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2 Western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Löve) is a perennial, cross-pollinating,  
3 native grass that is a common component of rangelands in the mixed grass prairies throughout  
4 the central and northern Great Plains and in some areas of the Intermountain West (Asay and  
5 Jensen, 1996; Hart et al., 1996). Western wheatgrass has low seed yields and is difficult and  
6 slow to establish because of seed dormancy and poor seedling vigor; however, thick stands may  
7 result over time from extensive rhizome development (Asay and Jensen, 1996). Because of its  
8 sod-forming characteristics, it is widely recommended for use in rangeland improvement and  
9 revegetation after disturbances such as mining, construction, military training, and fire (Asay  
10 and Jensen, 1996). However, the inherent slow establishment of western wheatgrass limits its  
11 effectiveness in reducing erosion and controlling invasive weeds in areas with frequent, severe  
12 disturbances.

13 The ability to emerge from a deep planting depth has been used as selection criteria for  
14 improving seedling vigor in grasses (Andrews et al., 1997; Asay and Johnson, 1983; Kalton et al.,  
15 1959; Lawrence, 1963). This strategy was successfully used to develop the cultivars 'Bozoisky-II'  
16 Russian wildrye (Jensen et al., 2006), 'Hycrest-II' crested wheatgrass (Jensen et al., 2009), and  
17 'Vavilov-II' Siberian wheatgrass (Jensen et al., 2009). These cultivars/germplasms are known for  
18 their improved seedling vigor and establishment ease in comparison to older cultivars. Waldron  
19 et al. (2006) recently reported variation in ability to emerge from a deep planting depth among  
20 western wheatgrass populations and recommended breeding for improved seed production  
21 and seedling vigor in western wheatgrass. Therefore, the principle objective of this research  
22 was to develop a new western wheatgrass cultivar with improved seedling establishment.

23 'Recovery' western wheatgrass (Reg. No. CV-\_\_\_\_\_, PI \_\_\_\_\_) was released by the  
24 USDA-ARS, the U.S. Army Corps of Engineers-Engineer Research and Development Center, and  
25 the USDA-NRCS. It was developed as a rapidly establishing grass for revegetation of semiarid  
26 rangelands in the Intermountain West, Great Basin, and Northern Great Plains regions of the  
27 western United States. It is especially intended for revegetation of frequently disturbed  
28 rangelands, military training lands, and areas with repeated wildfires. Recovery was evaluated  
29 in field trials as TC3, TC-Rich, Army WWG, SERDP WWG, and 9076517 (NRCS designation).

1 Recovery was developed as part of the Strategic Environmental Research and Development  
2 Program project CS-1103 to identify resilient plant characteristics and develop wear-resistant  
3 plant cultivars for use on military training lands. Recovery was selected for seedling  
4 establishment under rangeland conditions. It has been evaluated extensively at semiarid sites  
5 representative of different ecological regions in northern plains and western U.S. Overall, it has  
6 shown superior and faster seedling establishment compared to commercially available cultivars  
7 Arriba, Barton, Flintlock, Rodan, and Rosana.

## 8 9 **Methods**

### 10 **Breeding History**

11 The development of Recovery western wheatgrass was initiated to breed a western wheatgrass  
12 cultivar with rapid establishment for use in areas that are frequently disturbed such as military  
13 training lands. Recovery traces its parentage to three maternal sources and was selected for  
14 superior vegetative vigor, seed yield, and seedling establishment. The parentage consists of  
15 Rosana (28%), D2945 (50%), and WW117FC (22%). Rosana traces to USDA-NRCS, Bridger Plant  
16 Materials Center collections from a native meadow near Forsyth, MT and was released in 1972  
17 having improved seedling establishment, sod-forming ability, and forage and seed production  
18 (U.S. Department of Agriculture, 1995). Accession D2945, evaluated as Mandan456 or T05659,  
19 is a different seed lot of the same population that gave rise to Rodan western wheatgrass.  
20 WW117FC is a native western wheatgrass collection made by the USDA-ARS Forage and Range  
21 Research Lab from the Fort Carson Army base near the site of the initial evaluations.

