

Emergence and Growth of Four Winterfat Accessions in the Presence of the Exotic Annual Cheatgrass

Ann L. Hild¹
Jennifer M. Muscha²
Nancy L. Shaw³

Abstract: Winterfat (*Krascheninnikovia lanata* [Pursh] A. D. J. Meeuse & Smit; synonym: *Ceratooides lanata* [Pursh] J. T. Howell) is a desired shrub species and an integral component of salt desert shrublands in the Intermountain West. On the Snake River Birds of Prey National Conservation Area in southwestern Idaho, extensive loss of winterfat-dominated communities has been linked to altered fire regimes associated with cheatgrass (*Bromus tectorum* L.) invasions. Post-fire revegetation efforts are often hampered by the quick emergence of cheatgrass seedlings with autumn or spring moisture. We compare the establishment of four winterfat populations (Birds of Prey; northeastern New Mexico; Northern Cold Desert Select Germplasm; and Open Range Tested Germplasm) with and without cheatgrass competition. Seed of each accession was planted in 15 cm diameter pots containing four densities of cheatgrass (0, 2, 4, and 8 plants per pot) in a greenhouse. Plant measurements were made 4, 5, 7, 9, 11, 13, 15, 17, 19, and 21 weeks after planting. Measurements included winterfat survival, height and two canopy diameters, and cheatgrass height and number of leaves and culms per plant. Initial establishment was greatest for the New Mexico winterfat source at all cheatgrass levels. Growth of this source exceeded the others in the absence of cheatgrass. However, the presence of cheatgrass depressed growth of all sources by at least 90 percent. Establishment of winterfat on cheatgrass infested rangelands necessitates seeding on sites where cheatgrass densities are low or reduced by site preparation procedures.

Introduction

Widely distributed across the interior western United States, winterfat (*Krascheninnikovia lanata* [Pursh] A. D. J. Meeuse & Smit; synonym: *Ceratooides lanata* [Pursh] J. T. Howell) (U.S. Department of Agriculture, Natural Resources Conservation Service 2004) is an important subshrub on millions of acres of salt desert shrublands, often occurring as a landscape-dominating species. Although it is most common in valley bottoms and foothills, it is found on sites ranging from the Lower Sonoran and Mojave Deserts to mountain ridges above 3,050 m in Utah to mixed-grass prairies of the Midwest (Carey 1995; Stevens and others 1977). A highly variable species morphologically, dwarf forms of winterfat are common on desert floors, salty soils, and high mountain ridges, while larger, more woody forms, grow on alluvial fans, foothills, and mesas in the southern portion of the species' range (McArthur and Monsen 2004).

On the Snake River Birds of Prey National Conservation Area (listed hereafter as 'Birds of Prey') located southwest of Boise, Idaho, extensive loss of winterfat-dominated communities has been linked to shortened fire intervals associated with the advance of the annual exotic invasive, cheatgrass (*Bromus tectorum* L.). Winterfat communities at Birds of Prey are especially important for supporting high Townsend ground squirrel (*Spermophilus townsendii* Bachman) densities that provide a prey base for nesting raptor species (Nydegger and Smith 1986; Van Horne and others 1998).

Efforts to reestablish winterfat in the Birds of Prey following wildfires are often hampered by the lack of local seed supplies and the reportedly poor establishment of the indigenous seed source, particularly with competition from cheatgrass. Winterfat seeding efforts may be hampered by the rapid germination and root growth of cheatgrass seedlings with spring or autumn precipitation that allows them to compete successfully for available resources (Harris 1967, 1977; Harris and Goebel 1976). Concerns for reestablishing and maintaining the local winterfat population on the Birds of Prey make it essential that we understand the impact of cheatgrass competition on its germination and establishment. The purpose of this study was to compare germination and seedling growth of four native winterfat seed collections with cheatgrass competition.

Methods

The winterfat seed sources were: (1) Birds of Prey; (2) northeastern New Mexico; (3) Northern Cold Desert Selected Germplasm; and (4) Open Range Tested Germplasm. All seed was harvested in fall 2003.

