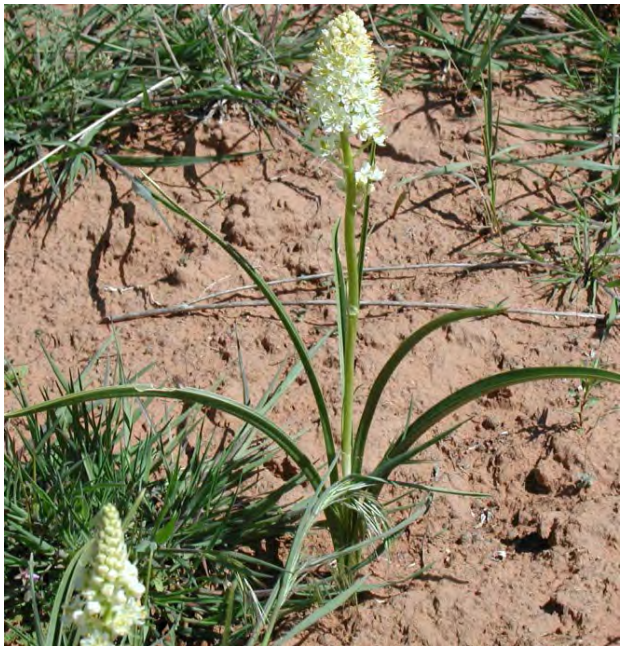
Plant Guide

MEADOW DEATHCAMAS

Zigadenus venenosus W. Watson

Plant Symbol = ZIVE

Contributed by: USDA NRCS Idaho Plant Materials Program



Meadow deathcamas. Photo by Eve Warren, USDI BLM.

Alternate Names

Common Alternate Names: meadow death camas, grassy death camas

Scientific Alternate Names: *Z. intermedius* Rydb., *Z. salinus* A. Nelson, *Z. gramineus* Rydb.

Caution: This plant can be toxic.

Uses

Livestock: Deathcamas is toxic to all classes of livestock and wildlife. Sheep and cattle are most commonly affected, but occasional losses of horses and domestic chickens have also been reported (Burrows and Tyrl 2001). Marsh et al. (1915) reported the loss of 500 sheep in a single event.

Pollinators: Deathcamas has been promoted for pollinator plantings; however its use by bees is limited to a few specialist species due to the toxicity of the pollen (Cane et al 2004).

Ethnobotanical: The toxic nature of meadow deathcamas was well known to Native Americans (Burrows and Tyrl 2001; Chestnut 1902; Turner 1980). Several tribes applied mashed bulbs externally to heal bruises, sprains and boils (Chestnut 1902; Blankinship 1905).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Weediness

Meadow deathcamas may be considered weedy in some regions or habitats (Whitson et al. 1996). Consumption of deathcamas has been linked to deaths of livestock and humans (Burrows and Tyrl 2001). Please consult with your local NRCS Field Office, Cooperative Extension Service office, state natural resource, or state agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at http://plants.usda.gov/. Please consult the Related Web Sites on the Plant Profile for this species for further information.

Description

General: Meadow deathcamas is a perennial bulbous native forb in the lily family (liliaceae). The plants are 1 to 2 feet tall with linear grass-like leaves mostly arising below the stem middle. The flowers are born in panicles with flower bearing stems 1/4 to 1 inch in length. The petals are creamy white, 1/4 inch long, with a large gland at the base. The fruit is a capsule which dries and splits at maturity releasing the seed (Welsh et al. 2003). There are approximately 130,000 seeds per pound (Vance 2010). The common name refers to the toxicity of the plant and its similarity in appearance to camas (*Camassia quamash*).

Distribution:
Meadow deathcamas occurs in western North America from Saskatchewan to British Columbia and south to Baja California and New Mexico (USDA NRCS 2014). For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Meadow deathcamas is commonly found in moist meadows to dry rocky hillsides in ponderosa pine, mountain shrub, wet grasslands and prairie communities at elevations from 1,400 to 8,000 feet (Hickman 1993; Welsh et al. 2003).

Adaptation
Meadow deathcamas is adapted to sandy to rocky soils (Hauser 2006) in areas receiving 12 to 20 inches annual precipitation. It is shade intolerant (Klinka et al 1989). This species is well adapted to areas prone to wildfire. The tops of the plants are killed, but the bulbs survive and deathcamas is among the first plants to regenerate after fire (Volland and Dell 1981).

Establishment
Deathcamas is not recommended for rangeland plantings. See "Seed and Plant Production" for more information on plant propagation.

Management
Meadow deathcamas is typically very sparse on the landscape but can become prominent on overgrazed sites (USDA FS 1937). It greens up early in the spring and offers tempting forage. The best way to avoid problems is to keep livestock away from heavily infested areas (USDA FS 1937). A proper grazing regimen is recommended to prevent deathcamas from increasing on rangelands. The likelihood of consumption increases following fire as deathcamas regenerates quickly from underground bulbs.

Deathcamas species contains a wide range of toxic alkaloids with meadow deathcamas having the most diverse group of alkaloids in the genus (Burrows and Tyrl 2001). A lethal dose is estimated to be 1% of body weight of green plants in sheep, but severe illness can occur with dosages as low as 0.2 to 0.5% body weight (Panter and James 1989). Cattle are more susceptible to illness from deathcamas ingestion, but sheep are at greater risk because they are more likely to eat the plants (Marsh et al. 1915).

Signs of poisoning can begin several hours to a day after ingestion. Indications include frothy salivation and strings of saliva hanging from the mouth (Burrows and Tyrl 2001). Depression, vomiting, and grinding of the teeth are also signs. In severe cases, loss of appetite, loss of coordination, weakness and death follow.

Treatments for deathcamas poisoning include atropine for relief of the cardiovascular effects and picrotoxin to counteract depression (Burrows and Tyrl 2001).

Pests and Potential Problems
Deathcamas has been mistaken for other edible bulbous plants such as wild onion, sego lily and camas, especially when flowers are lacking (Cronquist et al. 1977). Eating one or two bulbs is enough to cause severe illness in children, and 4 or 5 can cause death depending on the species (Burrows and Tyrl 2001).

Environmental Concerns
Meadow deathcamas is highly toxic. It has been linked to the deaths of thousands of sheep and other livestock. It increases with overgrazing.

Control
Spraying deathcamas with 2,4-D in early spring when plants are in the 3 to 5 leaf stage provides fair control (Hyder and Sneva 1962).

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Seeds and Plant Production
Insect pollination is required for seed production in deathcamas (Cane et al 2004; Moldenke 1976). Pollen and nectar of foothills death camas (*V. paniculatus*) was found to contain the same toxins as are found in the vegetative plant parts. Adults of the generalist solitary bee, *Osmia lignaria* (Megachilidae), were paralyzed and soon after died when fed biologically relevant doses of deathcamas toxins; larval progeny eating dosed provision masses likewise died. Similarly, pollen of meadow deathcamas shaken into sugar water killed 89% of the bees that fed on it within 16 hours (Hitchcock 1959). This high mortality rate probably explains the absence of the 50+ native bee species from this potential host (Cane et al 2004). The solitary bee, *Andrena astragali*, is known to use death camas pollen to feed itself and its progeny.

Seed falls easily from mature capsules and can be cleaned with a hammermill and airscreen cleaner. Seeds placed in cold/moist stratification for 90 days resulted in 90% germination compared to 0% germination from the non-stratified control (Bartow 2003). All portions of the plant, including the fruit and seed are toxic and should be handled with care.

Plants can also be propagated by division and bulb offshoots (Hauser 2006).

Cultivars, Improved, and Selected Materials (and area of origin)
There are no releases of meadow deathcamas. Common seed harvested from native stands is available in limited quantities.

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SHADSCALE SALTBUSH

Atriplex confertifolia (Torr. & Frém.) S. Watson

Plant Symbol = ATCO

Contributed by: USDA NRCS Idaho Plant Materials Program

Shadscale saltbush. Gary Monroe @ USDA-NRCS PLANTS Database.

Alternate Names

Common Alternate Names: shadscale, spiny saltbush

Scientific Alternate Names: *Atriplex jonesii* Standl, *A. subconferta* Rydb., A. *collina* Woot. & Standl.

Uses

Wildlife: Shadscale saltbush provides forage and cover for wildlife in arid environments. A small number of leaves are shed in the fall, but the majority of leaves remain during the winter providing a valuable source of food when little else is available (Holmgren et al. 2012). The fruit and leaves are browsed by deer, pronghorn, bighorn sheep, rodents, jackrabbits and birds. Small mammals and reptiles use the spiny shrubs for cover from predators and the sun.

Livestock: The palatability of the leaves and fruit of shadscale saltbush has been rated as fair to good for cattle and sheep making shadscale an important part of winter diets on desert rangelands. However, the spiny branches limit utilization of shadscale saltbush.

Restoration/reclamation: Attempts to establish shadscale saltbush in restoration plantings have been largely unsuccessful. Arid conditions common to shadscale saltbush habitat make seeding efforts highly unpredictable. Establishment from containerized stock has shown the greatest success.

Ethnobotanical: The Gosiute and Hopi used the leaves of shadscale saltbush to be eaten as greens or to be cooked with meal to make a pudding (Chamberlin, 1911; Whiting 1939).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

Shadscale saltbush is a low growing shrub (1-3 ft) with spine tipped branches. The gray-green leaves are alternate, 1/4 to 1 inch long and orbicular to ovate in outline with entire margins. Shadscale saltbush is dioecious (separate male and female plants). The staminate (male) flowers are yellow and gathered in clusters or spikes. Female flowers are arranged in a 1 to 6 inch long panicle. Each flower is enclosed in 2 fruiting bracteoles fused at the base.

There is considerable variation in ploidy races of shadscale saltbush. 2n=18, 36, 54, 72, 90 (Holmgren et al. 2012).

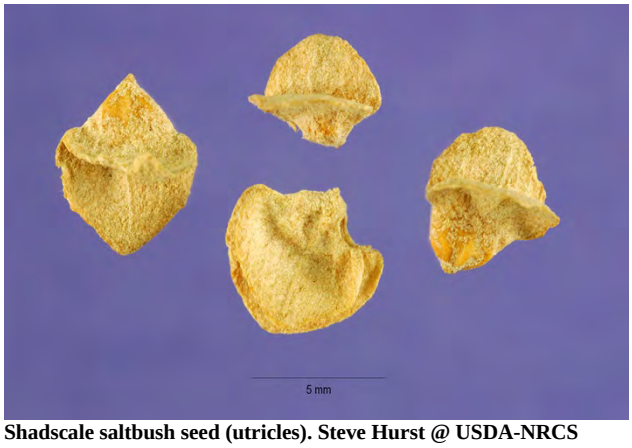
Distribution: Shadscale saltbush occurs throughout western North America from California and Oregon east to North Dakota and south to Arizona and Texas. The greatest concentrations of shadscale saltbush are found in the Great Basin and Colorado Plateau (Simonin 2001).