22 The breeding of Recovery was initiated with an evaluation trial at the Fort Carson,  
23 Turkey Creek Recreation area approximately 20 km south of Colorado Springs, CO (38°37'20" N  
24 lat; 104°52'40" W long; 1920 m elevation). Soil type at Turkey Creek is a Neville fine sandy loam  
25 (fine loamy, mixed, calcareous mesic Ustic Torriorthence) and the dominant vegetation include  
26 western wheatgrass, blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Steudel), and sideoats  
27 grama (*B. curtipendula* [Michx.] Torr.). Colorado Springs mean annual precipitation is 383 mm  
28 with 80 % received April through September.

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1 Breeding Chronology

2 1996: A 560-spaced-plant nursery comprised of 14 sources (cultivars Rosana, Flintlock, and  
3 Arriba; PIs 421274 and 477993; breeding populations EPC181, Mandan3459, D2945,  
4 NE1, and KJ48; and four seed collections from Fort Carson) was established in May 1996  
5 at Fort Carson, Turkey Creek Recreation area. A complete description of these sources  
6 can be found in Waldron et al. (2006). Plants were evaluated in 1997 and 1998 for vigor,  
7 color, and rhizomatous spread.

8 1998: Five entries were identified with the desired phenotype from above evaluations (35%  
9 among entry selection intensity). Open-pollinated seed was harvested in August 1998  
10 from all plants within the five entries. The 17 plants with the highest seed yield were  
11 identified; five from D2945, two from Rosana, three from WW117FC, two from  
12 WW124FC, and five from PI477993 (5 to 12.5% within entry selection). The seed from  
13 these 17 plants was designated cycle-1.

14 The OP seed from the 17 plants was used in a greenhouse evaluation in Logan,  
15 Utah to screen for seedling vigor by determining rate of emergence from 6.35 cm as  
16 reported by Waldron et al. (2006). Four of the 17 plants were determined to have  
17 superior seedling vigor (one from Rosana, two from D2945, and one from WW117FC).  
18 Forty-nine random seedlings from each of the four sources were dug up from the deep  
19 seeding study and transplanted to containers in the greenhouse during the winter of  
20 1998. These 196 seedlings (49 from each of four parents) were transplanted to an  
21 isolated crossing block near Logan, Utah in May of 1999 using a blocking design that  
22 maximized crossing among the four maternal sources.

23 2000: Seed was harvested from individual plants from the 196-plant crossing block and  
24 designated as cycle-2. Seed yield from the crossing block was determined and 155 of the  
25 plants were identified with high seed production and used in the next cycle. Twenty-  
26 eight seeds from each of the 155 plants were planted at a 5 cm depth in cones. Those  
27 seedlings that emerged on or before 14 DAP were saved and pooled together by  
28 maternal source (559 plants from Rosana, 490 plants from D2945-1, 537 plants from

1 D2945-2, and 446 plants from WW117FC). Seedlings were randomized and transplanted  
2 to an isolation block in Richmond, Utah, May 2001.

3 2002: Seed was harvested from the isolated block and designated as breeder seed. This seed  
4 was used for testing and morphological evaluation.