The Birds of Prey seed was a composite of three local wildland collections made at the Birds of Prey National Conservation Area on the Lower Snake River Plain south of Boise, Idaho. The area ranges from 850 to 1,000 m in elevation and is characterized by dry, hot summers and mild

In: Sosebee, R.E.; Wester, D.B.; Britton, C.M.; McArthur, E.D.; Kitchen, S.G., comp. 2007. Proceedings: Shrubland dynamics—fire and water; 2004 August 10-12; Lubbock, TX. Proceedings RMRS-P-47. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 173 p.

winters. Annual precipitation in Boise averages 306 mm (U.S. Department of the Interior, U.S. Geological Survey, Biological Resource Division 1996). The dwarf, spreading growth form of this seed source averages about 0.2 m in height (Nydegger and Smith 1986) and is typical of populations found in association with other salt desert species such as shadscale (*Atriplex confertifolia* [Torr. & Frem] S. Wats.), squirreltail (*Elymus elymoides* [Raf.] Swezey), and cheatgrass.

New Mexico seed was collected from native stands near Mora in northeastern New Mexico's Colfax County. The growth form is large, upright, and woody. Plants commonly grow on rocky foothills and valleys in association with ponderosa pine (*Pinus ponderosa* P. & C. Lawson) and pinyon-juniper (*Pinus* L.-*Juniperus* L.) communities at elevations from 1,500 to 2,000 m (Stevens and others 1977). This morphological variant has sometimes been given the subspecific or variety epithet *subspinosa* (see Booth 2005 for discussion). Annual precipitation in Colfax County ranges from 380 mm at lower elevations and increases to 400 mm in higher foothills (U.S. Department of Agriculture, Soil Conservation Service and Forest Service 1982). Northern Cold Desert Winterfat Selected Germplasm (NCD) was released by the U.S. Department of Agriculture, Natural Resources Conservation Service, Aberdeen Plant Materials Center in 2001 (St. John and Blaker 2004). A composite of four eastern and southern Utah and one western Colorado population, it was selected for cold, drought, and alkalinity tolerance. Plants have an upright growth habit, growing to 0.9 m in height. The germplasm is recommended for Intermountain sites receiving 180 to 400 mm of annual precipitation (U.S. Department of Agriculture, Natural Resources Conservation Service 2002). The seed used in this study was produced in a seed orchard.

The Open Range Tested Germplasm Winterfat is a composite of three accessions from eastern and south-central Montana and south-central Wyoming, selected for their seedling vigor and forage and seed production. Plants are spreading and 0.3 to 0.75 m tall. Recommended area of use includes the northern Great Plains, northern Intermountain area, and the Snake River Plain (Majerus and Holzworth 2003). Open Range seed was harvested from a nursery planting.

Cheatgrass seed and soil for greenhouse competition studies were collected from the Birds of Prey National Conservation Area in summer 2003. Soil texture was a silty clay loam, organic matter averaged 1.5 percent, and pH was 7.8. Potting soil was prepared by first sieving the field soil to remove large rocks and pieces of organic material. A soil mix of two parts of field soil to one part vermiculite by volume was prepared to insure water infiltration into the pots. All seed was allowed to afterripen for 12 weeks prior to study initiation to enhance germination (Springfield 1972) and then cleaned to remove debris and small utricles. For each source of winterfat, 12 pots, each 15 cm in diameter, were prepared for each block. Four winterfat seeds were centered in each pot. On the same date, cheatgrass seeds were placed around the perimeter of three pots for each source to obtain one of four densities: 0, 2, 4, or 8 seedlings per pot. Three pots containing no winterfat were also planted at each grass density to document cheatgrass

growth without winterfat present. Seeds were covered with a 0.5 cm layer of washed masonry sand to insure good seed-to-soil contact and to prevent seed movement during watering.

Because we hand selected large seed for both cheatgrass and winterfat (Springfield 1973) to optimize germination success, we had little problem in obtaining the desired densities. Excess seedlings of either species were thinned as necessary to obtain target densities by clipping seedlings at the plant base. However, at the time of seeding, we did start germination of both winterfat and cheatgrass seeds in additional identical pots to serve as replacement plants in case seeds in treatment pots did not germinate. In two cases, we transplanted winterfat seedlings into the study pots within the first 2 weeks of the study because winterfat seeds did not germinate in the center of treated pots. We did no additional transplanting or thinning after the second week.