Shadscale saltbush can be found in warm and cold desert shrub-steppe environments. Populations occur in low valleys, foothills and mesas from 2,500 to 7,500 ft elevation (Simonin 2001). It often grows in association with other halophytes including mat-atriplex, glasswort and greasewood, but can also be found in sagebrush and pinyon-juniper communities (McArthur and Monsen 2004; Welsh et al. 2003).

Shadscale saltbush is highly drought tolerant and is adapted to sites receiving 6 to 12 inches annual precipitation. This species is tolerant of high saline conditions (pH 7.5-9.0) and is classified as a facultative halophyte (Branson et al. 1973). It prefers well drained soils but may inhabit a wide range of soil textures from fine to gravelly.

Differences can be seen between communities of diploid and polyploid shadscale saltbush. Diploid plants are widely spaced and mixed with many other species. Polyploid stands are dense and uniform with few other species intermingled (Tiedemann et al. 1983). Diploids also have more genetic flexibility and tend to occupy a broader variety of sites. Within the Great Basin diploid shadscale saltbush populations are most commonly found above the levels of Pleistocene lakes. As the water receded following the ice age, polyploid populations expanded into the newly available sites (Tiedemann et al. 1983).

Establishment
Shadscale saltbush seed is highly dormant, largely due to the inhibitive role of the pericarp (hard tissue surrounding the seed). Warren and Kay (1983) tested germination following various methods of pericarp removal. Zero seeds germinated with intact pericarps. Germination increased to 21% with the pericarps mechanically removed.



Shadscale saltbush seed (utricles). Steve Hurst @ USDA-NRCS PLANTS Database.

Baskin and Baskin (2002) placed seeds in cold stratification and saw germination at 12° C and 16/12° C temperature cycles. Germination was equal in light and dark; however they did not report whether or not the pericarp had been removed, the length of the stratification period, or the total percent germination.

Pericarp removal is difficult and feasible methods for use in large scale seed processing are lacking. Fall seeding for natural breakdown of the pericarp is recommended, however germination from outdoor stratification is erratic (Tiedemann 1984).

Seed should be drill seeded to a depth of 1/4 to 1/2 inch in a firm, weed-free seed bed. Due to the nature of the soils common in shadscale saltbush habitat, soil crusting is common and may prevent seedlings from emerging. Shadscale saltbush is slow to develop and not competitive in the first years of establishment. It should be planted in solid stands or in alternate rows from grasses and other more competitive species (McArthur and Monsen 2004).

Transplanting greenhouse grown stock (containerized or bareroot) is the most successful method of establishing shadscale saltbush. Transplants are not competitive, and a 30 inch diameter clearing is recommended to reduce seedling competition (McArthur and Monsen 2004).

Management
Overgrazing the plant is largely prevented by the presence of spiny branches. Typically only 15 to 20% of fresh growth is browsed by domestic sheep (Holmgren and Hutchings 1972). Extensive late spring and summer grazing however can cause reduction in stands.

Shadscale saltbush is killed by fire; however the lack of continuous fine fuels in shadscale saltbush communities has historically prevented major losses. The introduction of invasive annuals such as cheatgrass has altered the plant communities and increased the risk of wild fire. Slow establishment and development of shrubs like shadscale saltbush following fires allows invasive annuals to thrive and inhibit shrub reestablishment.

Pests and Potential Problems
Surveys of commercial seed lots have shown damage to shadscale saltbush by insects (Haws et al. 1984). Seed should be stored in cold conditions and treated with an insecticide (McArthur and Monsen 2004).

Environmental Concerns
Shadscale saltbush is native to western North America. It will spread under favorable conditions but does not pose any environmental concern to native plant communities.

Seeds and Plant Production
Seed is harvested by hand or vacuum from wild native stands. Seed is hammermilled to remove the bracteoles and pericarp, but care should be taken to not damage the seed. Inert matter can be removed with an air screen cleaner. There are approximately 60,500 seeds per pound (USDA 2014). Seed quality from native stands is variable depending on climatic conditions. Low seed fill in lots of shadscale saltbush is common (McArthur and Monsen 2004).

Cultivars, Improved, and Selected Materials (and area of origin)
There are no releases of shadscale saltbush. Common seed harvested from native stands is available commercially.

Ecotypes should be selected that are adapted to the site and conditions to be planted. Diploid shadscale saltbush typically shows better adaptive flexibility and competitive ability and should be chosen for upland sites. Polyploids are typically more drought tolerant and adapted to lower elevation arid sites, but are less competitive with other species.

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United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

PLAINS PRICKLYPEAR

Opuntia polyacantha Haw

Plant Symbol = OPPO

Contributed by: USDA NRCS Idaho Plant Materials Program

Plains pricklypear. Al Schneider @ USDA-NRCS PLANTS Database

Alternate Names

Common Alternate Names: Plains prickly-pear, hairspine cactus, starvation pricklypear, central pricklypear

Scientific Alternate Names: none

Uses

Livestock: Plains pricklypear is palatable to livestock once the spines are removed (Mueller et al. 1994). In the Great Plains, plains pricklypear yields can range from 1,300 to 1,780 lb/ac. The spines of plains pricklypear however make it and other desirable vegetation growing underneath unavailable to livestock (Smith et al 1985).

Digestibility of despined plains pricklypear measured at least equal to that of alfalfa hay. It has less digestible protein but more soluble carbohydrates than alfalfa. Supplementation with protein is recommended when providing a diet of plains pricklypear (Shoop et al. 1977).

Wildlife: Plains pricklypear provides protection and cover for a variety of small mammals, reptiles, birds and insects. Other animals including bison, pronghorn and white-tailed deer eat plains pricklypear, especially after fire when the spines have been burned off (Courtney 1989; Peden 1976).

Xeriscape: Plains pricklypear is easily propagated with cuttings and is popular for low water-use gardens and xeriscaping. The flowers are showy and last from late May to late June (Osborn et al. 1986).

Pollinators: Numerous genera of native bees have been documented visiting plains pricklypear. Osborn et al. (1986) observed species of *Diadasia, Lithurge, Melissodes, Bombus, Agapostemon* and *Megachile* effectively pollinating plains pricklypear in southern Colorado.

Ethnobotanical: Numerous tribes used plains pricklypear as a food source or as a drug. Cheyenne, Hopi and Montana Indians ate the fruit dried or fresh (Hart 1981; Nequatewa 1943; Blankinship 1905). The Goshute, Hopi and Paiutes also cooked and ate the fleshy stems (Chamberlin 1911; Whiting 1939; Fowler 1989). Stems and fruit were used to make dye (Hart 1992), and the spines were used to make fish hooks (Turner et al. 1980). The flesh of the stem joints was used by the Flathead to soothe backache, and the Okanagan-Colville applied a poultice of flesh to sores and infections (Hart 1992; Turner 1980).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Weediness

Plains pricklypear may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed (Whitson et al. 1996). It is often a problem on overgrazed rangeland (Taylor and Whitson 1999). Please consult with your local NRCS Field Office, Cooperative Extension Service office, state natural resource, or state agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at http://plants.usda.gov/. Please consult the Related Web Sites on the Plant Profile for this species for further information.

Description

General: Plains pricklypear is a native perennial shrub with enlarged photosynthetic stem joints (cladophylls) which function as leaves (Harris and Harris 1997). The plants are mainly 1to 2 ft tall and can spread into wide colonies by layering and sprouting from fallen segments. The flattened stem joints are 2 to 6 inches long, obovate

to orbicular, with numerous areoles (localized areas bearing spines). Each areole can bear from 0 to 18 spines, the longest typically averaging 1 to 6 inches in length depending on the variety (Holmgren et al. 2012). The flowers are large, 2 to 3.5 inches across, with numerous yellow, pink or violet petals. The fruit is a dry capsule (1 to 2 inches long) which splits upon maturity (Welsh et al. 2003). There are approximately 145,000 seeds per pound (USDA-NRCS 2014).

Distribution:
Plains pricklypear occurs throughout western North America. It can be found from British Columbia to southern California and east to Saskatchewan and south to Texas. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Plains pricklypear occupies a broad range of habitats in western North America. It is found in cold desert shrublands in the Intermountain West and northern Great Plains and grows in association with sagebrush, horsebrush, rabbitbrush, western wheatgrass, bluebunch wheatgrass and Idaho fescue (Welsh et al. 2003). In the South and the shortgrass prairie it is common in blue grama, buffalo grass, threeawn, sand oak, yucca and mesquite communities (Shiflet 1994).

Adaptation
Plains pricklypear is adapted to arid and semi-arid regions receiving 8 to 20 inches annual precipitation at elevations from 1,000 to 8,000 feet (Johnson 2000). It can be found growing on fine to coarse textured soils but is not frequently found on sand dunes. It is moderately saline tolerant and is adapted to pH levels of 7.0 to 8.8 (USDA-NRCS 2014).

Establishment
Plains pricklypear is generally not used in rangeland seedings, but is more commonly established with cuttings for pollinator and low-water use gardens. See the "Seed and Plant Production" section for propagation details.

Management
Removal of plains pricklypear can increase forage availability (Hyde et al. 1965). It is often removed from rangelands by mechanical beaters. Mueller et al. (1994) proposed a mechanical harvester for plains prickly pear. They modified a side-delivery rake to uproot and windrow pricklypear which was then despined (Mueller and Forwood 1994) and fed to cattle. This provided an average of 1,040 lb/ac of cactus as potential feed. The removal of the cactus also increased the availability of desirable forage.

Pests and Potential Problems
The spines of plains pricklypear can make other desirable vegetation unavailable to livestock (Smith et al 1985). The spines are known to cause injury to the nose, mouth and tongues of livestock (Burrows and Tyrl 2001).

Environmental Concerns
The presence of plains pricklypear is often viewed as a sign of overgrazing. Colonies of plains pricklypear can provide physical protection to more desirable forage as livestock are hesitant to graze in its vicinity. It is unclear however if plains pricklypear increases on overgrazed rangeland or if it is merely more visible (Bemet 1968).

Control
Plains pricklypear can be controlled by mechanical or chemical means. The herbicide Picloram can be applied at 8 ounces (1/2 pint) or 16 ounces (1 pint) per acre. Apply at peak of flowering. Use of an oil-water emulsion spray mixture may improve control. Application of Picloram at the lower rate will provide partial control (stand reduction), and the high rate will provide more complete control. Treatment response is slow however and may take 2 years or more to see full effect (Taylor and Whitson 1999).

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Seeds and Plant Production
Plants of plains pricklypear are typically established vegetatively using stem joint segments. Joints can be removed from established plants at any time of year. The joints should be dried for 2 to 3 days to allow a callus to form over the wound (Toogood 1999). Once callused, the cutting can be placed in a container or directly planted at the located site. Cuttings will root in 2 to 6 weeks. Flowering can occur in the first growing season. Establishment from seed is also successful, but seed takes 1 to 2 years to germinate and years to develop into mature plants.

Cultivars, Improved, and Selected Materials (and area of origin)
There are no releases of plains pricklypear. Common seed harvested from native stands is available commercially.