### 6 **Seeded Trials**

7 Between 2002 and 2005, six fall-dormant-seeded and two spring-seeded evaluation trials were  
8 established to compare seedling establishment and stand development of Recovery to standard  
9 western wheatgrass and other range grass cultivars. The sites and ecoregions (Level III and  
10 Level IV Ecoregions of the Continental United States, National Health and Environmental Effects  
11 Research Laboratory, U.S. Environmental Protection Agency) they represent were: Beaver, UT  
12 (38° 20' 51.60" N, 112° 35' 50.58" W; elevation 1979 m; 37 cm annual precipitation; Level III -  
13 Central Basin and Range, Level IV - Woodland- and shrub-covered low mountains); Malta, ID  
14 (42° 18' 6.78" N, 113° 11' 42.24" W; elevation 1480 m; 31 cm annual precipitation; Level III -  
15 Northern Basin and Range, Level IV - Saltbush-dominated valleys); Fillmore, UT site 1 (39° 13'  
16 26.94" N, 112° 12' 16.26" W; elevation 1843 m; 40 cm annual precipitation; Level III - Central  
17 Basin and Range, Level IV - Woodland- and shrub-covered low mountains); Fillmore, UT site 2  
18 (39° 12' 10.74" N, 112° 14' 14.04" W; elevation 1776 m; 37 cm annual precipitation; Level III -  
19 Central Basin and Range, Level IV - Sagebrush basins and slopes); Curlew Valley, ID (42° 02'  
20 24.96" N, 112° 40' 18.12" W; elevation 1405 m; 31 cm annual precipitation; Level III - Central  
21 Basin and Range, Level IV - Shadscale-dominated saline basins); Yakima, WA (46° 50' 45.96" N,  
22 120° 22' 16.20" W; elevation 698 m; 27 cm annual precipitation; Level III - Columbia Plateau,  
23 Level IV - Yakima folds); Guernsey, WY site 1 (42° 15' 0.60" N, 104° 44' 5.34" W; elevation 1320  
24 m; 35 cm annual precipitation; Level III - High Plains, Level IV - Moderate relief rangeland); and  
25 Guernsey, WY site 2 (42° 14' 23.10" N, 104° 44' 18.12" W; elevation 1393 m; 35 cm annual  
26 precipitation; Level III - High Plains, Level IV - Moderate relief rangeland). The two WY sites  
27 were the spring-seeded trials and were representative of the warm- and cool-season grass  
28 transition zone where western wheatgrass is often a dominant species. Plots in each trial were  
29 arranged in a randomized complete block with four replications. Entries were seeded at a rate

1 of one pure live seed  $\text{cm}^{-1}$  at a seeding depth of 0.63 cm in five rows. Plots size was 1.5 m wide  
2 by 8 m long.

### 3 **Seedling Establishment**

4 Seedling establishment and subsequent stand persistence were measured as plant frequency  
5 using the grid system described by (Vogel and Masters, 2001). Seedling frequency was  
6 determined by laying a grid of 48 5.1- by 5.1-cm quadrants over the drilled rows and  
7 determining the percentage of quadrants containing at least one seedling. If a plant occurred in  
8 every quadrant, establishment was considered to be 100%. This was repeated three times  
9 along the 8-m row for a total of 144 quadrants. The same procedure was used to determine  
10 subsequent stand frequency except that the quadrants were 10.2- by 10.2-cm for a total of 72  
11 quadrants per plot. All data were subjected to analysis using the MIXED procedure of SAS (SAS  
12 Institute Inc., 1999). For the across location analyses, both locations and replications were  
13 considered random, and lsmeans were determined (SAS Institute Inc., 1999). All mean  
14 separations were made on the basis of least significant differences at the 0.05 probability level.

### 15 **Morphological Characterization**

16 Six morphological characters were measured from at least 40 different plants each of Recovery,  
17 Rosana, Rodan, Barton, Arriba, and Flintlock western wheatgrass at Nephi, UT (39° 38' 43" N,  
18 111° 52' 11" W; elevation 1600 m) and Blue Creek, UT (41° 56' 02" N, 112° 26' 20" W; elevation  
19 1563 m) in 2007. The experimental design was an RCBD with six replications at Nephi and four  
20 replications at Blue Creek with 10 plants per replication. Statistical analyses were conducted as  
21 described in Seedling Establishment.

### 22 **Forage Yield**

23 Forage yield was evaluated in 2008 by harvesting the spaced-plant morphological nursery at  
24 Nephi, UT described above and a spaced-plant nursery at Blue Creek, UT (41° 56' 02" N, 112°  
25 26' 20" W; elevation 1563 m) identical to the Nephi nursery with the exception that Blue Creek  
26 contained six replications. At both of these locations, individual plots were harvested with a  
27 sickle-bar harvester to an 8-cm stubble height just prior to anthesis. Forage samples were taken  
28 from each plot and dried to a constant weight in a forced-air oven at 60° C to determine dry  
29 matter percentage. In addition, forage yield from the seeded trial at Curlew Valley, ID was

- 1 determined by clipping 1-m frames within each plot and drying the clipped forage to a constant
- 2 weight as described above. Forage yield data were statistically analyzed as described in
- 3 Seedling Establishment.
- 4