Pots within each block were randomized on greenhouse benches and re-randomized weekly. Soils were thoroughly wetted at the time of planting. Pots were rewatered every 2 days for the first 2 weeks after seeding. For the remainder of the treatment period, pots were allowed to dry until cheatgrass plants in the four plants/pot treatments showed evidence of temporary wilt, when all treatments were again watered with equal amounts (200 ml) of water using a graduated cylinder. Temperatures in the greenhouse ranged from 20°C at night to 37°C during the day; day length averaged 12 hours.

Plantings were replicated on five dates (blocks) in 2003. We documented winterfat and cheatgrass seedling growth for 21 weeks following seeding (at 4, 5, 7, 9, 11, 13, 15, 17, 19, and 21 weeks). On each evaluation date, winterfat seedling survival, height, and two perpendicular canopy diameter measurements were recorded for determination of plant size (canopy volume). Cheatgrass seedling height and number of leaves and culms per plant were recorded on the two consecutive days prior to the winterfat measurements. At 21 weeks, we harvested plants, washed roots, and separated plants into above-ground and below-ground biomass for measurements of leaf and root area with a leaf area meter. Samples were oven-dried at 60°C for 48 hours and weighed.

Data were analyzed using ANOVA appropriate to a factorial arrangement in a randomized complete block design using sampling dates as repeated measures. Because winterfat seedling size was much smaller in the presence of cheatgrass plants than when grown without cheatgrass competition, we also compared the four winterfat seed sources to each other when grown only with three densities of cheatgrass (excluding the 0 cheatgrass treatment). Least significant difference (LSD) mean separations were evaluated at the 0.05 alpha level in SAS (SAS 2002).

Results and Discussion

Two-thirds of winterfat mortality occurred in the first 5 weeks after planting. After 21 weeks, survival of winterfat varied significantly among sources and was greatest for the northern New Mexico collection (98.3 percent) followed

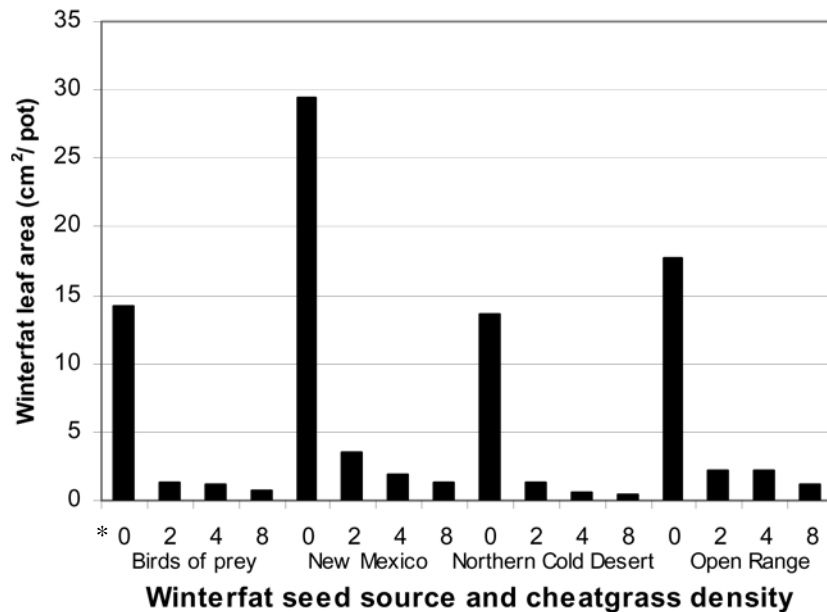


Figure 1. Winterfat seedling leaf area by seed source and cheatgrass density per pot (2, 4, or 8 seedlings) after 21 weeks of growth in a greenhouse.
*Number of cheatgrass seedlings per pot.

by the Open Range (79.7 percent) and Birds of Prey (78.7 percent) sources, with survival of the Northern Cold Desert seed source lowest (56.7 percent) when averaged across all four cheatgrass competition levels.

Winterfat leaf area was greatly reduced by the presence of cheatgrass at any density (fig. 1) and total biomass followed the same trend (data not shown). Leaf area of winterfat from New Mexico (2.23 cm²/plant) and Open Range (1.87 cm²/plant) sources were significantly greater than the Birds of Prey (1.09 cm²/plant) and Northern Cold Desert (0.71 cm²/plant) sources when grown without cheatgrass. Similar trends were noted for total winterfat biomass (data not shown). During weeks 11 through 21, New Mexico plants produced greater canopy volume (fig. 2 a-d) than other sources only in the absence of cheatgrass competition. The same differences were significant for winterfat leaf area (data not shown).