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LEAFY SPURGE

Euphorbia esula L.

Plant Symbol = EUES

Contributed by: USDA NRCS Aberdeen, Idaho Plant Materials Center

Leafy spurge. William M. Ciesla, Forest Health Management International, Bugwood.org.

Alternate Names

Common Names: wolf's milk, faitours-grass, tithymal
Scientific Names: Considerable taxonomic confusion surrounds leafy spurge varieties, subspecies and hybrids. The PLANTS Database recognizes 2 varieties *Euphorbia esula* var. *esula*, and *Euphorbia esula* var. *uralensis* (= Russian leafy spurge)

Caution: This plant is highly invasive.
Caution: This plant can be toxic.

Uses

Leafy spurge is a noxious, introduced, aggressive invader plant that can overtake large areas, displace desirable plant communities, and reduce aesthetic and economic values and wildlife habitat. Cattle and horses avoid leafy spurge. The milky sap, which contains ingenol, a toxic compound, can cause severe diarrhea and weakness in cattle and horses forced to consume it. Leafy spurge can also cause blistering and hair loss around horses' hooves and can be irritating to the skin, eyes and digestive tracts of humans and other animals. Sheep and goats tend to be less bothered by the toxic sap properties and are often used in concert with herbicides and other biological agents to manage heavy infestations of leafy spurge (Bourchier, et. al., 2006; Gucker, 2010).

Leafy spurge seed is consumed by mourning doves. The plant provides nesting habitat for western meadowlarks but are not utilized by other bird species (Gucker, 2010). Grasshopper sparrows and savannah sparrows have had their populations reduced in areas of heavy weed infestation. Leafy spurge reduces habitat for bison, deer, and elk and is a major threat to the endangered western prairie fringed orchid (*Platanthera praeclara*) because leafy spurge has established and spread into much of the only remaining suitable habitat of the orchid (Bourchier, et. al., 2006).

Although leafy spurge is an invasive plant and most efforts are to control or manage the plant, it has been evaluated for use as a biofuel, as an antiviral against herpes simplex and in China, as a dilution of boiled plant material to control maggots, mosquito larvae, rats, and some plant diseases (Gucker, 2010).

Status

Leafy spurge is recognized as a noxious weed in Alaska, Arizona, California, Colorado, Connecticut, Hawaii, Idaho, Iowa, Kansas, Massachusetts, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wisconsin, and Wyoming.

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Weediness

Leafy spurge produces a prolific, and often deep, massive root system. It can produce abundant seed in the second and subsequent growing seasons. Seed is forcibly ejected from the plant when ripe and all animals that come in contact with the plant can disperse seed. Vehicles and road maintenance equipment can also disperse seed. Seed can also be spread by ants and by water as the seed can float and survive underwater storage (Gucker, 2010).

This plant is weedy and invasive in many regions and habitats and will displace desirable vegetation if not properly managed. Please consult with your local NRCS Field Office, Cooperative Extension Service office, state natural resources department, or state agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at http://plants.usda.gov/. Please consult the Related Web Sites on the Plant Profile for this species for further information.

Description

General: Leafy spurge is a member of the spurge (Euphorbiaceae) family. It is a strongly rooted (often growing in clumps), introduced broadleaf weed that grows 30-70 cm tall. The roots can extend to soil depths of up to 4.5 m. It does not have morphologically structured runners or rhizomes as some have reported but does exhibit shoot-bud production by roots (Gucker, 2010). The plants are glabrous and erect with numerous leaves and the stems ooze a milky sap when damaged. The principal leaves are alternate, broadly linear to narrowly oblong, 3-9 cm long and 3-8 mm wide and essentially 1-nerved. The leaves just below the flowers are heart-shaped. The inflorescence is an umbel with showy yellowish-green colored bracts that are flared horn-like on each side. Flowers are greatly reduced and lack both sepals and petals. A central female flower is surrounded by five groups of male flowers. The fruit is a small, 3-chambered capsule 3-3.5 mm long and the seed is ellipsoid, 2-2.5 mm long, and mostly smooth (Cronquist et. al., 1997; Gucker, 2010). When seed is ripe the capsules explode to eject seeds up to 15 feet from the plant. The seeds have elaisomes (fleshy structures attached to the seed) that aids in dispersal by some ants (Gucker, 2010).

Leafy spurge seed with elaisomes attached on left 2 seeds. Julia Scher, USDA APHIS PPQ, Bugwood.org.

There is considerable taxonomic confusion with leafy spurge because multiple introductions into North America resulted in a complex of variable genotypes. The only species recognized to hybridize with leafy spurge is cypress spurge (*Euphorbia cyparissias*). The hybrid is known as *Euphorbia x pseudoesula* (Gucker, 2010).

Distribution: Leafy spurge is native to Europe and Asia and was first reported in Massachusetts in 1827, likely established from contaminated soil from ship ballasts. Contaminated crop seed including oats, smooth brome and alfalfa brought by European settlers accelerated the spread westward into North America. Leafy spurge is abundant in the northern Great Plains and prairie regions of Canada. It has been found in 35 states with the most extensive infestations in the mid-western and western states of Minnesota, North Dakota, South Dakota, Nebraska, Colorado, Idaho, Montana, and Wyoming as well as the southern portions of all six provinces in Canada (Bouchier, et, al., 2006). By 2005, leafy spurge had infested approximately 5 million acres in the United States (Gucker, 2010). For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Leafy spurge is found in many different habitats from streambanks to dry, upland sites and invades disturbed and undisturbed areas including pastures, abandoned cropland, roadsides, woodlands, riparian communities, meadows and mountain ridges (USDA Forest Service 2012).

Adaptation

In Europe, leafy spurge is often found on sandy soils. In North America it is found on fine to coarse textured, and on moist to dry soils but is most aggressive under dry conditions where competition from desirable plants is reduced. Leafy spurge can tolerate temperatures from -50-100°+ F and annual precipitation ranging from 7-25 inches. Soil texture and fertility can affect growth and distribution of leafy spurge roots. In fine textured soils leafy spurge roots are thicker (greater branching) in the top 6 inches of soil and on coarse textured soils, roots are thicker with less branching at soil depths greater than 30 inches. High levels of soil nitrogen can reduce the biomass of leafy spurge roots with greater root concentrations closer to the soil surface (Gucker, 2010).

Establishment

Leafy spurge reproduces by seed and from root sprouting. First-year plants do not produce seeds. Seed dormancy is controlled by the seed coat and is overcome by warm, moist conditions with temperature ranging from 79-82° F. Most seedlings emerge early in the spring often following heavy precipitation. Seeds planted to a depth of 0.5 and 2 inch depth achieved maximum germination and seeds typically germinate better in fine textured soils than coarse textured soils. Seedlings grow rapidly and are capable of vegetative regeneration within a week of emergence and able to resprout even after being severed 1 inch below the soil surface (Gucker, 2010).

Leafy spurge shoots emerge from established plants from mid-April to early May and flowering begins in late May to mid-June but can extend to later months depending on latitude and environment. In the northeastern states

flowering may occur until October. Mature seeds develop about 30 days after pollination. Flowers are pollinated primarily by insects and high levels of seed can be produced (up to 3,400 pounds per acre in a Saskatchewan study). Ripe seed is forcibly ejected up to 15 feet from parent plants and seed may remain viable in the soil for up to five years (Gucker, 2010)

Leafy spurge can spread prolifically from the root crown, root buds and root pieces and can occupy a large area in a relatively short time (from 0.5-11 feet annually), and is considered to be more important to the persistence and spread of established stands than from seed production (Gucker, 2010).

Leafy spurge may also exhibit allelopathic properties to inhibit competition from other plants but field studies have not shown allelopathy to be a consistent property of the species (Gucker, 2010).

Management

Leafy spurge stands that are established over large areas are extremely difficult and expensive to eradicate. Early detection and eradication of stands just beginning to occupy otherwise desirable plant communities should be given high priority for treatment. Manage for and maintain healthy plant communities; use of certified weed-free hay, straw, mulch and gravel; detect, map and eradicate new stands as soon as possible; implement monitoring and follow up treatment for missed plants and seedlings; and combine mechanical, cultural, biological, and chemical methods for effective control are all actions that should be considered when planning management of leafy spurge (USDA, Forest Service, 2012).

Environmental Concerns

Leafy spurge is highly invasive, listed as a noxious weed in many states, is able to establish and persist in many different plant communities, and is difficult to control once it has established in an area.

Control

Physical: Physical methods alone are mostly ineffective in controlling leafy spurge. Because of the expansive root system, hand pulling or grubbing are not effective. Hand cutting or mowing can reduce seed production and its competitive ability but will only suppress growth. Plants should be clipped within 4 inches from the ground just before seed set and then repeated throughout the growing season. Flowering parts that have been mowed must be removed and destroyed since seed will ripen if left in place (USDA, Forest Service, 2012).

Tillage can be effective but only when reseeding takes place. Areas that are suitable for tillage and seeding should be tilled at 3 week intervals to a depth of at least 4 inches beginning when leafy spurge begins growth in the spring. If using tillage in conjunction with herbicide application allow plants to grow 4-6 inches tall before spraying and wait at least 1 week after spraying before resuming tillage. Equipment must be cleaned after field operations to prevent movement of seeds or root parts to uninfested areas (USDA, Forest Service, 2012).

Prescribed fire is not recommended for control of leafy spurge because the plant rapidly regenerates new shoots from the root system. Fire may be used in conjunction with herbicide control or grazing to remove litter which could enhance reseeding efforts (USDA, Forest Service, 2012).

Land managers, road crews, and the public need to be educated to identify noxious species so they can help report suspected infestations and the importance of not travelling through infested sites. Vehicles, humans and livestock should be discouraged from moving through infested areas and to check and remove seeds prior to leaving an infested area to help stop the spread of leafy spurge. Weed screens on irrigation water from infested areas can help prevent seed transportation through irrigation canals (USDA, Forest Service, 2012).

Chemical: Long-term control of large, well established leafy spurge stands with herbicides alone usually has not been very successful and is very expensive. A waxy layer on the leaves and stems makes chemical control difficult without the use of surfactants and the roots are able to purge chemicals from the root system (Gucker, 2010). Herbicide application is most effective during the fall because chemicals are more easily transported to the root system after flowering. Picloram (Tordon 22K) has long been used on leafy spurge because of its selective control while allowing grasses to return naturally but is a restricted use herbicide. Aminocyclopyrachlor (Perspective or Streamline) is a newer herbicide that is showing effective control in laboratory testing. Imazapic (Plateau) is effective and especially useful on permeable soils, around trees, or near surface water. Dicamba (Clarity) is less expensive than Picloram products and is not a restricted use herbicide. Glyphosate (Roundup, Rodeo) is a non-selective herbicide that is recommended only in conjunction with grass seeding (USDA, Forest Service, 2012).

