SELECTING PLANTS FOR MINE RECLAMATION IN WESTERN WYOMING[1]

M. E. Majerus, J. G. Scheetz and L. K. Holzworth[2]

Abstract.--Areas in the arid rangelands (254 millimeters or less annual rainfall) in the Big Horn Basin and the Red Desert of western Wyoming are mined for coal, bentonite, gas, and oil. The sparse vegetative cover on mined areas results in accelerated wind and water erosion. Success in revegetating these mined sites has been limited, in part, because of the few, indigenous, drought-resistant species available. In 1980, the Soil Conservation Service started a cooperative project to identify additional species that have potential for reclamation and to evaluate techniques for their establishment on arid mine sites.

INTRODUCTION

There are 9 million hectares of arid lands in the Northern Intermountain Desertic Basin (MLRA 32), and Central Desertic Mountains, Basins, and Plateaus (MLRA 34), primarily in Wyoming. These lands support vegetation that is predominantly browse, although there are scattered stands of drought-tolerant grasses and forbs mixed in with the browse (Barnes et al., 1952). Packer (1974), using a rehabilitation potential classification system based on combined ratings of soil, vegetation, and precipitation, classified the rehabilitation potential for these arid regions as very poor, and as fairly poor for the semiarid portions of the rolling plains. Attempts to renovate or reclaim these arid sites, using the commercially available species, have been relatively unsuccessful without some surface manipulation or waterspreading. Fisser et al. (1963) used a water-spreading system on saltbush *Atriplex nuttallii* range and seeded crested wheatgrass *Agropyron cristatum*, tall wheatgrass *Thinopyrum ponticum* (Podp.) Barkworth and D. R. Dewey, and firebush *Kochia scoparius* to increase forage production fourfold to 1,685 kilograms-per-hectare (kg/ha). Contour furrowing, pitting, and ripping without reseeding has inproved some arid sites in Montana and Wyoming (Bronson et al. 1966, Soiseth et al. 1974, Rauzi 1975, and Wight et al. 1978). At the present time, surface treatment is generally not used as a range improvement practice on arid sites because unfavorable economics have discouraged its use by private landowners; and management philosophies have restricted its use by state and federal land management agencies (Wight 1978).

Crested wheatgrass has been the most successful and most widely used species on arid soils of Montana and Wyoming over the last 40 years (Barnes 1952, Nichols 1964, Fisser et al. 1974, and Hemmer et al. 1977). Hull (1963) experimented with seeding many grass and shrub species in the desert region of western Wyoming. Although initial stands of the various seedings were encouraging, only Russian wildrye *Psathyrostachys juncea* (Fisher) Nevski and crested wheatgrass were still successfully established after 12 years. Native species adapted to these desert sites that have exhibited the most success have been accessions of thickspike wheatgrass *Elymus lanceolatus* (Scribner & J. G. Smith) Gould (Scheetz 1974 and Hemmer 1977), western wheatgrass *Pascopyrum smithii* (Rydb.) A. Love (Barnes et al. 1952), bottlebrush squirreltail *Elymus elymoides* (Raf.) Swezey (Hemmer 1977), and Indian ricegrass *Oryzopsis hymenoides* (Roem. & J. A. Schultes) Ricker ex Piper, basin wildrye *Leymus cinereus* (Scribner & Smith) Pilge, blue grama *Bouteloua gracilis* (H.B.K.) Lag. ex Griffiths, and needleandthread *Stipa comata* Trin. & Rupr. (McArthur et al. 1978).

Many reasons have been suggested for rehabilitation failures from direct seeding in the salt-desert shrublands (Van Epps and McKall 1980), including low seed germination, unadapted species or ecotypes, frost or winterkill of emerging seedlings, improper depth or season of planting, inadequate seedbed preparation, seed removal by animals, grazing damage, excessive competition from other plants, lack of soil moisture, low precipitation and hot winds during critical periods, soil compaction, diseases, and perhaps the absence of beneficial mycorrhiza.

METHODS AND MATERIALS

The Red Desert and Big Horn Basin of Wyoming are primarily classified as rangeland; however, the range resource is overshadowed in importance by the mineral resources--coal, bentonite, uranium,

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[2]M. E. Majerus is Assistant Manager, Plant Materials Center, Soil Conservation Service, Bridger, Mont. J. G. Scheetz is Manager, Plant Materials Center, Soil Conservation Service, Bridger, Mont. L. K. Holzworth is Plant Materials Specialist, Soil Conservation Service, Bozeman, Mont.