## Characteristics

### Seedling Establishment

Rapid establishment is one of the keys to successful revegetation in the western U.S. Thus, western wheatgrasses' inherent slow establishment limits its effectiveness in reducing erosion and controlling weeds in areas with frequent, severe disturbances. During the spring of the establishment year, Recovery had significantly higher ( $P \leq 0.05$ ) frequency of seedlings (0.60) than parental/closely-related cultivars Rosana (0.48) and Rodan (0.45), and the western wheatgrass cultivars of Arriba (0.45), Barton (0.42), and Flintlock (0.53) when analyzed across all locations (Table 1). Within locations, Recovery had significantly better establishment than Rodan in three of five test locations, and more than Rosana in three of eight test locations (Table 1). On average, Recovery's establishment was better than Bozoisky Russian wildrye, similar to Bozoisky II and Vavilov Siberian wheatgrass, and lower than Vavilov II and Hycrest and Hycrest II crested wheatgrasses (Table 1).

The ability of seedlings to survive the first year after planting can be difficult due to competition from invasive annual and biennial grasses and forbs that benefit from the disturbed, open environment. Across locations, Recovery had significantly ( $P \leq 0.05$ ) more surviving plants (frequency of 0.77) the year after establishment than parental/closely-related cultivars Rosana (0.68) and Rodan (0.66), and the western wheatgrass cultivars of Arriba (0.63), Barton (0.68), and Flintlock (0.66) (Table 2). In fact, Recovery had higher frequency ( $P \leq 0.05$ ) of plants than any other western wheatgrass cultivar until the fourth to sixth year after planting (Fig. 1). The equilibrating of stand frequency after this period of time is in part due to western wheatgrasses' extensive rhizomes that fill in blank areas of the plot, and in part because of the limited resources available on rangelands, thus restraining the number of plants that can be supported in a given area (Asay and Jensen, 1996). The rapid establishment of Recovery, in comparison to other western wheatgrass cultivars, will allow land managers to use this native grass species to help limit weed infestation and soil erosion in areas where the regularity of disturbances normally prevents western wheatgrass from becoming fully established.

## **Morphological Characterization**

Overall, Recovery is similar in height as other western wheatgrasses, but has a longer spike than Arriba, Barton, and Rodan, and a wider spike than Barton, Flintlock, and Rodan (Table 3). Recovery's flag leaf is oriented lower on the culm than Arriba and Barton, and at a similar position as Flintlock, Rodan, and Rosana (Table 4). Recovery has a shorter flag leaf than Barton, but is similar to other western wheatgrass cultivars (Table 4). On average, the flag leaf width of Recovery is similar to other cultivars; however, at the Nephi, UT location it was narrower than that for Arriba, Barton, Flintlock, and Rosana. These results indicate that in appearance, Recovery is most like Rosana and the least like Barton.

## **Forage Yield**

Forage yield of Recovery was not significantly different than other western wheatgrass cultivars at the Blue Creek, UT location and the Curlew Valley, ID location with the exception of a higher yield than Rosana at Curlew Valley (Table 5). However, at Nephi, UT, Recovery forage yield was significantly lower than all other western wheatgrass cultivars except Arriba (Table 5). Overall, these results suggest that Recovery will yield comparable or slightly less than other western wheatgrasses.

## **Environmental Considerations and Evaluation**

The USDA-NRCS conducts an environmental evaluation of all plant material releases. From this evaluation and the USDA-NRCS Plant Guide (Ogle et al., 2009) the following has been determined. Western wheatgrass is a long-lived perennial species that spreads primarily via rhizomes. It establishes only in areas where major disturbance has occurred, and has no perceivable negative impacts on native plant populations. It has no known allelopathic effects on other plants, and no negative impact on wildlife habitat. Western wheatgrass is not regarded as having any adverse negative characteristics that would preclude its use.