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Biological: Grazing of sheep or goats in combination with either herbicide application or use of insects can lower seed production of leafy spurge and decrease its spread. Sheep and goats (especially Angora goats) will readily graze young leafy plants and are not as susceptible to poisoning as other livestock. To maximize suppression of leafy spurge, sheep or goats should graze the plants at a

moderate to severe rate of utilization. Studies have shown that stocking rates of 3-6 sheep per acre per month, 1-2 ewes with lambs per acre per month, or 12-16 Angora goats per acre per month are usually adequate. Grazing should begin in the spring when plants are 2-6 inches tall and continue until all of the yellow bracts on the stem have been consumed. If using grazing in combination with herbicide application, remove animals early in the fall and allow 3-4 inches of regrowth before application. Animals should be quarantined 5-6 days to prevent spreading seed to noninfested sites (USDA, Forest Service, 2012).

Using host-specific natural enemies of leafy spurge is referred to as "classical biological control". Numerous biological agents for control of leafy spurge have been tried throughout the United States with varying degrees of success. Currently there are twelve leafy spurge biological control species permitted for release in the United States. Bourchier et. al. (2006) provides detailed information on the permitted insects for control of leafy spurge and guidelines to plan, implement, monitor and evaluate an effective leafy spurge biological control program. There are seven beetles (Coleoptera), two flies (Diptera), and three moths (Lepidoptera) permitted for release. Leafy spurge flea beetles (*Aphthona* spp.) appear to be the most successful control agents for leafy spurge in North America. Larvae are root and stem feeders which do the greatest damage by creating wounds on the roots that allow plant pathogens to enter and cause deterioration of the root system. Adults feed on leafy spurge leaves and flowers but have little or no impact on growth and development of leafy spurge. Different flea beetle species have different habitat preferences and for optimal biological control, a variety of flea beetle species should be released and the beetles will sort out their preferred habitats (Bourchier, et. al., 2006). If using grazing in combination with flea beetles, graze once in the spring and once in the fall to allow the beetle to complete its life cycle on the plant (USDA, Forest Service, 2012).

Any strategy adopted for managing leafy spurge must involve careful planning, maintaining repetitive treatment over multiple consecutive years, periodically monitoring treated areas and spot treatment, using sound grazing management practices and monitoring the return of desirable plant species (USDA, Forest Service, 2012).

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ROCKY MOUNTAIN PENSTEMON

Penstemon strictus Benth.

Plant Symbol = PEST2

Rocky Mountain Penstemon. Sally and Andy Wasowski, Ladybird Johnson Wildflower Center

Alternate Names

Common Alternate Names: Strict beardtongue, Toadflax beardtongue

Uses

Grazing/rangeland: Rocky Mountain penstemon is used by wildlife and is rated as fair forage for cattle and fair to good forage for sheep (Forest Service, 1937). It provides diversity in the plant communities where it is found.

Erosion control/reclamation: Penstemon species are used in seed mixes for erosion control and reclamation.

Pollinators: Rocky Mountain penstemon is used by bumblebees to gather nectar and is also visited by various other bees and wasps. Hummingbirds only visit Rocky Mountain penstemon occasionally (Castellanos et. al., 2003).

Ornamental: The beautiful flowers and evergreen basal leaves of Rocky Mountain penstemon make it attractive for ornamental and landscape planting (Smith, et. al., 2009). Rocky Mountain penstemon has been identified as a compatible and beneficial companion plant to grow along with several paintbrush (*Castilleja*) species for ornamental applications (Nelson, 2005). Paintbrush plants require a companion plant to serve as host for its semi-parasitic needs.

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Rocky Mountain penstemon, a member of the Figwort family (Schrophulariaceae) is a semi-evergreen, native, perennial forb with fibrous roots and is 35-70 cm tall. Plants are mostly glabrous and the leaves are entire. Basal and lower leaves are 5-15 cm long, 5-16 mm wide, narrowly oblanceolate, rounded at the tip and tapering to the base. The upper leaves are 4-10 cm long, 2-7 mm wide, linear and often folded. The flower stalks have a whorl of 1 or 2 flowers (sometimes 4) at each node. The sepals are 3-5 mm long, glabrous and ovate or rounded to obtuse and are glabrous. The petals are 24-32 mm long and the flower tube is 6-10 mm long, deep blue in color with a whitish color at the opening and often with red-violet lines inside the throat and sparsely bearded to sometimes glabrous. The fruit is a capsule 8-13 mm long (Cronquist et. al., 1984).

Distribution: Rocky Mountain penstemon is native to the western United States from southern Wyoming south into northern New Mexico, and the eastern portions of Utah and Arizona. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Rocky Mountain penstemon is found with sagebrush in pinyon-juniper woodland, oak scrub and in openings of ponderosa pine and spruce-aspen forests (Cronquist et. al., 1984).

Adaptation

Rocky Mountain penstemon is best adapted to well drained, rocky and sandy loam soils that are weakly acidic to alkaline and in areas with 15-20 inches annual precipitation (Monsen et. al., 2004) and 6,000-10,500 feet elevation (Cronquist et. al., 1984).

Establishment
Monsen et. al., (2004) state that the planting process for Rocky Mountain penstemon is similar to other penstemon species. The general recommendation is to plant seed in the fall from 1/8 to no more than ¼ inch depth into a firm, weed-free seedbed. Good seed to soil contact is important for germination and establishment. There are approximately 490,000 seeds per pound (USDA, NRCS, 2013). To achieve a target seeding rate of 30 seeds per square foot, 2.7 pounds PLS (Pure Live Seed) per acre should be planted to achieve a full stand. When used as a component of a seed mix adjust the seeding rate to the percent of mix desired. Rocky Mountain penstemon should be drilled with a seed dilutent such as rice hulls because the seeds are small and may separate from other seeds in the mix.

Mulching, irrigation and weed control benefit stand establishment. Some seed may not germinate until the second growing season. Plants begin growth early in the spring and flower blossoms appear in the late spring and early summer. Flowering should not be expected until the second growing season.

Weed control will be required during establishment. Because penstemon is a broadleaf plant, the use of broadleaf type herbicides is not recommended. Mowing broadleaf weeds when they are beginning to bloom will help reduce weed seed development in subsequent years.

Management
Rocky Mountain penstemon should be used as a minor component of seed mixtures. Management strategies should be based on the key species in the established plant community. Grazing should be deferred on seeded lands for at least two growing seasons after seeding to allow for full stand establishment. With proper management, natural regeneration should maintain plants in the vegetative community.

Pests and Potential Problems
Information on pests and diseases of Rocky Mountain penstemon is not well known. In general, penstemon is susceptible to soil-borne fusarium and rhizoctonia root rot which can be severe in poorly drained loam and clay textured soils. Grasshoppers and other insects may also damage plants. Colorado State University Extension (2013) has identified a penstemon weevil (*Hesperobarus sp.*- precise species not yet confirmed) that has caused catastrophic damage to several species of penstemon (including Rocky Mountain penstemon) seed production fields in southwestern Colorado. Penstemon weevil damage is difficult to control because no control methods are available. Weevils damage the plant by feeding in the taproot.

Environmental Concerns
Rocky Mountain penstemon is a native plant species found in western North America and has no known negative impacts on wild or domestic animals. It is not considered a weedy or invasive species but can spread to adjoining vegetative communities under ideal conditions. It co-exists with other native species and adds biodiversity to plant communities.

Seed and Plant Production
There can be considerable variability in seed dormancy among collections of the same species of penstemon. A few methods can be used to overcome dormancy including the use of aged seed where after-ripening causes seed to lose dormancy, moist pre-chilling (stratification), and the use of plant hormones referred to as gibberellins (GAs). Allen and Meyer (1990) found that 3-4 year old seed of 'Bandera' Rocky Mountain penstemon germinated to full viability without stratification and 1-2 year old seed responded favorably to stratification treatments, although the 1 year old seed failed to germinate to full viability even with an 8-week stratification. Lindgren and Schaaff (2004) indicated that 2-6 year old seed of Rocky Mountain penstemon does not need a stratification treatment to enhance emergence. Kitchen and Meyer (1991) determined that treatment of Rocky Mountain penstemon with GA_3 was not necessary but caution may be warranted for special treatment as more dormant seed lots are likely to exist. Abella (2009) evaluated emergence of 61 plant species where seed was subjected to liquid smoke treatments and found significant difference between non-treated seed and seed exposed to a 10 % (vol/vol) aqueous smoke. Although Rocky Mountain penstemon was not included in this study, there were 5 of 8 penstemon species in the study that were significantly stimulated by smoke treatment.

A standard method for propagating penstemon for transplants is to stratify the seed for 8-12 weeks in cold and moist conditions. Seed should be surface sown into plant containers, pressed into the soil surface then stored under cool (36° F), dark conditions for 8-12 weeks. After the stratification period, bring plants into greenhouse conditions and allow plants to grow for 8-12 weeks before transplanting in the field. Rocky Mountain penstemon can be produced with fertilizer concentrations (up to 200 ppm N) and media pH ranges (5.5-7.2) similar to those used to produce other common greenhouse plants (Cardoso et. al., 2007). Propagation of new plants from division of older plants is also possible. Sprigs need some roots and a few leaves for best results. The basal portions of the stems also layer or root readily in moist soil (Smith, et. al., 2009).
Fields for seed production can be established from direct seeding or from transplanting greenhouse grown containerized stock. Direct seeding should occur in late fall to allow for natural stratification of the seed. Rocky Mountain penstemon should be seeded in 30-36 inch spaced rows at a rate of 0.9-1.0 pounds PLS/ac (target 30 pure live seeds per linear foot of drill row) to allow for mechanical weed control (Cornforth et. al., 2001). The use of weed barrier fabric is an alternative to allow closer

spacing, reduce weeds and conserve soil moisture. Plant spacing of 18 inches provides for maximum growth and seed yield when using weed barrier fabric.

Seed normally ripens from mid-August to mid-September and is mature when seed capsules dry and become hard and dark in color. Seed will shatter once capsules have opened. Removal of the flowering stalk at harvest will ensure flowers the following year (Smith, et. al., 2009). Seed can be harvested by hand-stripping or with a combine. Seed is separated from the capsule with use of a hammermill or barley debearder followed by fan cleaning. Seed yields average 100 pounds per acre.

Cultivars, Improved, and Selected Materials (and area of origin)

'Bandera' Rocky Mountain penstemon was released by the Agricultural Experiment Stations at New Mexico State University and Colorado State University, New Mexico State Highway Department and USDA Natural Resources Conservation Service in 1973 (Smith, et. al., 2009).

Bandera was originally collected near Mountainair, Torrance County, New Mexico in the ponderosa pine zone at approximately 7,400 feet elevation and 16-18 inch annual precipitation and was tested at the Los Lunas, NM Plant Materials Center. It is best adapted to medium to sandy and rocky textured soils that are well-drained and elevation ranging from 6,000-10,000 feet with 15-20 inches annual precipitation. Its intended uses are for erosion control, diversity, and beautification. In gardens or landscape with cultivation it can be grown at lower elevations (Smith, et. al., 2009). Breeder and Foundation seed is maintained by the Upper Colorado Environmental Plant Center and Certified seed is commercially available.