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gas, and oil. Slow plant establishment on the rangeland that has been mined doesn't provide soil protection and stabilization. There has been limited success in revegetating these arid sites, in part because of limited availability of indigenous, drought-resistant plant materials.

In 1980 the USDA Soil Conservation Service (SCS), Bridger Plant Materials Center (PMC), with some support funding from the Office of Surface Mining (OSM), started to assemble and evaluate plant materials adapted to areas receiving less than 25 centimeters (cm) annual precipitation. The primary objectives were to increase the number and diversity of species available for revegetating arid range and mining sites in Montana and Wyoming, and to evaluate techniques for successful plant establishment.

Two field evaluation planting (FEP) sites were chosen: one at the Bridger Coal Mine near Point of Rocks, 50 kilometers (km) east of Rock Springs, Wyo. (Red Desert); and one at the Dresser Minerals Bentonite Mine, 25 km northeast of Greybull, Wyo. (Big Horn Basin). A control plot was also maintained under dryland conditions at the Bridger PMC.

Bridger Coal Site

The test plots are at an elevation of approximately 2,083 meters (m). The average annual precipitation is 15 to 25 cm, with a peak in the spring (March-May) and a secondary peak in the fall (September-October). Strong and frequent winds result in high evapotranspiration rates. The growing season varies from 80 to 100 days. The soils of the Red Desert are characterized by having been formed in material weathered from interbedded clay, shale, sandstone, limestone, and siltstone. These soils are mapped in a Torriorthents-Haplargids-Natrargids association. The soils at this site were Entisols before being stockpiled by horizon. After handling and mixing, the soil remains a loam or sandy loam. The actual test site was strip mined and backfilled with subsoil. A minimum of 30 cm of topsoil was placed on the area. Prior to planting, the area was ripped in two directions to a depth of 45 cm, disked and harrowed.

Dresser Minerals Site

These test plots are at an elevation of approximately 1,400 m. The average annual precipitation is 13 to 23 cm, with a peak in late May and early June, and a secondary peak in September. The growing season is from 90 to 110 days. Big Horn Basin soils are some of the most complex in the entire state. The soil at the Dresser Minerals FEP site is Lithic Natrargid, clayey-skeletal, montmorillonitic, mesic. These are well drained soils formed in residuum on anticlinal backslopes and uplands. Typically, the surface layer is a pale brown, channery clay loam about 8 cm thick. The subsurface is a very pale brown, channery clay about 15 cm thick, and is underlain by channery shale. The stockpiled soil material replaced, following mining, lost much soil horizon identity and soil structure, but the texture of the surface layer remains a channery clay loam.

Soil analyses were made of the topsoil material used at both sites:

	Dresser Minerals	Bridger Coal
pH	7.60	7.70
Cond. (mmhos/cm)	8.57	1.08
Saturation %	63.60	27.50
Sand %	46.00	49.80
Silt %	22.00	34.40
Clay %	32.00	15.80
Calcium (meq.1)	26.30	2.98
Magnesium (meq.1)	6.85	1.92
Sodium (meq.1)	77.30	7.41
S.A.R.	19.00	5.00
Selenium (ppm)	.02	.02
Boron (ppm)	1.20	1.80

The precipitation patterns in the desert regions of Wyoming are very irregular and unpredictable. The most moisture occurs in early spring (April-May) and/or early fall (September-October). Precipitation in any significant amount during the rest of the year occurs as unusual thunderstorms or snowstorms. The strong, steady winds diminish the effectiveness of the precipitation. The winds deplete soil moisture and reduce its effectiveness for plant establishment and growth. The precipitation patterns for the two sites during the planting trials were erratic, and somewhat below the long-term average (table 1).

Local Soil Conservation Service and PMC personnel collected seeds and plants throughout the Big Horn Basin and Red Desert regions. Additional accessions were obtained from other PMCs, universities, seed companies, and other researchers.

Released cultivars were used as a standard of comparison to help evaluate the performance of the new native collections. Each accession was planted in individual, 5-m rows, spaced 1 m apart. Spring and fall plantings were established during two consecutive years to determine optimum climatic conditions for planting time. Most accessions were planted in all the major plantings, with new accessions being added as they were collected.