Growth of cheatgrass (biomass and leaf area) was not different among the 2, 4, and 8 plants/pot cheatgrass densities, but did differ among the winterfat seed sources (figs. 3 and 4) grown with cheatgrass. Cheatgrass biomass was reduced by 46 percent when grown with the Northern Cold Desert seed source and leaf area was reduced by 35 percent when grown with the Northern Cold Desert or Birds of Prey seed sources relative to the New Mexico source.

Our results indicate that initial emergence and survival of the larger-statured New Mexico source with or without cheatgrass competition, and 21-week growth (leaf area and biomass) of this source in the absence of cheatgrass competition, were greater than for any of the remaining sources. Booth (2005) commented that several authors (Booth 1992; Moyer and Lang 1976; Springfield 1968) have found differences in seed quality and seedling vigor among other accessions and suggested that these may result as adaptive responses to stressful environments. However, in the presence of

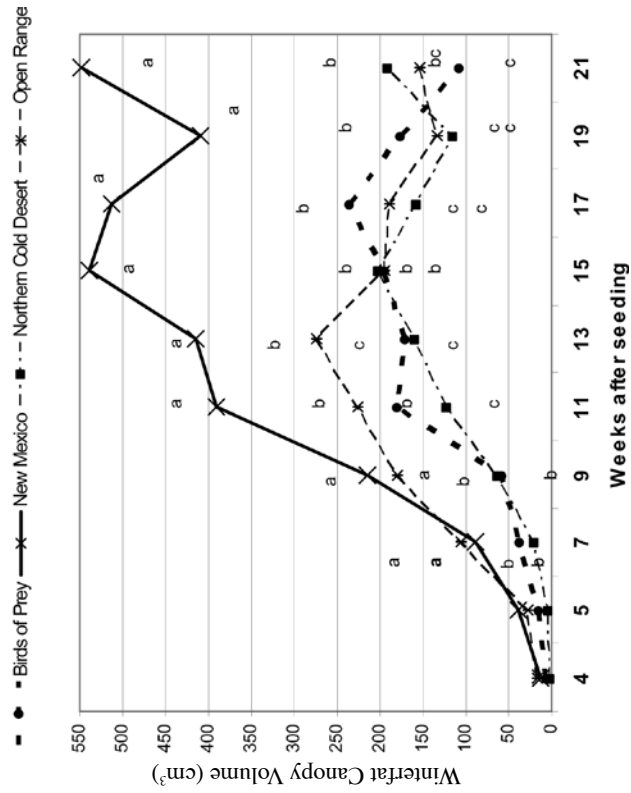
cheatgrass at any competition level, growth of all four sources was reduced by at least 90 percent. Consequently, winterfat at the seedling stage appears vulnerable to cheatgrass competition, even when the annual occurs at the lowest densities tested. However, it should be noted that as cheatgrass production did not vary among the cheatgrass densities, all of our treatments appear to have provided similar levels of competition (in terms of cheatgrass biomass present within a 7.5 cm radius of the winterfat seedling). Repeating the experiment using the same cheatgrass densities, but larger pots, might reveal whether there is a differential in competitive ability of the four winterfat sources at lower competition levels.

Both the Northern Cold Desert and Birds of Prey sources reduced cheatgrass production, while the more rapidly growing New Mexico source had no effect on cheatgrass growth. Although cheatgrass is generally considered to be a strong competitor with seedlings of other species, Francis and Pyke (1996) found that seedlings of 'Hycrest' crested wheatgrass (*Agropyron desertorum* x *crisatum*), but not those of 'Nordan' crested wheatgrass (*Agropyron desertorum*), significantly reduced growth of cheatgrass seedlings. Identification of the mechanism responsible for differential suppression of cheatgrass growth by the winterfat seed sources included in this study would aid in understanding the dynamics of competitive interactions between cheatgrass and winterfat.