## **Availability**

1 A Foundation seed production field was established at the USDA-NRCS Aberdeen Plant  
2 Materials Center in August 2005 and again in 2008. Foundation seed has been harvested each  
3 year beginning in 2007. The first Registered/Certified seed will be produced in 2009 in North  
4 Dakota and in 2010 in Idaho. Breeder, Foundation, Registered, and Certified seed classes will be  
5 recognized. Breeder seed will be maintained by the USDA-ARS Forage and Range Research  
6 Laboratory at Logan, UT, and Foundation seed will be maintained by the USDA-ARS Forage and  
7 Range Research Laboratory and the USDA-NRCS Plant Materials Center at Aberdeen, ID. Plant  
8 Variety Protection (PVP) will not be sought for this cultivar. Foundation seed is available  
9 through the following contacts: Utah Crop Improvement Association (435-797-2082;  
10 [sayoung@mendel.usu.edu](mailto:sayoung@mendel.usu.edu)) and University of Idaho Foundation Seed Program (208-423-6655;  
11 [Williams@kimberly.uidaho.edu](mailto:Williams@kimberly.uidaho.edu)).

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Table 1. Establishment year stand of ‘Recovery’ western wheatgrass compared with standard western wheatgrass and other rangeland grass checks at eight locations. Stand establishment measured as seedling frequency during the first May or June following a late-fall-dormant or early-spring planting.

Cultivar†	Beaver, UT	Guernsey, WY – site 1	Guernsey, WY – site 2	Malta, ID	Fillmore, UT – site 1	Fillmore, UT – site 2	Curlew Valley, ID	Yakima, WA	Across loc. Mean
<b>Recovery</b>	<b>0.54</b>	<b>0.61</b>	<b>0.51</b>	<b>0.68</b>	<b>0.66</b>	<b>0.63</b>	<b>0.46</b>	<b>0.73</b>	<b>0.60</b>
<i>WWG checks</i>									
Arriba	0.21*	.	.	0.41*	0.54	0.82	0.44	.	0.45*
Barton	0.36*	.	.	0.55*	0.38*	0.64	0.37	.	0.42*
Flintlock	.	0.57	0.22*	.	.	0.84	.	.	0.53*
Rodan	0.25*	.	.	0.55*	0.48*	0.78	0.39	.	0.45*
Rosana	0.51	0.55	0.39	0.45*	0.35*	0.73	0.49	0.40*	0.48*
SB3	0.40*	0.54	0.49	0.69	0.45*	0.88	0.34*	.	0.53*
<i>Other checks</i>									
Bannock	0.73	0.50	0.51	.	.	.	.	.	0.61
Bozoisky	0.72	0.17	0.65	0.61	0.21	0.63	0.56	.	0.50
Bozoisky_II	0.70	0.48	0.50	0.67	0.23	.	0.60	0.54	0.55
Firststrike	0.84	0.81	0.62	0.86	0.56	0.81	.	0.82	0.75
Hycrest	0.86	.	.	0.92	0.65	.	0.56	.	0.74
Hycrest_II	0.90	.	.	0.94	0.64	0.63	0.72	.	0.73
Vavilov	0.82	0.38	0.65	0.92	0.54	.	0.40	0.23	0.58
Vavilov_II	0.94	0.54	0.67	0.95	0.79	.	0.70	0.52	0.76
WWG mean	0.38	0.57	0.40	0.56	0.48	0.76	0.41	0.56	0.50
Entry Mean	0.62	0.52	0.52	0.71	0.50	0.74	0.50	0.54	0.58
LSD (0.05)	0.13	0.23	0.18	0.12	0.18	0.18	0.12	0.17	0.06

†Designations in this column include: WWG=western wheatgrass; SB3 is a WWG breeding population closely related to Recovery; Bannock is a thickspike wheatgrass; Bozoisky and Bozoisky II are Russian wildryes; Firststrike is a slender wheatgrass; Hycrest and Hycrest II are crested wheatgrasses; and Vavilov and Vavilov II are Siberian wheatgrasses.

\*Western wheatgrass check cultivars with stand frequency significantly ( $P < 0.05$ ) lower than Recovery western wheatgrass.

Table 2. Second year stand of 'Recovery' western wheatgrass compared with standard western wheatgrass and other rangeland grass checks at eight locations. Stand establishment measured as plant frequency during the second May or June following a late-fall-dormant or early-spring planting.