Bridger Coal

Spring 1980	April 22, 1980	243 accessions
Fall 1980	October 7, 1980	280 accessions
Spring 1981	April 29, 1981	234 accessions
Fall 1981	October 13, 1981	281 accessions
Fall 1984	October 24, 1984	101 accessions

Dresser Minerals

Spring 1981	April 22, 1981	282 accessions
Fall 1981	October 15, 1981	285 accessions
Spring 1982	April 20, 1982	324 accessions
Fall 1982	October 20, 1982	318 accessions
Fall 1984	October 25, 1984	101 accessions

All plantings were periodically evaluated for emergence, stand, seedling vigor, plant uniformity, cover, forage production, ability to spread, and any animal, insect, or disease damage. Evaluations were made using ocular estimates, giving each accession a

Table 1.—Monthly precipitation for Bridger Coal and Dresser Minerals Field Evaluation Plots.

	Bridger Coal				Dresser Minerals			
	1980	1981	1982	1985	1981	1982	1983	1985
	cm	cm	cm	cm	cm	cm	cm	cm
January	3.33*	1.09*	.23	.28	.25*	4.17*	.00*	.30
February	.13*	.46*	.15	.03	1.47*	.30*	.00*	2.54
March	1.50*	.51	2.11	.03	.71*	1.78*	.20*	.58
April	1.04*	.38	.76	.10	1.12*	1.02	.64	.38
May	(6.91*)	1.12	3.58	.76	(7.39*)	2.54	3.18	1.98
June	.15*	.33*	.74		1.09*	5.08	1.78	
July	1.04*	3.02*	3.25		1.09*	1.52	1.02	
August	1.22*	1.80*	.15		2.24*	1.27	.58	
September	.18*	1.45*	4.85		1.45*	6.60	1.32	
October	4.42*	2.06	.41		1.65*	.76	1.32	
November	.46*	.59	.00		.03*	.76	.76	
December	1.19*	.64	.38		1.47*	.76	.94*	
Total	21.57	13.45	16.61		19.96	26.56	11.74	

* Precipitation data from the nearest National Climatic Data Station was substituted for data not available from on-site recorders. Those national recording stations were at Greybull and the Rock Springs airport.

() Unseasonably high precipitation that resulted in excellent germination and survival.

relative rating (1 to 10, with 1 being best). Weeds were not controlled at the Bridger Coal site, but the first two plantings at Dresser Minerals were sprayed to control broadleaf weeds.

RESULTS AND DISCUSSION

Because of dry, windy conditions, unpredictable precipitation, and poor quality soil material, it was highly improbable that any one seeding would be subjected to the optimum conditions for germination and establishment. Of the five plantings at each of the evaluation sites, only one at each site could be considered a success. Other plantings had little or no establishment. The timing and amount of spring moisture was the most important factor affecting germination and establishment (table 1). The successful plantings were the Spring 1980 planting at Bridger Coal (84% accessions emerging) and the Spring 1982 planting at Dresser Minerals (89% accessions emerging). They produced the best initial stands, and have maintained the best stands over the duration of the study. At Bridger Coal, 58% of the accessions are surviving after 5 years; while at Dresser Minerals, 47% remain after 4 years.

The 6.91 cm of precipitation during May 1980 at the Bridger Coal site was sufficient for germination and emergence of the cool-season plants. However, the very dry June (.15 cm ppt.) that followed created extensive crusting of the soil surface, limiting emergence of the later developing, warm-season plants. Upon close inspection, it was found that germination had occurred, but plants were unable to emerge. At the Dresser Minerals site, the 7.39 cm of precipitation during May 1981 resulted in germination of both cool-season and warm-season plants, but the warm-season ones were unable to survive the dry June and July that followed.

The successes in the fall 1984 plantings were strongly correlated to 1985 spring precipitation at the two sites. There was no emergence at Bridger Coal site (.76 cm May ppt.), while at Dresser Minerals site (1.98 cm May ppt.), 50% of the accessions emerged, all of which were cool-season plants.

