UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
BRIDGER, MONTANA

and

MONTANA AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

and

WYOMING AGRICULTURAL EXPERIMENT STATION
LARAMIE, WYOMING

NOTICE OF RELEASE OF OPEN RANGE WINTERFAT TESTED CLASS OF NATURAL GERMPLASM

The Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture and the Montana and Wyoming Agricultural Experiment Stations announce the release of a 'Tested Class Germplasm' of winterfat (*Krascheninnikovia lanata* [Pursh] Guldenstaedt, syn. *Ceratoides lanata* [Pursh] J.T. Howell, syn. *Eurotia lanata* [Pursh] Moq.), a low growing, shrub, native to the northern Great Plains and Intermountain Desertic Basin. Winterfat has also been referred to as whitesage, lambstail, or sweetsage. This release was evaluated and selected by the USDA-NRCS Plant Materials Center (PMC) at Bridger, Montana.

Collection Site Information: Open Range Tested Class Germplasm of winterfat is a composite of three accessions: 9039363 collected near Terry, Montana (Custer County), by D. Grandbois (1985), 9039365 collected near Bridger, Montana (Carbon County), by B. Thompson (1985), and 9039416 collected near Rawlins, Wyoming (Carbon County), by R. Baumgartner (1985).

Description: The Open Range release is typical of the species, having the same general morphological and physiological characteristics. Winterfat is a half-shrub measuring 0.3 to 0.75 meters (1.0 to 2.5 ft.) tall. From a woody base, the plants produce numerous erect, annual branches. The stems and leaves are covered with soft, woolly hairs that give the plants a whitish to gray-green appearance. The sessile to short-petioled, lanceolate leaves have enrolled edges and persist through the winter season. The plants are monoecious. The flowers are arranged in dense clusters in the leaf axils on the upper portions of the stems. The white-woolly fruit is enclosed in two, densely hairy bracts. The seed embryo consists of the horseshoe-shaped cotyledons protected by a thin seed coating.

The native range of this shrub extends from Saskatchewan and Manitoba south to Nebraska, Colorado, West Texas, and west to California, Oregon, and Washington. It occupies the lower foothills, plains, and valleys that are relatively dry and often slightly saline. Because of its deep taproot and numerous lateral roots, winterfat has good drought tolerance.

Method of Breeding and/or Selection:

Initial Evaluation Plantings (IEP's). The initial testing of any new collections begins with Initial Evaluation Plantings. This involves the establishment of single 5 meter (16 ft.) rows in comparison with other collections of the same or similar species and released cultivars of the same or similar species as Standards of Comparison. Plantings are established at the Bridger Plant Materials Center (PMC) and at Off-Center sites to evaluate adaptation to various climatic conditions, soil types, and restoration situations.

IEP--Bridger PMC, 1984. A demonstration area was developed to exhibit a variety of grasses, legumes, and shrubs available as forages and reclamation species. Although these single, 5-meter (16 ft.) long rows were not established as Initial Evaluation Plantings, this was the first opportunity to observe 9019121 winterfat at the Bridger PMC. This accession was growing at the same time as the later established 1986 IEP, and was performing comparably to other accessions being tested in a field close-by.

IEP--Rock Springs/Greybull, WY. As part of the Arid-Lands Project, collections were made of grasses, forbs, and shrubs from the Red Desert and Big Horn Basin of Wyoming. Other germplasm was brought in from other sources to test their adaptation to arid coal strip mine and bentonite mines in areas with less than 250 mm (10 in.) of annual precipitation. Plantings were established both spring and fall starting in the spring of 1980. At that time only six accessions were available, NM-333 (which eventually was released as 'Hatch'); AB-585 and AB-764 from Idaho; 9039324 from Elko, Nevada; 9005626 from Goshen County, Wyoming; and 9039234 from Dawson County, Montana. None of these accessions performed well at these sites. Their poor performance can be attributed in part to the age of the seed used, but also to the severity of the climatic and edaphic conditions at these two sites.

IEP--Bridger PMC, 1986. On May 1, 1986, 18 accessions of winterfat were seeded into an IEP planting in Field 2 at the Bridger PMC. The plants were evaluated for seedling vigor, stand establishment, cover, forage production, and seed production (appendix table 1). On October 10, 1988, seed was hand stripped off the 12 best seed producing accessions and cleaned. The cleaning process consisted of running the seed through a small hammermill, and then over a single-screen Office Clipper™. The amount of pubescence and the ease with which the bracts and pubescence could be removed were noted. Six accessions were selected for a replicated study to further evaluate establishment, forage production, and seed production. These included the released cultivar 'Hatch' from New Mexico; 9019121, a superior performing accession from a 1984 demonstration planting; and the four best accessions from the 1986 IEP (9039363, 9039365, 9039416, and 9039828).