Wildland collected Rocky Mountain penstemon seed can also be obtained through commercial vendors (Native Seed Network).

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Citation

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For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program Web site http://plant-materials.nrcs.usda.gov.

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DAHURIAN WILDRYE

Elymus dahuricus Turcz. ex Grieseb.

Plant Symbol = ELDA3

Dahurian wildrye. Photo courtesy of Bismarck Plant Materials Center, USDA-NRCS, Bismarck, North Dakota.

Alternate Names

Common Names: None
Scientific Names: None

Description

General: Dahurian wildrye is an introduced, self-pollinating, short-lived (1-3 yrs) perennial bunchgrass with culms reaching 40 to 60 inches. The stems are leafy with leaves 11 to 18 mm wide and lax. The seed head forms a tight spike with 2 to 4 spikelets per node (Dobb and Burton 2013). There are approximately 80,000 seeds/lb. The root system is shallow and fibrous. Dahurian wildrye is similar in appearance to blue wildrye (*E. glaucus*) but differs in palea shape (Barkworth and others 1993).

Distribution: Dahurian wildrye is native to Siberia, Mongolia and China. In North America it has been used in pasture and hay production in western Canada from Saskatchewan to British Columbia. Its use is limited in the northern Great Plains region of the United States (Alderson and Sharp 1994). For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: This species has been used in North America on rangeland and for pasture and hay forage.

Adaptation

Dahurian wildrye is adapted to sites receiving 12 to 24 inches annual precipitation (Dobb and Burton 2013), but persists longer with higher precipitation. It is said to have high saline tolerance and is adapted to all soil textures (Dobb and Burton 2013). It was grown in test plots in Saskatchewan with electrical conductivity levels up to 6.7 dS/m (Glover and others 2004). It is not as winter hardy as crested or intermediate wheatgrass in semi-arid climates with little snow cover. It is very competitive during establishment but loses competitive ability as the stand ages.

Uses

Hay and pasture: Dahurian wildrye is a tall plant with leaves growing high up on the stem providing excellent forage for pasture. It also has better regrowth after harvest than intermediate and crested wheatgrass and can be grazed 2 to 3 times per season. It produces significantly greater amounts of forage than crested and intermediate wheatgrass in the first growing season but decreases as stands lose vigor in subsequent years (Lawrence and Ratzlaff 1988). Forage quality and palatability of Dahurian wildrye is high, comparable to intermediate and crested wheatgrass.

Dahurian wildrye is a short-lived perennial with quick establishment and is used as an early forage component with other slower growing species. It should be limited in mixes to less than 25% to prevent it from outcompeting less vigorous species. Montana State University Extension (Dixon 2014) recommends the following mixes based on grazing seasons in south central Montana:

Spring Pasture:
- 5 lb crested wheatgrass
- 0.5-1 lb alfalfa
- 1 lb Dahurian wildrye

Summer Pasture:
- 6 lb western wheatgrass
- 1-2 lb white prairie clover or small burnet
- 1 lb Dahurian wildrye

Fall pasture:
- 6 lb Russian wildrye
- 0.5-1 lb alfalfa
- 1 lb Dahurian wildrye

Because it regrows quickly after harvesting it has a better yield distribution than other forage grasses.

Status
Please consult the PLANTS Web site (http://plants.usda.gov/) and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Planting Guidelines
The full stand seeding rate for Dahurian wildrye is 14 lbs/ac for a target of 25 seeds/ft². This species shows excellent emergence and seedling vigor, better than crested or intermediate wheatgrass and has established from deep seeding trials as deep as 1.5 in. Drill seeding to a depth of 0.5 to 0.75 inches is recommended (Lawrence and others 1991).

Due to high seedling vigor and competition, Dahurian wildrye should be seeded in alternate rows or cross seeded perpendicular to slower establishing species such as Russian wildrye (Holt and Lawrence 1994). This will provide good forage while other species develop.

Management
Dahurian wildrye has exceptional grazing recovery (Dobb and Burton 2013). It can be grazed in early spring without negative effects. However Dahurian wildrye has a shallow root system and plants can be pulled easily from the ground in wet spring soils during the establishment year. New seedings should be protected from grazing until they are well established (Ogle and others 2011).

Pests and Potential Problems
There are no known pests or potential problems associated with Dahurian wildrye.

Environmental Concerns
This species is not native to North America and may spread via seed under ideal conditions. Its use however, has been limited to managed pastures. It is not noted for weedy tendencies. Dahurian wildrye is self-pollinating and will not form hybrids with native species (Lawrence and Ratzlaff 1988).

Seeds and Plant Production
Seed production for Dahurian wildrye is similar to that of other wildryes and wheatgrasses. Wide row spacing of 24 to 36 inches is recommended for mechanical weed control, however tighter row spacing of 12 inches provides higher yields. Seeders should be calibrated to deliver approximately 8 seeds per foot of row. For 12 inch spacing this equates to 4 lbs/ac. Fertilizer is not recommended during establishment but fall or early spring applications of nitrogen after establishment can increase yields.

Seed can be harvested either with swathing or with direct combining. Seed heads can shatter seed even when the heads are still green. Seed yields on irrigated fields average 600 to 1050 lbs/ac, while dryland yields average 260 to 600 lbs/ac. Dahurian wildrye is self-pollinated, so minimal isolation distance is required for certified seed production.

Cultivars, Improved, and Selected Materials (and area of origin)
'Arthur' and 'James' Dahurian wildrye were selected at Agriculture Canada Research Station in Saskatchewan in 1989 from collections made in China. Both were released for high establishment year yields compared to other wildryes. There are no distinguishing features which separate Arther from James Dahurian wildrye. Arthur heads slightly earlier than James (Sharp and Alderson 1994).

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Citation
Tilley, D. and L. St. John. 2014. Plant Guide for Dahurian wildrye (*Elymus dahuricus*). USDA-Natural Resources

Conservation Service, Aberdeen Plant Materials Center. Aberdeen, Idaho 83210.

March 2014

Edited: 25February2014 ls

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United States Department of Agriculture
Natural Resources Conservation Service
Plant Materials Program

‘Rush’ Intermediate wheatgrass

Thinopyrum intermedium (Host) Barkworth & D.R. Dewey

A Conservation Plant Release by USDA NRCS Aberdeen Plant Materials Center, Aberdeen, Idaho

'Rush' Intermediate wheatgrass

‘Rush’ intermediate wheatgrass was released in 1994 in cooperation with the University of Idaho Agricultural Experiment Station. It was selected for superior seedling emergence and vigor compared to other intermediate wheatgrass cultivars.

Description
Rush intermediate wheatgrass grows to 3 to 4 feet tall. It is an introduced, long-lived, cool season grass with short rhizomes and a deep feeding root system. The leaves are flat and narrow. There is variation in leaf color from green to moderately glaucous (whitish, waxy covering). The seed spikes are 8 to 12 inches long and spikelets are 0.70 to 0.90 inches long. There are usually fewer than seven florets per spikelet.

Source
The USDA Natural Resources Conservation Service, Plant Materials Center at Aberdeen, Idaho received the original seed from the German Botanical Garden, Berlin, in 1962. Intermediate wheatgrass is native to Eurasia and has been cultivated there and in the United States for many years.

Rush was compared with seven released cultivars of intermediate wheatgrass and other cool season grasses at sites throughout the western United States. It was selected for superior seedling emergence and vigor. Rush has equal to or superior forage production compared to other intermediate wheatgrass releases.

Conservation Uses
Rush intermediate wheatgrass is used for rangeland and pastureland seeding in 12 to 20 inch precipitation zones for erosion control, forage and cover. It competes well with aggressive annuals such as cheatgrass and medusahead because of its ability to establish quickly. Rush is used in critical area stabilization where a fast germinating, rhizomatous perennial is needed and in filter strips to trap sediment. It is also used as irrigated pasture to provide feed and cover.

Area of Adaptation and Use
Rush is adapted to the Northwest and Intermountain West regions of the United States where annual precipitation is 12 inches or more. It may be adapted to the mountains of the Southwest, the Western and Northern Great Plains and the Southern Canadian Plains. Rush is well adapted to moderately deep, loamy soils but also grows on sandy and clayey soils.

Establishment and Management for Conservation Plantings
Rush intermediate wheatgrass should be seeded with a drill at a depth of ½ inch or less on medium to fine textured soils and no more than 1 inch deep on coarse textured soils. The recommended seeding rate is 10 pounds Pure Live Seed (PLS) per acre. For critical area stabilization, double the seeding rate. If used as a component of a mix, adjust seeding rate to percent of mix desired. The best dryland results are obtained from seeding in very early spring on heavy to medium textured soils and in late fall (dormant) on medium to light textured soils. Irrigated lands should be seeded in spring and late summer. Late summer (August - mid September) seedings are not recommended unless irrigation is available.

Rush establishes quickly and seedling vigor is excellent. It makes good spring growth, fair summer growth, and good fall growth, if moisture is available. Light, frequent irrigation is beneficial for stand establishment.

New seedings should be protected until fully established and the plants are able to withstand pulling by grazing animals without being uprooted. It is beneficial to cut at least one hay crop prior to grazing.

Stands may require weed control measures during establishment. Application of herbicides should not be made until plants have reached the four to five leaf stage (be sure to read and follow label directions). Mowing the stand when weeds are beginning to bloom will reduce weed seed development. Grasshoppers and other insects may also damage new stands and pesticides may be needed for control.

Rush is highly palatable to livestock and wildlife. Livestock and wildlife will graze it throughout the growing season, but it is most preferred as forage in spring, early summer, and fall. A healthy, productive stand will not withstand heavy continuous grazing.

Eight inches of new growth should be attained in spring before grazing is allowed on established stands. A four-inch stubble height should be maintained following grazing or mowing and going into winter.

On irrigated stands apply fertilizer as needed to maintain vigorous growth. A balance of nitrogen and phosphate fertilizer needs to be considered in order to maintain a legume component in a mixture. A soil test is recommended.

Forage production can be restored and stands may benefit from ripping if sod bound conditions occur. Care should be taken to avoid excessive tillage because stands may be damaged.

Ecological Considerations
This release is from a species that was introduced to the United States in the early 1900's. Rush represents an incremental improvement in performance within a well documented species. Rush spreads slowly vegetatively and very little via seed distribution. It is not considered a weedy or invasive species but can spread into adjoining vegetative communities under ideal environmental conditions. There are no known negative impacts on wild or domestic animals.

Seed and Plant Production
Seed production of intermediate wheatgrass is generally not difficult. Rush should be seeded in 36 inch rows at a seeding rate of 4.9 pounds PLS per acre to allow mechanical weed control and to maintain rows. Rush may be seeded during the spring, late summer, or fall (dormant).Intermediate wheatgrass is rhizomatous and to maintain seed production it should be maintained by cultivation in rows.