The climatic conditions of the Red Desert and the Big Horn Basin are not conducive to the establishment of warm-season plants. The higher soil temperatures necessary for germination of warm-season plants does not coincide with the spring precipitation pattern. Only with supplemental irrigation or some moisture retention technique will warm-season plants be established consistently on these cold, desert sites.

The accessions that have exhibited the best overall performance (with stand ratings of 60% or more, and ocular vigor ratings of three or better) at both sites are:

Released Cultivars

- streambank wheatgrass--Sodar
- thickspike wheatgrass--Critana
- Siberian wheatgrass--P-27
- crested wheatgrass--Parkway, Nordan
- western wheatgrass--Rosana
- bluebunch wheatgrass--Secar
- basin wildrye--Magnar
- Russian wildrye--Vinall
- fourwing saltbush--Wytana

Unreleased Accessions

- bottlebrush squirreltail--T5549, T19220, T19219, T19223, T19218
- slender wheatgrass--PI-432403
- Montana wheatgrass--T5203
- needleandthread--T19232, T19234, T19239, T19241, T19248

Sandberg bluegrass—T16282, T19193, T19197, T19198
Gardner saltbush—T5293, T16136, T16134, T19109, T19093
shadscale—T5291, T16127
quackgrass-bluebunch hybrid—T30985, T30986
basin wildrye—T5358, PI-478831
Indian ricegrass—T5432, T16252, T16259
beardless wheatgrass—PI-285272

Some of the accessions performed better at the more southern Bridger Coal site, while others were superior at the northern Dresser Minerals site. Other accessions that have only fair performance (with at least a 30% stand and ocular vigor rating of five or better), but worthy of further consideration on less harsh sites are:

Released Cultivars
altai wildrye—Prairieland
Indian ricegrass—Paloma, Nezpar
sheep fescue—Covar
beardless wheatgrass—Whitmar
big bluegrass—Sherman
green needlegrass—Lodorm

Unreleased Accessions
alkali bluegrass—T16281
plains bluegrass—PI-434231
prairie junegrass—PI-230256
mammoth wildrye—PI-478832

Those accessions that emerged under favorable conditions have since gone through at least three unfavorably dry years. The success of these two good plantings and the relative failure of all other plantings tends to support the use of limited irrigation when spring moisture is inadequate for proper germination, emergence, and establishment. Drought-tolerant plants that emerge under good soil moisture conditions continue to do well during the dry years. However, those plants that managed to emerge under poor soil moisture conditions never established well, and the stands are deteriorating rapidly.

Those plants that did manage to emerge during the dry springs were those that were in microenvironments that received additional moisture, had reduced water loss, or were protected from wind desiccation, e.g., in the bottom of furrows or depressions, beside rocks, or under the canopy of large weeds.

Rabbit damage has been significant at both sites. At Dresser Minerals, the most severely damaged rows were accessions of intermediate wheatgrass, pubescent wheatgrass, Indian ricegrass, and green needlegrass.

As presented above, there are some released cultivars available on the commercial market that can be used for reseeding in arid regions of the Big Horn Basin and Red Desert. Other than Siberian wheatgrass, crested wheatgrass, and Russian wildrye, all the other cultivars are native species originating from arid areas of Oregon, Idaho, and Montana. Efforts are underway to further evaluate the best of the unreleased accessions. Seed from a one-half-hectare field of PI-432403 slender wheatgrass is being distributed for more extensive field testing.

The seed supply is being increased at the Bridger PMC of the best accessions of bottlebrush squirreltail, needleandthread, Sandberg bluegrass, Indian ricegrass, and Gardner saltbush; or, where possible, additional seed is being harvested from the original collection sites. Seed of PI-285272 beardless wheatgrass and PI-478831 basin wildrye has been increased and is already included in several other field evaluation plantings. The quackgrass-bluebunch hybrid is being evaluated by Montana State University, Bozeman, and the Range and Livestock Experiment Station at Miles City, Mont. More ecotypes of shadscale need to be collected before making any selections.

For the species that presently do not have any previously released cultivars, there is a need to develop cultural, management, seed production, and seed processing techniques to insure their public availability and use. Seed of species such as needleandthread and bottlebrush squirreltail are extremely difficult to harvest and process because of their awns. Gardner saltbush can be harvested with conventional farming equipment as readily as 'Wytana' fourwing saltbush (Carlson et al. 1983). Because of the more prostrate growth characteristics of Gardner saltbush, special pickup guards on the swather will help facilitate a more thorough harvest.