IEP--Bridger PMC, 1988. On April 28, 1988, a large IEP was established to evaluate 495 different grasses, forbs, and shrubs. This planting included ten new collections of winterfat (appendix table 2). Although there were some promising accessions of winterfat in this IEP, none were considered any better than the accessions in an advanced replicated trial just a short distance away. None of these accessions are being considered for advanced testing.

Comparative Evaluation Plantings (CEP's). Comparative Evaluation Plantings are usually replicated, multi-row plots to compare superior accessions in a statistically valid manner. Plots consist of four rows, with the center two rows being evaluated and the outer rows utilized to minimize edge-effect.

CEP--Bridger PMC, 1989. Six accessions were established in a randomized complete block design in Field 7 at the Bridger PMC (April 21, 1989). Each plot consisted of three,

6-meter (20 ft.) long rows with 0.9-meter (3 ft.) spacing and replicated three times. Seed was planted at a rate of 60 seeds per linear meter (18/ft.) with a single-row belt seeder. All plots were sampled for forage production in 1990 and 1991, and the three top accessions were sampled for seed production in 1990 and 1991, then seed harvested in 1992 was bulked (table 1). Forage was sampled on August 24, 1990, and August 6, 1991, by clipping four, 30-centimeter (1 ft.) sections of the center row. Seed was harvested by clipping the seed bearing stems, drying, and stripping the seed from the stems.

Table 1. Comparative Evaluation Planting--Field 7, Bridger PMC. Evaluation of five superior accessions of winterfat compared to the released cultivar 'Hatch'. Established 4/21/89.

Accession	Origin	Establishment Year Ranking	Forage Production 1990	Forage Production 1991	Seed Increase 1990	Seed Increase 1991	Seed Increase 1992
			kg/ha	*kg/ha*	*grams*	*grams*	*grams*
9039363	Custer County, MT	2	2316 a*	6774 a**	370	341}	
9039365	Carbon County, MT	1	1903 a	5502 ab	576	584}	836
9039416	Carbon County, WY	3	2071 a	4147 b	319	330}	
9039282	Dawson County, MT	4	1703 a	6759 a			
9039121	Uinta County, WY	5	955 ab	5734 ab			
Hatch	Los Lunas PMC, NM	6	55 b	450 c			

* Means followed by the same letter in the same column are not significantly different (P=.05) using Newman-Kuels Multiple Comparison Test. CV=42.3%.

** Means followed by the same letter in the same column are not significantly different (P=.05) using Duncan's Multiple Range Test. CV=38.3%.

CEP-Bridger/Pullman/Aberdeen PMC's, 1994. Inter-Center Strain Trials were established at the PMC's in Bridger, Montana, Aberdeen, Idaho, and Pullman, Washington, in the spring of 1994 as part of a cooperative project between the Grassland Research Institute, Inner Mongolia, People's Republic of China and the USDA-NRCS Plant Materials Center (PMC) in Bridger, Montana. A total of 46 Chinese accessions were compared to 16 American accessions in four-row, 6-meter (20 ft.) long plots replicated three times in a randomized complete block design with three replications. Open Range (9063535) winterfat (a composite of 9039363, 9039365, and 9039416) was compared to 9067481 (Northern Cold Desert germplasm) winterfat from Aberdeen, Idaho PMC and 9057950 *Ceratoides arborescens* from Inner Mongolia. The plots at the Pullman PMC site failed to maintain an adequate stand because of drought and rodent damage, and were discontinued in 1997. Trials at the Bridger and Aberdeen PMC's were evaluated from 1994 through 1998 (table 2). The *Ceratoides arborescens* from Inner Mongolia is a taller and more robust plant than the native winterfat. It was more productive than winterfat at Bridger, but at Pullman the winterfat was the most productive during the third growing season. The Idaho winterfat (9067481) did not establish well at any of the test sites.

Field Evaluation Plantings (FEP's). Plantings made off-Center and established by the cooperators are considered Field Evaluation Plantings. Seed is made available to other agency and university researchers for testing in their particular area.