Cultivar†	Beaver, UT	Guernsey, WY – site 1	Guernsey, WY – site 2	Malta, ID	Fillmore, UT – site 1	Fillmore, UT – site 2	Curlew Valley, ID	Yakima, WA	Across loc. Mean
<b>Recovery</b>	<b>0.84</b>	<b>0.73</b>	<b>0.74</b>	<b>0.73</b>	<b>0.91</b>	<b>0.74</b>	<b>0.60</b>	<b>0.81</b>	<b>0.77</b>
<i>WWG checks</i>									
Arriba	0.63*	.	.	0.32*	0.86	0.88	0.59	.	0.63*
Barton	0.72	.	.	0.55*	0.85	0.84	0.57	.	0.68*
Flintlock	.	0.50	0.71	.	.	0.83	.	.	0.66*
Rodan	0.59*	.	.	0.49*	0.87	0.84	0.61	.	0.66*
Rosana	0.81	0.77	0.78	0.32*	0.72*	0.90	0.61	0.53	0.68*
SB3	0.67*	0.46*	0.76	0.66	0.72*	0.89	0.56	.	0.67*
<i>Other checks</i>									
Bannock	0.85	0.58	0.81	.	.	.	.	.	0.73
Bozoisky	0.88	0.26	0.82	0.57	0.42	0.72	0.70	.	0.61
Bozoisky_II	0.87	0.61	0.81	0.79	0.42	.	0.64	0.67	0.70
Firststrike	0.94	0.65	0.89	0.38	0.83	0.90	.	0.74	0.75
Hycrest	0.91	.	.	0.93	0.88	.	0.77	.	0.87
Hycrest_II	0.91	.	.	0.97	0.86	0.65	0.82	.	0.82
Vavilov	0.92	0.63	0.77	0.91	0.71	.	0.54	0.36	0.71
Vavilov_II	0.99	0.68	0.91	1.00	0.88	.	0.62	0.63	0.83
WWG mean	0.71	0.62	0.75	0.51	0.82	0.85	0.59	0.67	0.68
Entry Mean	0.82	0.59	0.80	0.66	0.76	0.82	0.64	0.62	0.72
LSD (0.05)	0.17	0.25	0.14	0.18	0.16	0.17	0.19	0.32	0.06

†Designations in this column include: WWG=western wheatgrass; SB3 is a WWG breeding population closely related to Recovery; Bannock is a thickspike wheatgrass; Bozoisky and Bozoisky II are Russian wildryes; Firststrike is a slender wheatgrass; Hycrest and Hycrest II are crested wheatgrasses; and Vavilov and Vavilov II are Siberian wheatgrasses.

\*Western wheatgrass check cultivars with stand frequency significantly ( $P < 0.05$ ) lower than Recovery western wheatgrass.

Table 3. Mature plant height and spike characteristics of Recovery western wheatgrass compared to standard western wheatgrass cultivars at Nephi and Blue Creek, Utah in 2007.

ENTRY <sup>†</sup>	Mature Plant Height			Spike Length			Spike Width		
	Nephi, UT	Blue Creek, UT	Across Loc. Mean	Nephi, UT	Blue Creek, UT	Across Loc. Mean	Nephi, UT	Blue Creek, UT	Across Loc. Mean
	----- cm -----			----- cm -----			----- mm -----		
<b>Recovery</b>	<b>74.7</b>	<b>74.8</b>	<b>74.5</b>	<b>13.0</b>	<b>9.9</b>	<b>11.5</b>	<b>9.8</b>	<b>6.6</b>	<b>8.4</b>
Arriba	84.5*	67.5	76.3	12.4	7.8	10.2*	10.2	6.4	8.5
Barton	78.9	75.6	77.2	11.9	8.6	10.3*	8.8	6.6	7.8*
Flintlock	75.4	70.9	73.1	12.5	11.5	11.9	8.4*	6.1	7.4*
Rodan	75.3	69.4	72.4	11.5	9.9	10.7*	9.0	6.7	8.0*
Rosana	72.9	---	---	12.7	---	---	9.7	---	---
SB3	74.9	70.1	72.5	11.7	10.9	11.2	10.0	6.4	8.4
Mean	76.7	71.4	73.8	12.2	9.8	11.0	9.4	6.4	8.1
LSD (0.05)	5.6	9.2	2.9	1.8	1.9	0.7	1.2	0.7	0.3

<sup>†</sup>All entries are western wheatgrass cultivars with the exception of SB3; SB3 is a western wheatgrass breeding population closely related to Recovery.