As seed supplies of the best accessions are increased, larger replicated plantings will be established at the two trial sites to test compatibility of various accessions in mixtures, and to further evaluate seeding equipment, time of seeding, and stand longevity.

SUMMARY

This plant materials project has identified those released cultivars and new accessions that will establish on coal and bentonite mines. The released cultivars are readily available on the commercial market. Seed of unreleased material is acquired almost exclusively through native seed collectors. Although some is excellent seed, the purity, origin, and viability vary extensively. Native harvesting is also very labor-intensive, sometimes driving the cost of seed to prohibitive levels. The development and release of new cultivars of adapted species will increase the quality and diversity of species for reclamation needed for soil stabilization and stand establishment, as well as for compliance with state reclamation laws.

LITERATURE CITED

Barnes, O. K., R. L. Lang, and A. A. Beetle. 1952. Grass establishment on Wyoming dryland. Wyo. Agricultural Experiment Station. Bulletin 314.
Branson, F. A., R. F. Miller, and I. S. McQueen. 1966. Contour furrowing, pitting, and ripping on rangelands of the western United States. Journal of Range Management 19:182-190.
Carlson, Jack R., John G. Scheetz, and Wendall R. Oaks. 1983. Seed production techniques of two chenopods: Gardner saltbush (*Atriplex gardneri* [Moq.] D. Dietr.) and winterfat (*Eurotia lanata* [Pursh.] Moq.). p. 191-195. *In* Proceedings—

Branson http://dx.doi.org/10.2307/3895644

Symposium on the Biology of Atriplex and Related Chenopods. [Provo, Utah, May 2-6, 1983]. General Technical Report INT-172. Intermountain Forest and Range Experiment Station.

Fisser, H. G., J. T. Nichols, R. W. Hamner, and J. R. Wight. 1963. Summer steer grazing studies on saltsage range (Worland). 6 p. In University of Wyoming Cooperative Research Report to the Bureau of Land Management. Wyo. Agricultural Experiment Station.

Fisser, Herbert G., Michael H. McKay, and James T. Nichols. 1974. Contour-furrowing and seeding of Nuttall saltbush rangelands of Wyoming. Journal of Range Management 27:459-462.

Hemmer, D., S. Johnson, and Ray Beck. 1977. Bentonite mining related reclamation problems in the northwestern states. Mont. Department of State Lands.

Hull, A. C. 1963. Seeding salt-desert shrub ranges in western Wyoming. Journal of Range Management 16:253-258.

McArthur, E. D., A. P. Plummer, J. N. Davis. 1978. Rehabilitation of game range in the salt desert. p. 23-50. In Wyoming shrublands. University of Wyoming, Laramie.

Nichols, James T. 1964. Cover, composition, and production of contour-furrowed and seeded range as compared to native saltsage range. Wyo. Range Management 187:27-38.

Branson http://dx.doi.org/10.2307/3896722

Fisser http://dx.doi.org/10.2307/3895336

Packer, Paul E. 1974. Rehabilitation potentials and limitations of surface-mined land in the northern Great Plains. General Technical Report INT-14. Intermountain Forest and Range Experiment Station.

Rauzi, Frank. 1975. Severe mechanical and chemical range renovation in northeastern Wyoming. Journal of Range Management 28:319-26. http://dx.doi.org/10.2307/3897787

Scheetz, J. G. 1974. Adaptation and performance of drought-tolerant range plants on a desert site. p. 169-172. In Annual Technical Report. USDA Soil Conservation Service, Plant Materials Center, Bridger, Mont.

Soiseth, R. J., J. R. Wight, and J. K. Aase. 1974. Improvement of panspot (Solonetzic) range sites by contour furrowing. Journal of Range Management 27:107-110 http://dx.doi.org/10.2307/3896742

Van Epps, G. A., C. M. McKell. 1980. Revegetation of disturbed sites in the salt-desert range of the Intermountain West. 35 p. Land Rehab. Ser. 5. Utah Agricultural Experiment Station, Logan.

Wight, J. Ross, E. L. Neff, and R. J. Soiseth. 1978. Vegetation response to contour furrowing. Journal of Range Management 31:97-101. http://dx.doi.org/10.2307/3897652