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Reports to date show that Open Range tested germplasm of winterfat performs well in southern Idaho, northern Nevada, Montana, Wyoming, North Dakota, Kansas, Inner Mongolia, and Outer Mongolia. This ecotype of winterfat has been successfully established between the 40th and 49th parallel in the northern Great Plains and Intermountain region of the United States and the same latitudes in northern China and Mongolia.

Seed Morphology and Physiology. Winterfat seed is subtended and enclosed by two closely united bracts. Fine silky hairs arise externally from the bracts forming four dense tufts (Hilton, 1941). The conspicuous horseshoe-shaped endosperm is encased in a thin, somewhat transparent testa (seed coat). The embryo lies obovoid around the perisperm (food storage tissue) and the acute end of the seed, located at the point of attachment, is formed by adjacent radicle and cotyledon tips (Booth, 1988). The fluffy seed with the bracts still intact have approximately 106 seeds/gram (48,000 seeds/lb.), while processed seed has approximately 352 seeds/gram (160,000 seeds/lb.). Seed is dispersed by wind and by clinging to animals. Hilton (1941) found that winterfat seed is actually digested by sheep and, therefore, deduced that this seed is not distributed by animal feces as are many other hard seeded shrubs and forbs.

In the northern latitudes of Montana and Wyoming, winterfat seed matures in mid- to late October. Springfield (1972) found that winterfat has an after-ripening requirement of at least 9 weeks. The optimum time of seeding is dormant fall and spring. The seed requires shallow seeding: Springfield (1970) found that seed spread on the soil surface produced the best results; Springfield (1971) found that 1/16-inch (1.5 mm) planting depth to have maximum emergence; Booth and Schuman (1983), and Woodmansee and Potter (1971) both suggested planting at one-fourth inch (6 mm) or less. Plantings at the Bridger PMC have been done with double disk drill equipped with depth bands, placing the seed at one-fourth (6 mm) to one-half inch (12 mm) deep. There is conflicting research on whether or not the fluffy bracts should be removed. Booth and Schuman (1983) show that threshed seed has lower germination and emergence, and that there is also a risk of damaging the radicle tip when processing with a hammermill. Steven et al. (1977) mentions the importance of the bracts in protecting the seed and reducing precocious germination. Springfield (1970), who compared germination and survival of winterfat seedlings established from fruit and naked seed, found that threshed seeds sown on the soil surface to be the best. Winterfat seed, at the Bridger PMC, is threshed with a hammermill, creating a relatively naked utricle, which can be readily metered through standard drills. The unprocessed seed is very difficult to dispense through a drill, requiring a carrier such as rice hulls and extra large drop tubes to prevent plugging. Germination trials and the establishment of solid, uniform stands at the Bridger PMC indicate high germination rates and minimal damage to the processed seed. With most spring plantings at the Bridger PMC, seedlings emerge within 5 days of being planted.

Because of the thin seed coating and the pre-formed cotyledons and root radicle, winterfat seed germinates and emerges rapidly. These seed characteristics, however, also decrease seed life. The seed of winterfat, whether threshed or left enclosed in the fluffy bracts, have a relatively short shelf life (table 2). Springfield (1968) found little loss of viability in winterfat seed up to 3

years old. Hilton (1941) found germination of current year seed to be 97%; 1-year-old, 87%; 2-year-old, 23.5%; and germination of 3- and 4-year-old seed was negligible.

Table 2. Viability of winterfat seed at increasing ages. Seed stored in cloth seed sacks in enclosed drawers in the seed storage facility at the Bridger PMC. Growth chamber conditions: 16 hrs dark (15^0C/60^0F) and 8 hrs light (25^0C/77^0F). March 1 to 11, 2001.

Year Harvested	Germination 48 hours	Germination 10 days
	%	%
2000	97	97
1999	96	96
1998	4	15
1997	4	13
1996	0	0
1995	0	0

Optimum germination has been found with soil moisture conditions at field capacity and temperatures ranging from 10^0C to 30^0C (50^0 F to 86^0F). Springfield (1968) found that winterfat will germinate under moisture stress if the temperature is at or near 5^0C (41^0F). Fry (1969) found that winterfat seedlings will survive at temperatures as low as -11^0C (12^0F). Hilton (1941) found that air was critical for germination and that winterfat will not germinate under saturated conditions. He also found that light was not a factor in the germination of winterfat seed.