\*Western wheatgrass check entries significantly ( $P < 0.05$ ) different than Recovery western wheatgrass.

Table 4. Flag leaf characteristics of Recovery western wheatgrass compared to standard western wheatgrass cultivars at Nephi and Blue Creek, Utah in 2007.

ENTRY <sup>†</sup>	Flag Leaf Height			Flag Leaf Length			Flag Leaf Width		
	Nephi, UT	Blue Creek, UT	Across Loc. Mean	Nephi, UT	Blue Creek, UT	Across Loc. Mean	Nephi, UT	Blue Creek, UT	Across Loc. Mean
	----- cm -----			----- cm -----			----- mm -----		
<b>Recovery</b>	<b>52.0</b>	<b>58.5</b>	<b>54.9</b>	<b>9.7</b>	<b>7.9</b>	<b>8.9</b>	<b>2.2</b>	<b>2.6</b>	<b>2.4</b>
Arriba	59.3*	55.5	57.5*	11.6	8.7	10.3	2.6*	2.4	2.5
Barton	57.3*	62.8	59.8*	10.8	10.4	10.6*	2.5*	2.4	2.4
Flintlock	56.7*	56.0	56.4	8.7	8.3	8.4	2.5*	2.2*	2.4
Rodan	54.1	53.4	53.8	11.4	8.5	10.2	2.3	2.7	2.5
Rosana	49.2	---	---	11.4	---	---	2.6*	---	---
SB3	51.3	52.8	52.0*	9.6	8.4	9.0	2.3	2.6	2.4
Mean	54.3	56.5	54.8	10.5	8.7	9.7	2.4	2.5	2.5
LSD (0.05)	3.9	7.8	1.8	2.1	3.5	1.7	0.2	0.4	0.2

<sup>†</sup>All entries are western wheatgrass cultivars with the exception of SB3; SB3 is a western wheatgrass breeding population closely related to Recovery.

\*Western wheatgrass check entries significantly ( $P < 0.05$ ) different than Recovery western wheatgrass.

Table 5. Dry matter yield (DMY) of 'Recovery' western wheatgrass compared with standard western wheatgrass and other rangeland grass checks at three locations. Yield at Nephi and Blue Creek, UT evaluated just prior to anthesis in 2008 from 10-spaced-plant plots established in 2005. Yield from Curlew Valley, ID determined in 2006 just prior to anthesis using 1-m<sup>2</sup> clipped subsamples of plots established in 2002.

Cultivar	Nephi, UT	Blue Creek, UT	Curlew Valley, ID
	kg 10-plants <sup>-1</sup>	kg 10-plants <sup>-1</sup>	g m <sup>-2</sup>
<b>Recovery</b>	<b>2.0</b>	<b>2.7</b>	<b>262</b>
<i>WWG checks</i>			
Arriba	2.6	2.7	360
Barton	2.9**	3.1	285
Flintlock	3.3**	3.0	.
Rodan	3.0**	3.1	341
Rosana	2.9**	2.4	160*
SB3	2.5	2.2	276
LSD (0.05)	0.7	0.9	100

<sup>†</sup>Designations in this column include: WWG=western wheatgrass; SB3 is a WWG breeding population closely related to Recovery; Bozoisky and Bozoisky II are Russian wildryes; Firststrike is a slender wheatgrass; Hycrest and Hycrest II are crested wheatgrasses; and Vavilov and Vavilov II are Siberian wheatgrasses.

\*Western wheatgrass check cultivars with DMY significantly (P < 0.05) lower than Recovery western wheatgrass.

\*\*Western wheatgrass check cultivars with DMY significantly (P < 0.05) higher than Recovery western wheatgrass.