Average seed production of 250 to 350 pounds per acre can be expected under dryland conditions (minimum 14 inches annual precipitation required for sustainable seed production). Average production of 450 to 550 pounds per acre can be expected under irrigated conditions. Seed yields drop significantly after about four years of production. Harvesting is best completed by swathing, followed by combining of the cured rows. The seed heads will shatter when mature and if direct combining is desired the stand should be harvested when the top of seed heads just begin to shatter. Harvested seed must be dried to 12 percent moisture before storing in bins and to 15 percent before storing in sacks. Seed is generally harvested in mid to late August.

Availability
For conservation use: Certified seed is available from commercial seed vendors.

For seed or plant increase: Breeder and Foundation seed is maintained by the Aberdeen PMC. Foundation seed is available through the University of Idaho Foundation Seed Program and the Utah Crop Improvement Association. Certification of seed is limited to not more than two generations from Foundation seed. Variety protection has been granted under the Plant Variety Protection Act of 1970 and Rush may only be marketed as a class of Certified seed.

For more information, contact:
Aberdeen Plant Materials Center
P.O. Box 296, Aberdeen, ID 83210
Ph. 208-397-4133
Fax 208-397-3104
http://plant-materials.nrcs.usda.gov/idpmc/

Citation
Release Brochure for 'Rush' intermediate wheatgrass (*Thinopyrum intermedium*). USDA-Natural Resources Conservation Service, Aberdeen Plant Materials Center. Aberdeen, Idaho 83210. Published October, 2013

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NATURAL RESOURCES CONSERVATION SERVICE

IDAHO SPECIFICATION

CRITICAL AREA PLANTING
(Acre)
CODE 342

PLANS AND SPECIFICATIONS

A site investigation shall be conducted to identify any physical, chemical or biological conditions that could affect the successful establishment of vegetation, and to plan the needed site preparation and protective measures.

Plans and specifications are to be prepared for each treatment area and include planting area preparation, methods and rates of planting, species (mixture) to be planted, seed depth, time of planting, fertilizer requirements, irrigation requirements, establishment requirements, site protection requirements and long-term management requirements.

Form ID-CPA-025; Seeding/Planting Plan Specification will assist practice planning and documenting application for seedings.

Form ID-CPA-028; Tree-Shrub-Riparian Planting Specification will assist practice planning and documenting application for plantings.

Under severe circumstances, structural (engineering) practices may be required in association with this practice to ensure long-term site stability.

Seed/Planting Stock

Use of certified seed is encouraged. All seed and planting materials shall be labeled and meet state seed quality law standards.

Based on seed tags, adjust seeding rates at field site to ensure the required amount of pure live seed (PLS) is applied to site. See Plant Materials Technical Note 4 and 4A.

Most legume seed is pre-inoculated when purchased. If fresh inoculation is needed, guidance on inoculation and the proper species of viable Rhizobia for each legume is listed in Plant Materials Technical Note 26.

Tree and shrub planting stock should be as described in Idaho Plant Materials Technical Note 43.

Seedbed/Planting Site Preparation

The area will be shaped or graded if needed to eliminate existing surface erosion patterns and improve ease of seeding operations. Sites reshaped with heavy equipment may have a smooth hard surface and compacted soils making it difficult to prepare a good seedbed. Disking, ripping or other treatment may be necessary to prepare the site for seeding.

A firm weed-free seedbed that ensures seed contact with mineral soil and ample soil moisture to uniformly facilitate seedling emergence is desired. Use of chemicals as an alternative to mechanical seedbed preparation should be considered when appropriate. See Plant Materials Technical Note 13.

Seedbed Firmness Rule-of-thumb: a person's footprint will be no deeper than ½ inch.

A weed-free seedbed will generally not exceed one (1) seedling per square foot of an unwanted plant at time of planting.

The horizontal indentations left by tracked equipment operating up and down slope may provide a suitable seeding site on steep slopes.

Planting site preparation for trees and shrubs using tillage, scaling, chemicals and weed barrier fabric will be in accordance with

recommendations found in Idaho Plant Materials Technical Note 43.

Fertilizer

Based on a soil analysis, soil amendments will be added as necessary to ameliorate or eliminate physical or chemical conditions that inhibit plant establishment and growth. Consider initial and follow up applications of fertilizer to ensure stand establishment.

Amendments, such as compost or manure to add organic matter and improve soil structure and water holding capacity; agricultural limestone to increase the pH of acid soils; or elemental sulfur to lower the pH of calcareous soils shall be included in the site specification with amounts, timing, and method of application.

Fertilization will meet the requirements of Nutrient Management (590).

Seeding

Critical area planting sites are generally severely eroded or disturbed and have low fertility and few, if any, resident seeds. High seeding rates are commonly needed to insure adequate vegetative cover.

Seeding with a drill is recommended. The drill used should provide depth control with bands or other suitable method such that seed placement depth does not exceed recommended depths expressed in Plant Materials Technical Note 24 for that species or seed mixture.

Inspect, clean, repair and calibrate equipment prior to seeding to ensure proper rate, distribution and depth of seeding. See Plant Materials Technical Note 19.

Drill seeding rates will be 150 to 200 percent of the normal drill seeding rates listed in Plant Materials Technical Note 24.

Broadcast seeding rates will be 200 to 300 percent of the normal drill seeding rates. When seed is broadcast planted, where possible, seed should be covered by a roll-type packer or by trampling with grazing animals on mineral soil seedbeds. High organic residue seedbeds should be lightly dragged or raked.

Seeding rates on irrigated land will be 150 to 200 percent of rates specified in Plant Materials Technical Note 24.

Actual seeding rates of applied seeding mixture will be within approximately 80 to 125 percent of rate specified during the planning process in the ID-CPA-025 Seeding/Planting Plan Specification.

Seeding Dates

On light to medium textured soils, dormant fall planting is the preferred time for planting.

Heavy to medium textured soils that tend to form soils crusts over winter, early spring planting should be considered.

On temporarily irrigated land, seed anytime during the growing season when temperatures are favorable for seed germination and seedling growth. Sufficient irrigation water must be available, and applied often enough to allow the soil surface to remain moist and favorable for seed germination and seedling emergence. Avoid seeding during very hot periods such as mid to late June through mid-August.

Fall seeding requires irrigation and seedlings are expected to attain the 3-5 leaf stage prior to cessation of growth in the fall. This requires at least 30-45 days of growth from date of planting.

Generally accepted planting dates are:

MLRA	Spring* (before)	Fall** (before)	Dormant*** (after)
8	4/1	10/1	11/15
9	4/15	9/20	11/1
10	5/15	9/10	10/20
11	4/15	9/20	11/1
12	5/15	9/20	11/1
13	5/15	9/10	10/20
25	5/15	9/10	10/20
28A	5/1	9/20	11/1
43A	5/15	9/1	10/20
43B	5/15	9/1	10/20
43C	5/15	9/1	10/20
44	5/15	9/1	11/1
47	5/15	9/10	10/20

Seeding dates may vary from these guidelines based on local experience and conditions.

* Complete spring plantings as early as possible.
** Fall seedings on irrigated land only.

*** Earlier dormant planting dates are acceptable if the measured soil temperature is below 45^0 F.

Fall, dormant and very early spring seedings may expose legumes and forbs to potential killing frosts during seedling stage.

Planting Dates

Plant trees and shrubs in the spring after frost is out of the ground. All stock will be planted by:

MLRA	Spring (before)
8, 9, 11, 28A	May 1
10, 12, 13, 25, 44	May 15
43A, 43B, 43C, 47	June 1

The District Conservationist may extend these dates by 14 days if local soil, moisture and climate conditions justify an extension and conditions are documented.

When using weed barrier fabric, good soil moisture conditions will be extended beyond conditions when not using these materials.

When woody cuttings of willow, dogwood and cottonwood are planned, planting may occur in late fall or early spring (refer to Plant Materials Technical Note No. 23).

Be aware that time extensions may require increased need for supplemental irrigation, wind protection and/or shade protection.

Cover and Nurse Crops

On sloping land where relatively weed-free crop residues are present or will result from the existing or planned crop, consider minimizing seedbed operations to maintain adequate residues on the surface to protect the new planting.

Nurse crops will not be used for this practice.

Special Erosion Control Considerations

Straw is the preferred mulch but needs to be anchored in place with equipment such as rollers and crimpers. Wheat straw deteriorates less rapidly and results in less volunteer growth compared to barley straw. Use clean straw to minimize spread of weeds. Tackifiers, woven fabric, netting and other covers can be used to anchor mulch when slopes are too steep to use equipment on the site. Artificial mulches can also be used.

On degraded sites, additional practices such as erosion control fabric, hydro-mulching, hydro-seeding and sod should be considered in addition to soil amendments, to provide additional erosion control and to improve the chance of vegetation establishment.

Consider using hydro-seeding and mulching on steep, inaccessible sites not suitable for straw mulch planting. Do not use when high winds are expected to interfere. Consider the effective range of straw blowing equipment and hydro-seeders when use is planned.

A split hydro-mulch and hydro-seeding operation is recommended on sites suitable to hydro-mulch planting. Seed and fertilizer should be applied first to provide better seed to soil contact and then the mulch is hydro-mulched over the site. If mulching is needed, follow the Mulching (484) practice.

Fertilization, mulching, hydro-seeding, hydro-mulching, erosion control fabric or other facilitating practices shall be timed and applied to improve the chance of establishment of the planned species. Apply all nutrients in accordance with the Nutrient Management (590) practice.

When using sod, the soil surface will be smoothed so air pockets will not form beneath the sod.

Sod strips will be fit closely together and tamped tightly in place. Sod will be staked down as needed to protect it from movement on steep slopes.

Cut sod will be kept moist. The maximum time period between cutting and laying sod will not exceed 96 hours.

Areas covered with sod will be irrigated until sod is well established. Species that require permanent irrigation to maintain adequate sod cover are not recommended.

Seeding/Planting Protection

This practice will be undertaken only where domestic grazing animals can be excluded to

permit stand establishment. Temporary fencing may be required.

When plantings are irrigated for establishment, maintain adequate moisture at least in the upper six (6) inches of soil during the first four (4) weeks and then in the upper 12 inches until the end of the growing season.

Noxious and competitive invasive weeds should be controlled by mowing, clipping or herbicides. Grass seedlings should be allowed to attain at least 4-5 leaf stage before herbicides are applied. Be sure to read and follow label directions.

Planting Evaluations

Seeded species may be considered established when they are well-rooted (not easily pulled out of ground by hand) and/or are producing reproductive stems. A minimum of two full growing seasons are recommended prior to grazing.

Refer to Plant Materials Technical Note 12 for additional guidance to determine seeding establishment and Plant Materials Technical Note 43 for additional guidance to determine woody plant establishment.

OPERATION AND MAINTENANCE

Maintenance needed for this practice include:

1. Periodic inspection and evaluation of vegetation to determine establishment and maintenance needs.
2. Management of vegetation growth, as applicable, by mowing, approved chemicals or other means to establish the desired cover.
3. Replanting due to drought, insects or other event which prevented adequate stand establishment should be addressed within 1-3 years of planting. Recommendations may vary from complete re-establishment to overseeding or spot replanting. Thin stands may only need additional grazing deferment during the growing season.
4. Repair of appurtenances and fences.
5. Pest (weeds, grasshoppers, rabbits, rodents, etc.) control will be undertaken when pests are determined to be detrimental to establishing new seedlings. Any control specified shall be in accordance with Pest Management (595).