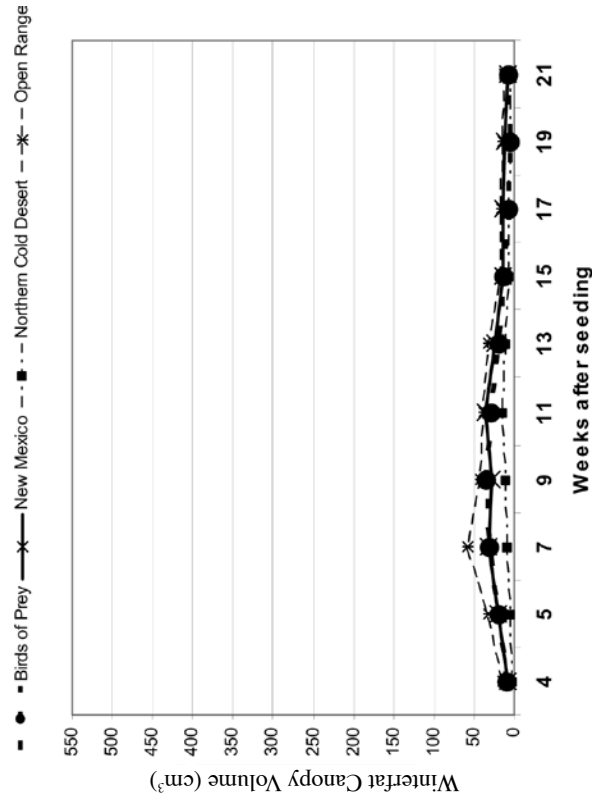
Although this research was conducted under greenhouse conditions, the results clearly indicate that sites where cheatgrass densities are high following wildfires are likely to be problematic for winterfat establishment regardless of the seed source planted.

Reduction of cheatgrass densities to low levels or seeding only in areas where competition is expected to be minimal is essential to permit emergence and growth of winterfat seedlings.