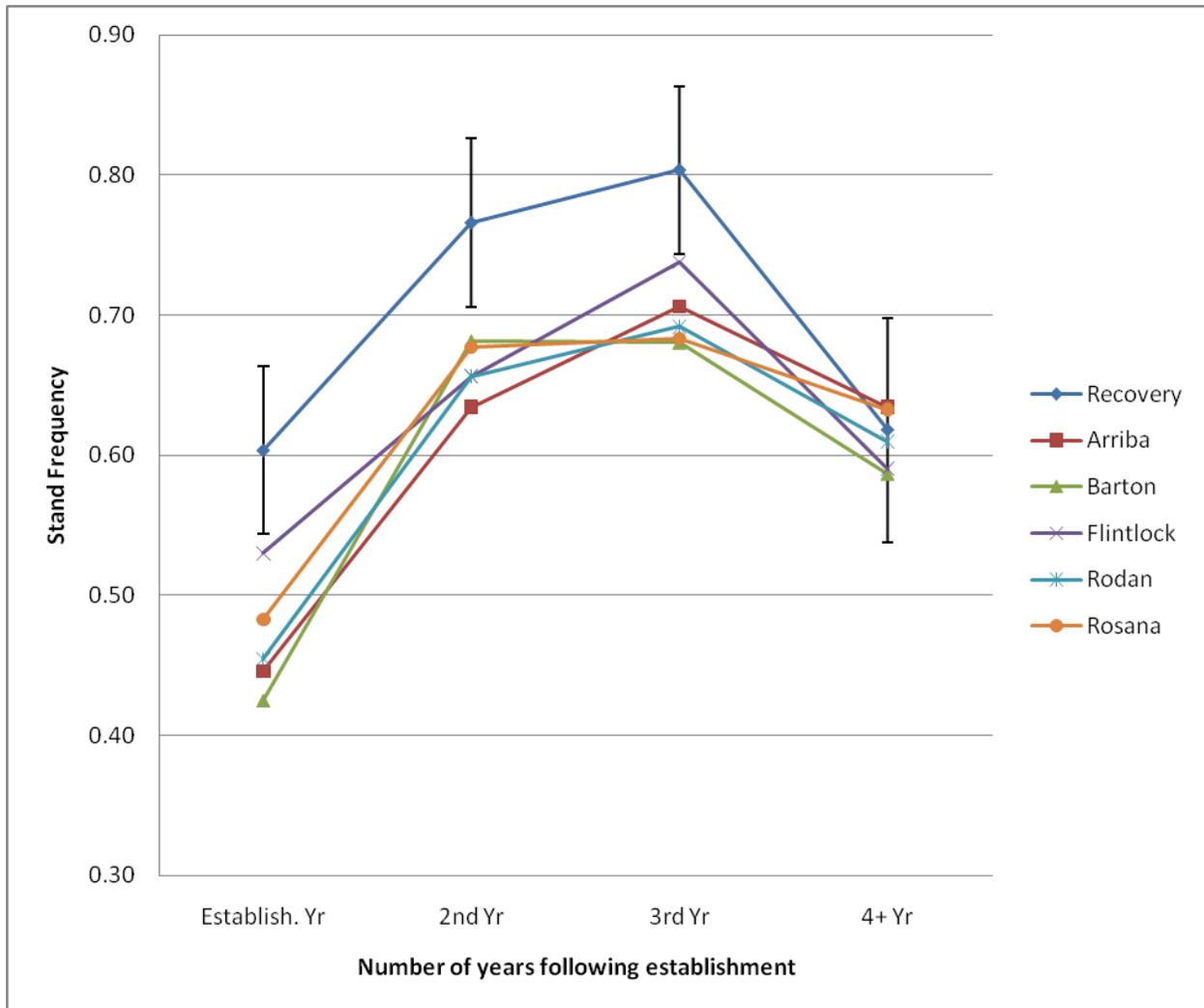


Figure 1. Stand of Recovery western wheatgrass as compared to standard western wheatgrass checks when evaluated at eight locations throughout the western U.S. Error bars are the LSD value at the P=0.05 probability level. The “4+ Yr” category is the latest evaluation taken at a given site and ranges from four to six years after planting.