Seed Production. Winterfat seed is harvested at the Bridger PMC by swathing the mature plants and combining the cured windrows. The light fluffy seed requires low wind settings and wide-open sieves. The combine-run product consists of approximately 50% seed by volume and 37.5% by weight. The clean-out material is primarily crushed leaves and small, immature fruit. Schellenberg (2000) compared four methods of seed harvest: hand stripping, combining, vacuuming, and using a flail-type stripper. The vacuum method of harvest produced the most viable seed with the combining method yielding the least. These methods were tested on a small scale and may be too labor intensive for large-scale production.

The average harvest date of Open Range winterfat and the three accessions from which it is derived is October 22. Open Range is capable of producing some seed the year of establishment. A stand seeded on April 13, 2000, at the Bridger PMC, when harvested on October 23, 2000, produced 35 kg/ha (31 lb/acre) of seed. Seed production from Open Range winterfat ranges from 35 to 288 kg/ha (31 to 257 lb/a) (table 3).

Table 3. Seed production at the Bridger PMC of the three accessions used to form the composite, Open Range winterfat.

	1988	**1990**	**1991**	**1992**	**1993**	**2000**	**2001**
	kg/ha	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*
9039363	144	185	85				
9039365	210	288	146				
9039416	122	159	83				
Open Range				139	48†	35†	120

† Establishment-year seed production.

Ecological Considerations and Evaluation: Winterfat (*Krascheninnikovia lanata*) is a native shrub, indigenous to most of the northern Great Plains and throughout the Intermountain Desert Basin. It is most commonly found as a minor component of the mid- and short-grass prairies, but

can be found as the dominant plant in some plant communities in the Great Basin. The plants have extensive tap and fibrous root systems and do not spread vegetatively, except for some layering of lower branches. This species is not an aggressive spreader and does not compete with more aggressive invasive plants. Winterfat is considered a 'decreaser', as it is susceptible to overgrazing. It is relished by wildlife and domestic livestock and has no known toxicity. Other releases of this species, 'Hatch' (New Mexico) and Northern Cold Desert (Idaho), are not well adapted to the eastern plains of Montana and the high plains of Wyoming. There is presently a big demand for native shrubs to include in reclamation and conservation plantings. At the present time, the only source of adapted winterfat is wild land collections, which are expensive and in relatively short supply.

Conservation Use: Winterfat is grazed with relish by all classes of domestic livestock and is an important food for deer, antelope, and elk. The persistent leaves and late season crude protein content make this plant an exceptional winter browse species. When utilized as winter forage, winterfat provides crude protein levels of 7 to 11 percent and is relatively high in calcium, phosphorus and potassium (Hamilton and Gilbert, 1972) (Sowell et al., 1985). This shrub can be established in seed mixtures for mined land, range renovation, and wildlife habitat restoration. Winterfat is one of the few arid land shrubs that can be commercially produced with standard seed production techniques.

Anticipated Area of Adaptation: This release of winterfat has been tested in Montana, North Dakota, South Dakota, Wyoming, Idaho, Utah, Nevada, and Washington. Commercially grown seed and plants can be used in the northern Great Plains, northern Intermountain Basin, and the Snake River Plains of southern Idaho. It is adapted for use in rangeland sites in association with saltbush *(Atriplex* sp*.)*, sagebrush (*Artemisia)*, and grasses such as blue grama (*Bouteloua gracilis)*, western wheatgrass (*Pascopyrum smithii)*, needleandthread (*Hesperostipa comata)*, and bluebunch wheatgrass (*Pseudoroegneria spicata).*

Availability of Plant Materials: G_0 seed (equivalent to Breeder seed) and G_1 seed (equivalent to Foundation seed) of Open Range Tested Class germplasm of winterfat will be maintained by the Bridger PMC. G_2 (equivalent to Registered seed) and G_3 (equivalent to Certified seed) can be produced by commercial growers from G_1 seed purchased through the Foundation Seed Program at Montana State University-Bozeman and the University of Wyoming. G_3 seed can also be produced by commercial growers from commercially available G_2 seed.

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Signatures for release of:
Open Range Tested Germplasm of winterfat
Krascheninnikovia lanata

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DIANE GELBURD Date
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Appendix Table 1. Initial Evaluation Planting--Field 2, Bridger PMC. Performance of winterfat accessions. Established 5/1/86.