REFERENCES

FORMS

ID-CPA-025 Seeding/Planting Plan – Specification

ID-CPA-028 Tree-Shrub-Riparian Planting Specification

NRCS – Idaho Plant Materials Technical Notes

No. 4 – Reading Seed Packaging Labels and Calculating Seed Mixtures

No. 4A – Filling out ID-CPA-025 Seeding/Planting Plan and UT Planting Specification Sheets.

No. 7 – Mixing Seed with Rice Hulls

No. 9A – Plants for Saline to Sodic Conditions

No. 10 – Pasture and Range Seedings

No. 11 – Pasture Species Selection and Grazing Management Guidelines

No. 12 – Guidelines for Determining Stand Establishment

No. 13 – Principles of Seedbed Preparation for Conservation Seedings

No. 19 – Calibrating a Seed Drill

No. 23 – Planting Willow, Dogwood and Cottonwoods

No. 24 – Conservation Plant Species for the Intermountain West

No. 26 – Legume Inoculation

No. 43 – Tree Planting, Care and Management

Land Resource Regions and Major Land Resource Areas of the United States, Issued 2006.

ASSOCIATED PRACTICES

Engineering practices

Fence (382)

Irrigation Water Management (449)

Mulching (484)

Nutrient Management (590)

Herbaceous Weed Control (315)

Upland Wildlife Habitat (645)

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

CRITICAL AREA PLANTING

(Ac.)

CODE 342

DEFINITION

Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices.

PURPOSE

This practice supports one or more of the following purposes:

- Stabilize stream and channel banks, pond and other shorelines – Resource concern (SOIL EROSION– Excessive bank erosion from streams shorelines or water conveyance channels).
- Stabilize areas with existing or expected high rates of soil erosion by wind or water – Resource concern (SOIL EROSION – Concentrated flow erosion and/or SOIL EROSION - Sheet, rill, & wind erosion and/or SOIL QUALITY DEGRADATION – Concentration of salts or other chemicals).
- Stabilize areas, such as sand dunes and riparian areas – Resource concern (SOIL EROSION – Concentrated flow erosion and/or SOIL EROSION - Sheet, rill, & wind erosion).

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to highly disturbed areas such as:

- active or abandoned mined lands;
- urban reclamation sites;
- construction areas;
- conservation practice construction sites;
- areas needing stabilization before or after natural disasters such as floods, hurricanes, tornados and wildfires;
- eroded banks of natural channels, banks of newly constructed channels, and lake shorelines;
- other areas degraded by human activities or natural events.

CRITERIA

General Criteria Applicable to All Purposes

Site Preparation. A site investigation shall be conducted to identify any physical, chemical, or biological conditions that could affect the successful establishment of vegetation.

Areas to be planted will be cleared of unwanted materials and smoothed or shaped, if needed, to meet planting and landscaping purposes.

A suitable seedbed shall be prepared for all seeded species. Compacted layers will be ripped and the soil re-firmed prior to seedbed preparation.

As site conditions dictate, when grading slopes, stockpile topsoil to be redistributed over area to be planted.

No plants on the Federal or state noxious weeds list shall be planted.

Species Selection. Species selected for seeding or planting shall be suited to local site conditions and intended uses, and be common to the site or location.

Selected species will have the capacity to achieve adequate density and vigor to stabilize

the site within an appropriate period.

Establishment of Vegetation. Seeds will be planted using the method or methods best suited to site and soil conditions.

Sod placement shall be limited to areas that can naturally supply needed moisture or sites that can be irrigated during the establishment period.

Sod will be placed and anchored using techniques to ensure that it remains in place until established.

Species, rates of seeding or planting, minimum quality of planting stock (e.g. pure live seed (PLS) or stem caliper), method of seedbed preparation, and method of establishment shall be specified before application. Only viable, high quality seed or planting stock will be used.

Seeding or planting shall be done at a time and in a manner that best ensures establishment and growth of the selected species

Planting shall be done during approved times for the species to be used.

Apply soil amendments (e.g. lime, fertilizer, compost) according to the requirements in the local Field Office Technical Guide.

Plantings shall be mulched as necessary to ensure establishment. Other disturbed areas shall be mulched as necessary to prevent erosion.

Additional Criteria to Stabilize Stream and Channel Banks, Pond and other Shorelines

Bank and Channel Slopes. Channel side slopes shall be shaped so that they are stable and allow establishment and maintenance of desired vegetation.

A combination of vegetative and structural measures may be necessary on slopes steeper than 2:1 to ensure adequate stability.

Species Selection. Plant material used for this purpose shall:

- be adapted to the hydrologic zone (see Fig. 1) into which they will be planted.
- be adapted and proven in the regions in which they will be used.
- be compatible with existing vegetation in the area
- protect the channel banks but not restrict channel capacity.

Establishment of Vegetation. The species used, planting rates, spacing, and methods and dates of planting shall be based on local planting guides or technical notes.

Identify and protect desirable existing vegetation during practice installation.

A combination of vegetative and structural practices using living and inert material shall be used when flow velocities, soils, and bank stability preclude stabilization by vegetative establishment alone.

If the existing vegetation on a site will compete with species to be established vegetatively (e.g. bare-root, containerized, ball-and-burlap, potted), it will be controlled in a manner that ensures the successful establishment of the planted species.

Streambank stabilization plantings shall be in accordance with the NRCS Engineering Field Handbook Part 650, Chapter 16 (Streambank and Shoreline Protection) and Chapter 18 (Soil Bioengineering for Upland Slope Protection & Erosion Reduction).

Site Protection and Access Control. Restrict access to planted areas until fully established. Grazing animal access to planted areas will be controlled for a minimum of two growing seasons during the establishment period.

All areas to be grazed will have a grazing plan that meets the criteria in the local Field Office Technical Guide.

Grazing will be permanently excluded on high hazard sites, such as cut banks, areas of seepage or other potentially unstable areas.

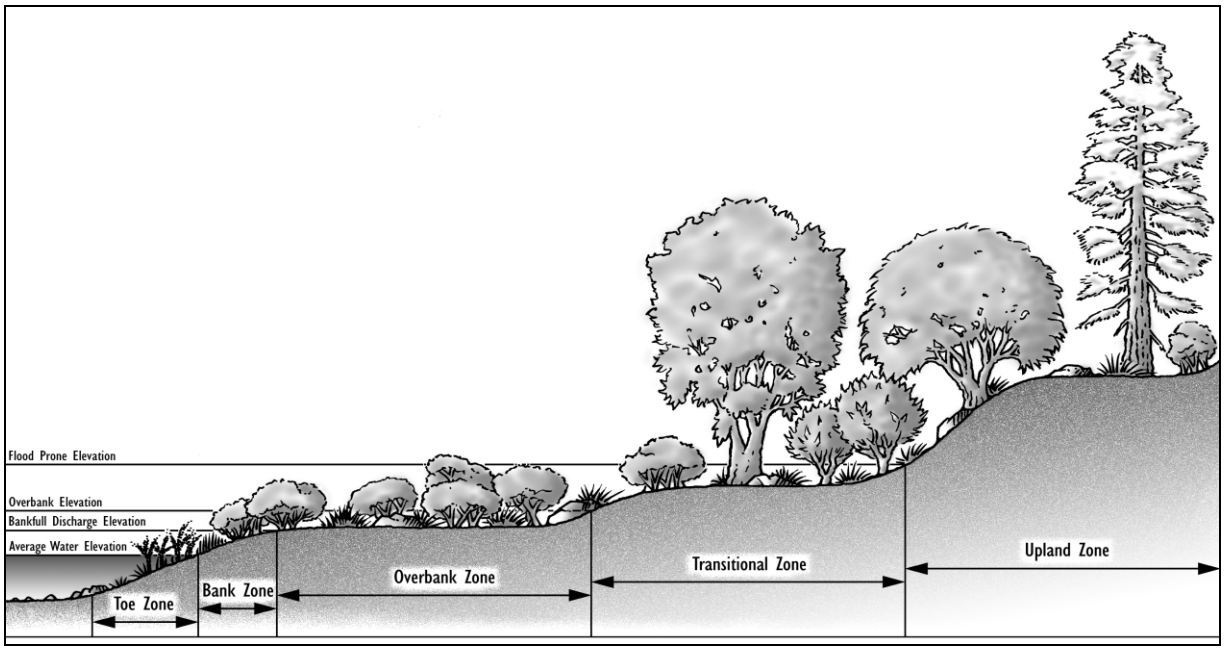

Figure 1. Location of hydrologic zones along a channel or shoreline.

Definitions and descriptions of hydrologic zones used for channels and shorelines:

Bankfull Discharge Elevation - In natural streams, it is the elevation at which water fills the channel without overflowing onto the flood plain.

Bank Zone - The area above the Toe Zone located between the average water level and the bankfull discharge elevation. Vegetation may be herbaceous or woody, and is characterized by flexible stems and rhizomatous root systems.

Overbank Zone - The area located above the bankfull discharge elevation continuing upslope to an elevation equal to two thirds of the flood prone depth. Vegetation is generally small to medium shrub species.

Toe Zone - The portion of the bank that is between the average water level and the bottom of the channel, at the toe of the bank. Vegetation is generally herbaceous emergent aquatic species, tolerant of long periods of inundation.

Transitional Zone - The area located between the overbank zone, and the flood prone width elevation. Vegetation is usually larger shrub and tree species.

Upland Zone – The area above the Transitional Zone; this area is seldom if ever saturated.

Note: some channels or shorelines have fewer than four hydrologic zones because of differences in soils, topography, entrenchment and/or moisture regime.

Additional Criteria to Restore Coastal Areas, such as Sand Dunes and Riparian Areas

Plants for sand dunes and coastal sites must be able to survive being buried by blowing sand, sand blasting, salt spray, salt water flooding, drought, heat, and low nutrient supply.

Sand trapping devices such as sand fences or brush matting shall be included in the re-vegetation/stabilization plans where applicable.

Additional Criteria to rehabilitate and revegetate degraded sites that cannot be stabilized through normal farming practices

If gullies or deep rills are present on sites that are or have been tilled, they will be filled and leveled as necessary to allow equipment operation and ensure proper site and seedbed preparation.

Based on soil tests and other appropriate site evaluations, soil amendments will be added as necessary to ameliorate or eliminate physical or chemical conditions that inhibit plant establishment and growth.

CONSIDERATIONS

Species or mixes that are adapted to the site and have multiple benefits should be considered. Native species may be used when appropriate for the site.

To benefit pollinators and other wildlife, flowering shrubs and wildflowers with resilient root systems and good soil holding capacity also should be considered for incorporation as a small percentage of a larger grass-dominated planting. Where appropriate consider a diverse mixture of forbs to support pollinator habitat.