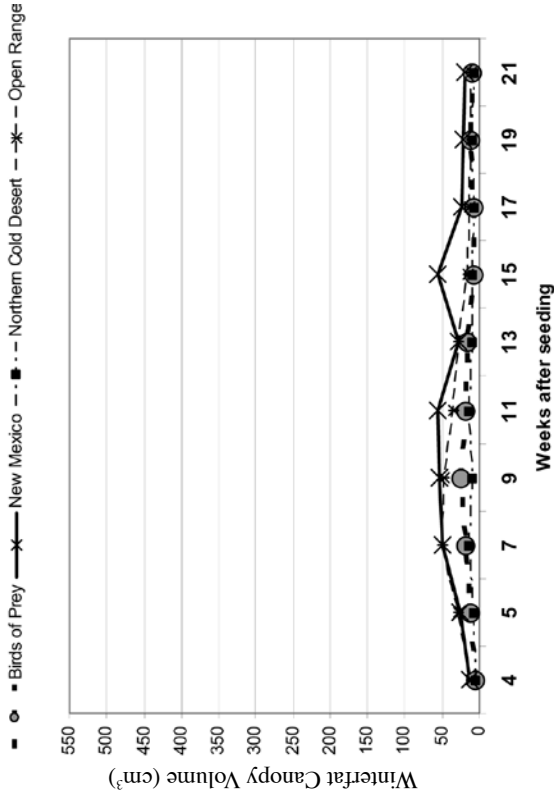
a. 0 cheatgrass/pot



c. 4 cheatgrass/pot



b. 2 cheatgrass /pot



d. 8 cheatgrass/pot

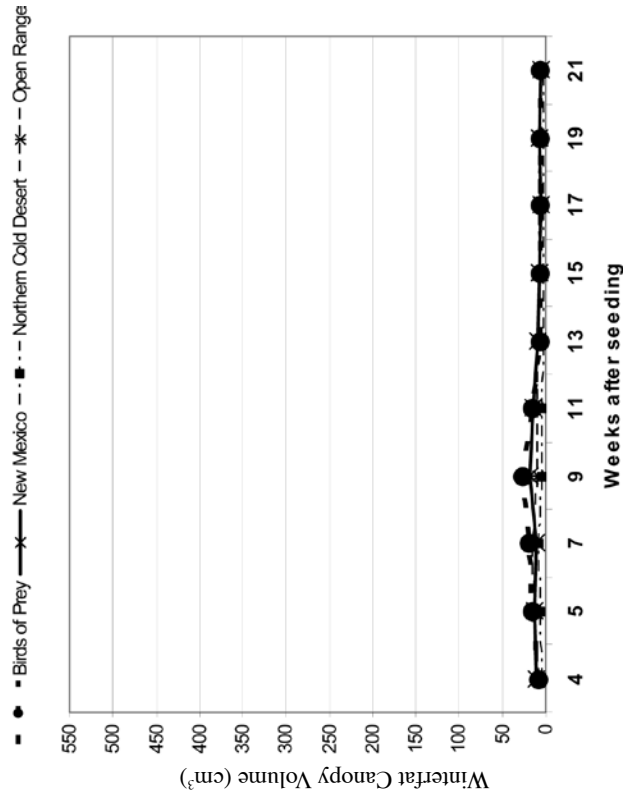


Figure 2. Canopy volume of winterfat seed sources in response to cheatgrass competition level during the 21-week period following seeding. Cheatgrass density: (a) 0 plants/pot; (b) 2 plants/pot; (c) 4 plants/pot; and (d) 8 plants/pot.

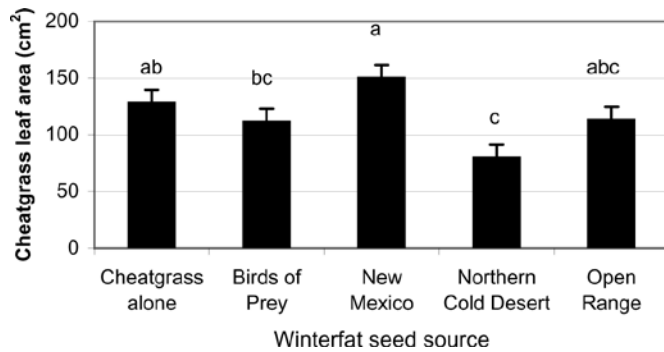


Figure 4. Cheatgrass leaf area (cm²) when planted at three densities (2, 4, or 8 seedlings per pot) alone or in the presence of winterfat seed sources.

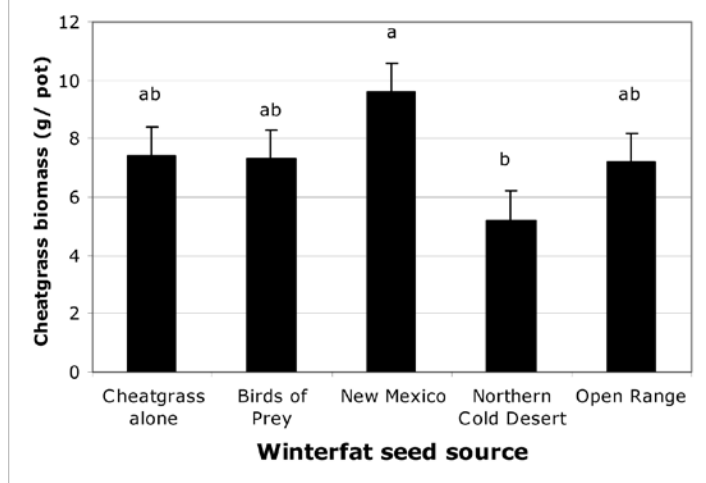


Figure 3. Cheatgrass biomass production (g) when planted at three densities (2, 4, or 8 seedlings per pot) alone or in the presence of winterfat seed sources.