Accession	Origin	Stand†			Vigor†			Forage†			Seed†			Cover†			Seed	Ease of
		86	87	88	86	87	88	86	87	88	86	87	88	86	87	88	-88	Harvest‡
																	kg/ha	
Hatch	**NM PMC**	**0**			**9**			**9**			**9**			**9**				
9005626	Goshen, WY	0			9			9			9			9				
9019121	**Uinta, WY**	**(plant evaluated in different location at same time)**															**.068**	**5**
9039204	Converse, WY	5	10	10	3	3	2	4	3	3	4	3	4	6	3	3	.014	3
9039234	Dawson, MT	10	5	5	3	3	2	3	3	4	3	3	4	3	3	3		
9039282	**Dawson, MT**	**80**	**80**	**80**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**.063**	**2**
9039306	Lincoln, WY	10	20	20	4	4	2	5	4	4	5	4	4	6	3	3	.015	2
9039324	Elko, NV	0	20	20	9	4	5	9	6	5	9	6	4	9	5	4	.027	2
9039326	Platte, WY	5	10	10	3	3	2	5	3	3	5	3	2	5	3	2		
9039360	Custer, MT	15	20	20	3	3	2	4	4	3	4	4	3	5	3	3	.018	3
9039361	Custer, MT	15	20	60	3	3	2	4	3	3	4	3	3	5	4	4	.055	5
9039362	Custer, MT	15	20	30	3	2	2	4	2	3	5	3	2	5	3	3	.049	3
9039363	**Custer, MT**	**30**	**80**	**80**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**.073**	**2**
9039364	Custer, MT	10	10	10	4	3	2	4	3	3	5	2	4	5	2	3	.040	3
9039365	**Carbon, MT**	**15**	**25**	**25**	**2**	**2**	**2**	**3**	**2**	**3**	**5**	**2**	**2**	**5**	**2**	**3**	**.105**	**5**
9039366	Chouteau, MT	5	5	0	3	2	9	3	2	9	5	2	9	5	2	9		
9039416	**Carbon, WY**	**20**	**25**	**25**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**5**	**2**	**2**	**.061**	**3**
9039417	Juab, UT	10	15	15	3	2	3	3	2	3	5	3	3	5	2	3	.020	5
9039418	Albany, WY	5	10	0	3	3	9	4	3	9	4	4	9	5	3	9		

† Ocular estimates on a scale 1-9, with 1 best.

‡ Ratings of seed bract pubescence on a scale of 1-5, with 1 having short pubescence and 5 being very tomentose.

Bolded accessions selected for advanced evaluation.

Appendix Table 2. Initial Evaluation Planting--Field 6 Bridger PMC. Performance of winterfat accessions. Established 4/28/88.

Accession	Origin	Stand†			Vigor†			Forage†			Seed†			Cover†		
	(County/State)	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990
9039495	Carbon, WY	0	--	--	9	--	--	9	--	--	9	--	--	9	--	--
9039496	Albany, WY	30	35	65	2	2	2	3	3	3	9	3	3	3	2	2
9039497	Albany, WY	5	5	0	4	3	0	3	4	--	9	5	--	4	4	--
9039498	Goshen, WY	5	5	15	2	2	3	2	2	2	9	2	4	4	4	2
9039499	Fremont, WY	0	--	--	9	--	--	9	--	--	9	--	--	9	--	--
9054654	Gallatin, MT	20	45	35	3	3	4	3	4	4	9	4	5	4	3	4
9054655	Stillwater, MT	25	30	60	2	3	3	2	3	3	9	5	5	3	3	3
9054695	Albany, WY	40	75	85	2	2	2	2	2	2	9	3	3	2	2	2
9054696	Carbon, WY	0	--	--	9	--	--	9	--	--	9	--	--	9	--	--
9054697	Sheridan, WY	50	75	90	2	2	2	2	2	2	9	3	3	3	2	

† Ocular rating 1-9, with 1 best.

Appendix Table 3. Comparative Evaluation Planting. Comparison of two accessions of winterfat with *Ceratoides arborescens* from Inner Mongolia. Bridger, Aberdeen, and Pullman PMC's. Established spring 1994.

Accession	Species	Percentage Stand											Forage Production (*kg/ha*)			
		Bridger					Aberdeen				Pullman		Bridger	Aberdeen	Pullman	
		94	95	96	97	98	94	95	96	97	94	95	95	95	95	96
9063535	**KRLA**	**83**	**47**	**50**	**47**	**37**	**58**	**80**	**78**	**47**	**92**	**88**	**2,325**	**No Data**	**4,022**	**2,541**
9074481	KRLA	4	1	0	0	0	0	0	0	0	0	2	64	No Data	0	0
9057950	CEAR	88	63	63	58	58	74	100	83	80	98	93	3,454	No Data	4,273	1,389