Avoid species that may harbor pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Planning and installation of other conservation practices such as Diversion (code 362), Obstruction Removal (code 500), Subsurface Drain (code 606), or Underground Outlet (code 620) may be necessary to prepare the area or ensure vegetative establishment.

Areas of vegetation established with this practice can create habitat for various type of wildlife. Maintenance activities, such as mowing or spraying, can have detrimental effects on certain species. Perform management activities at the times and in a manner that causes the least disruption to wildlife.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for each field or management unit according to the criteria and operation and maintenance sections of this standard. Record practice specifications using approved Implementation Requirement document.

The following elements shall be addressed in the plan, as applicable, to meet the intended purpose.

- Site preparation
- Topsoil requirements
- Fertilizer application
- Seedbed/planting area preparation
- Methods of seeding/planting
- Time of seeding/planting
- Selection of species
- Seed/plant source
- Seed analysis
- Seeding rate/plant spacing
- Mulching
- Supplemental water needed for establishment
- Protection of plantings
- Describe successful establishment (e.g. minimum percent ground/canopy cover, percent survival, stand density.

OPERATION AND MAINTENANCE

Use of the area shall be managed as long as necessary to ensure the site remains stable.

Plantings shall be protected from pests (e.g. weeds, insects, diseases, livestock, or wildlife) as necessary to ensure long-term survival.

Inspections, reseeding or replanting, and fertilization may be needed to ensure that this practice functions as intended throughout its expected life. Observation of establishment progress and success should be performed at regular intervals until the practice has met the criteria for successful establishment and implementation.

All areas to be grazed will follow a grazing plan that meets the criteria in the local Field Office Technical Guide.

Grazing will be permanently excluded on high hazard sites, such as cut banks, areas of seepage, or other potential unstable areas.

REFERENCES

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USDA United States Department of Agriculture
Natural Resources Conservation Service

How Does Soil Function?

By: Marlon Winger, Idaho NRCS, Jon Stika, North Dakota NRCS, Derek Tilley, Idaho NRCS

Soils are much more than an inert mass of sand, silt, and clay. They are an interconnected community of living or dead organisms, physical and chemical factors, and processes that create an ecosystem. Recognizing soil as an ecosystem helps us understand how a healthy soil functions as well as how limits on any part of the system can cause it to function poorly or fail. Knowing the roles of various players in the soil food web helps us foster healthy, highly functioning soil that is productive and resistant to drought, erosion and other external factors.

What do you know about soil function?

Soil Microbes
Actinomycetes
Bacteria
Collembola
Earthworms
Fungus
Insects
Mites
Nematodes
Protozoa

What feeds soil microbes?
Plants provide the primary food source for the soil ecosystem. Living plants or decomposing dead plant tissues feed hosts of soil microbes. Living plant roots actively exude sugars, amino acids and other compounds into the soil. This happens in the rhizosphere – a narrow region of soil surrounding the root. Dead plant tissues include residues on the soil surface or roots in the soil.

Why are plants green?
Chlorophyll is the green pigment found in the chloroplasts of plants and algae.

What does chlorophyll do?
Chlorophyll is critical in the process known as photosynthesis, which allows plants to absorb energy from sunlight.

What does photosynthesis produce?
Through photosynthesis, plants convert the sun's energy into simple sugars or carbohydrates. The plants use water (H_2O) from the soil and carbon dioxide (CO_2) from the air and recombine them to form carbohydrates (CH_2O) and oxygen (O_2). The plant releases oxygen into the atmosphere and used by us and other animals. The plant uses newly formed carbohydrates to create cellulose, starch, and other compounds that make up the structure and biomass of the plant.

Where do plants get carbon?
Tiny openings in leaves, called stomata, permit gaseous exchange. When the stomata in the leaf open, carbon dioxide (CO_2) from the air enters and is used in photosynthesis.

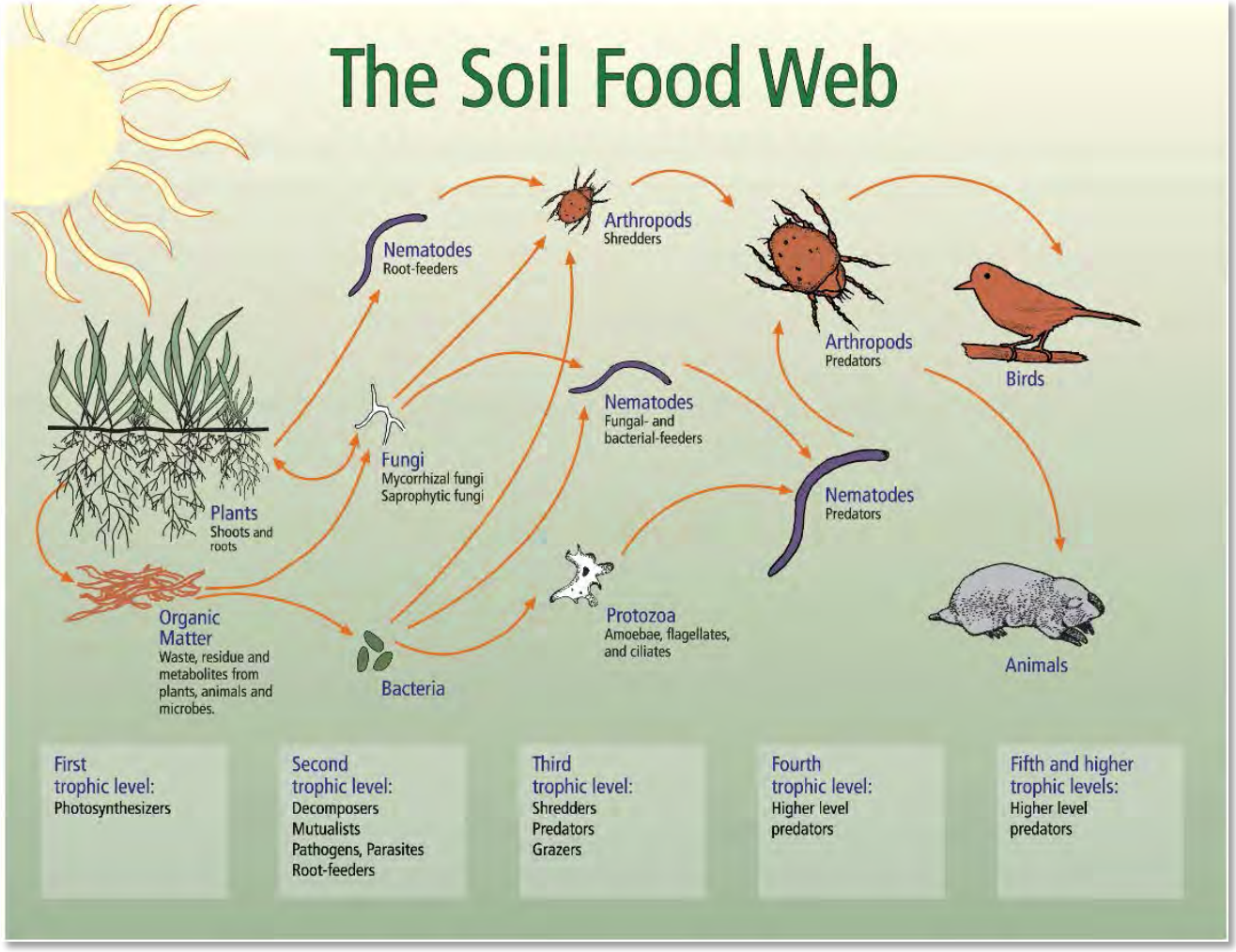
What elements are in the carbohydrate produced by photosynthesis?
Carbon (C), hydrogen (H) and oxygen (O).

What is the habitat for soil microbes?
The pore spaces in the soil formed by the creation of aggregates are the vital habitat for the diverse community of microbes.

How is habitat for soil microbes created?
Mycorrhizal fungi, bacteria, protozoa, nematodes, enchytraeids, and earthworms exude polysaccharides, glomalin, organic acids, and amino acids. These combine with exudates released by plant roots to work as glues to bind soil particles (sand, silt, and clay) into larger and larger aggregates. This forms the soil's granular structure. Aggregated soil also provides pore spaces for larger organisms like protozoa, nematodes, enchytraeids, earthworms, insects, and mites to thrive.

When soil habitat is undisturbed soil organisms burrow, shred residue, and create larger pore spaces. The result is a vast network of channels, nooks, and crannies that improve root growth as well as water and oxygen infiltration, allowing a diverse community of soil microbes to flourish.

How do plants and soil microbes help each other?
Plants feed soil organisms that in return provide nutrients to the plants. Microbes break down existing organic matter or mineral soil, making nutrients more available to the plant.



The soil food web can be broken down into numerous trophic (feeding) levels. Starting with plants converting the sun's energy into sugars, the web includes a diversity of predatory, decomposing, and grazing microbes. Disrupting any of these levels can cause the soil food web to break down, resulting in unhealthy, unproductive soil.

The importance of healthy soils

Healthy soil, composed of aggregated soil particles bound together by polysaccharides, glomalin and interwoven with roots and fungal hyphae, is resilient and able to withstand environmental stresses.

What are the results of healthy soils?
Managing for soil health gradually improves compacted or disrupted soil. Healthy soils have greater pore space enabling increased water infiltration, resulting in less ponding and runoff. Better porosity also allows for a deeper and more extensive root mass. A diverse community of soil organisms living in a favorable habitat can provide more beneficial services to the plants.

- Improved nutrient cycling
- Increased water infiltration and availability
- Improved physical support and structure
- Enhanced soil habitat for increased biodiversity
- Filtering and buffering to protect water quality

What is our role in soil health?
The loss or reduction of any of the key processes in soil function can be detrimental to the entire soil ecosystem. Understanding the interconnection in the soil ecosystem helps us manage our soils differently to improve soil health.

Tillage and other mechanical disturbance destroys soil structure (the aggregates) and results in the habitat loss for the majority of the organisms required for healthy soil. The absence of living plants (fallow periods) interrupts the food web – no plants present to create the sugars that feed the soil microbes. Loss of soil cover leaves the soil unprotected against the elements causing extreme swings in temperatures and excessive evaporation of soil water. The result of this type of management is a desert landscape, both above and below the soil surface.

What can you do?
Though the soil food web is a complex system with a diverse range of components and processes, you can promote healthy soils following four principles:

1. **Keep the soil covered as much as possible**
2. **Minimize soil disturbance**
3. **Keep plants growing throughout the year to feed the soil microbes**
4. **Diversify plants grown in the soil as much as possible using crop rotation and cover crops**

Applying these basic principles can significantly improve the function and productivity of the soil. A properly functioning soil cycles nutrients, has good water infiltration, and stores water in its pore spaces. Resilient soils provide physical stability and support as soil structure is improved.

Soil supports the growth of a variety of plants, animals, and soil microorganisms. Providing a diverse physical, chemical, and biological habitat will ultimately be more profitable for the producer.