References

- Booth, D. T. 2002. Seedbed ecology of winterfat: imbibition temperature affects post-germination growth. *Journal of Range Management*. 45: 159-164.
- Booth, D. T. 2005. *Krascheninnikovia lanata* (Pursh) A. D. J. Meeuse & Smit. In: Bonner, F. T.; Nisley, R. G., eds. *Woody Plant Seed Manual*. Washington, DC: U.S. Department of Agriculture, Forest Service. Online. Available: <http://nsl.fs.fed.us/wpsm/>
- Carey, J. H. 1995. *Krascheninnikovia lanata*. In: *Fire Effects Information System*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). : <http://www.fs.fed.us/database/feis>
- Francis, M.; Pyke, D. A. 1996. Crested wheatgrass-cheatgrass seedling competition using a mixed-density design. *Journal of Range Management*. 49:432-438.
- Harris, G. A. 1967. Some competitive relationships between *Agropyron spicatum* and *Bromus tectorum*. *Ecological Monographs*. 37: 89-111.
- Harris, G. A. 1977. Root phenology as a factor of competition among grass seedlings. *Journal of Range Management*. 30: 172-177.
- Harris, G. A.; Goebel, C. J. 1976. Factors in plant competition in seeding Pacific Northwest ranges. *Agric. Exp. Sta. Bull.* 820. Pullman, WA: Washington State University.
- Majerus, M.; Holzworth, L. 2003. Open Range Tested Class Germplasm Winterfat: a conservation plant for Montana and Wyoming. Bridger, MT: U.S. Department of Agriculture, Natural Resources Conservation Service: 4 leaves. Brochure.
- McArthur, E. D.; Monsen, S. B. 2004. Ch. 20. Chenopod shrubs. In: Monsen, S. B.; Stevens, R.; Shaw, N. L., comps. 2004. *Restoring western ranges and wildlands*. Gen. Tech. Rep. RMRS-GTR-136-vol-2. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 467-492.
- Moyer, J. L.; Lang, R. L. 1976. Variable germination response to temperature for different sources of winterfat seed. *Journal of Range Management*. 29: 320-321.
- Nydegger, N. C.; Smith, G. W. 1986. Prey populations in relation to *Artemisia* vegetation types in southwestern Idaho. In: McArthur, E. D.; Welch, B. L., comps. *Proceedings—symposium on the biology of Artemisia and Chrysothamnus*; 1984 July 9-13; Provo, UT. Gen. Tech. Rep. INT-200. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 152-156.
- SAS. 2002. *Jmp Statistical Discovery Software*. SAS Institute Inc., Cary, NC.
- Springfield, H. W. 1972. Winterfat seeds undergo after-ripening. *Journal of Range Management*. 25: 479-480.
- Springfield, H. W. 1968. Germination of winterfat seeds under different moisture stresses and temperatures. *Journal of Range Management*. 21: 314-316.
- Springfield, H. W. 1973. Larger seeds of winterfat germinate better. *Journal of Range Management*. 26: 153-154.
- St. John, L.; Blaker, P. 2004. New native plant releases from the USDA-NRCS, Aberdeen, ID, Plant Materials Center. In: Hild, A. L.; Shaw, N. L.; Meyer, S. E.; Booth, D. T.; McArthur, E. D., comps. *Seed and soil dynamics in shrubland ecosystems: proceedings; 2002 August 12-16; Laramie, WY*. Proceedings RMRS-P-31. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 138-139.
- Stevens, R.; Giunta, B. C.; Jorgensen, K. R.; Plummer, A. P. 1977. *Winterfat (Ceratooides lanata)*. Pub. 77-2. Salt Lake City: Utah State Division of Wildlife Resources. 41 p.
- U.S. Department of Agriculture, Natural Resources Conservation Service. 2002. Northern Cold Desert Winterfat Selected Class Germplasm. Fact Sheet. Aberdeen, ID: U.S. Department of Agriculture, Natural Resources Conservation Service, Aberdeen Plant Materials Center. USDA, NRCS. 2004. The PLANTS Database, Version 3.5 (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.
- U.S. Department of Agriculture, Soil Conservation Service and U.S. Department of Agriculture, Forest Service. 1982. *Soil Survey of Colfax County New Mexico*. Washington, DC: U.S. Department of Agriculture, Soil Conservation Service and U.S. Department of Agriculture, Forest Service. 187 p.
- U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division. 1996. *Effects of military training and fire in the Snake River Birds of Prey National Conservation Area*. BLM/IDARNG Res. Proj. Final Rep. Boise, ID: U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, Snake River Field Station. 130 p.
- Van Horne, B.; Schooley, R. L.; Sharpe, P. B. 1998. Influence of habitat, sex, age and drought on the diet of Townsend's ground squirrels. *Journal of Mammalogy*. 79: 521-537.

The Authors

¹ Associate Professor, University of Wyoming, Department of Renewable Resources, Laramie, WY. AnnHild@uwyo.edu

² Rangeland Scientist III, U.S. Department of Agriculture, Agricultural Research Service, Fort Keogh Livestock and Range Research Center, Miles City, MT.

³ Research Botanist, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Boise, ID.