Forage Species Establishment and Productivity on Mined Land

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Abilities of individual species to establish and produce must be considered in selecting species for use in reclamation. Thirty-six forage species were seeded on untreated spoil, on 6 inches of topsoil added to spoil, and on unmined agricultural land. Under all conditions, species usually recommended for dryland seedings provided best stand establishment, had good productivity, and should generally be recommended for spoil bank revegetation.

Introduction and Procedure

In deciding which species to seed in the revegetation of mined lands, one must consider long-term land use objectives, immediate revegetation needs, characteristics of the spoil and replaced surface soil, adaptation and characteristics of the species, and availability of seed. Limitations inherent in the species often are overlooked. For example, reestablishment of the "native" vegetation that existed before mining is an admirable objective, but one that is impossible to attain with present technology. Complexities of the previous ecosystem, coupled with low seedling vigor of most of the species and lack of seed sources for many species, contribute to failure to reestablish the premining vegetative condition. Many of these limitations are inherent within the species.

Which species, then, should be seeded in revegetation projects? For that matter, which species should be seeded when trying to establish any forage stand with a mixture of grasses and/or legumes? Long a major problem in forage management, stand establishment has received considerable research effort. However, data on performance of many species are still not readily available. Thus, some decisions on seeding forages have been made more on intuition than on scientific research results.

In the spring of 1974, we established an exploratory experiment to compare establishment and productivity of some forage species recommended for revegetation projects. Our objectives were preliminary and did not include considerations of spoil characteristics, long-term land use, etc., as listed above.

This study was a cooperative effort between the USDA-Agricultural Research Service, Mandan, USDA-Soil Conservation Service, Bismarck, North Dakota State University, Mandan, and Consolidation Coal Company, Stanton. It was made possible in part by research grants from the Old West Regional Commission (No. 10470016), Environmental Protection Agency (EPA), and the U.S. Forest Service's Surface Environment and Mining Program (SEAM).

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A representative variety from each of 36 species (Table 1) was seeded as a subplot in a split-plot field arrangement with two replications. Main plots were soil treatments and subplots were species. Subplots were 25 feet long and 5 feet wide, with 10 rows spaced 6 inches apart. Seeding rates are shown in Table 2.

An experimental site on the Glenharold Mine near Stanton was leveled to 2 to 3 per cent slope. Fertilizer, 55 lbs/A nitrogen (N) and 103 lbs/A phosphorus (P), was added in the form of 11-48-0 before disking and harrowing. Two replications of the same species were also seeded on agricultural land on the Research Center at Mandan. The species were seeded into a firm seedbed provided by our experimental plot seeder (1). No weed control or other cultural practice was applied after seeding, except removal of dead growth before winter.

Plant count areas about 1 yard long and 6 inches wide were permanently established along one of the center four rows of the plot. Forage samples were harvested from 15 square feet of plot area after most grass species had headed. Forage samples were dried and weeds were removed before oven-dry weight was determined.

Results and Discussion

It rained in the late afternoon and evening just after seeding of the mine spoils was completed in 1974. Another rain was received about one week later. This precipitation resulted in better-than-usual stands for most species seeded in our experiment. In the fall of 1974, most species had higher stand counts where topsoil had been added to spoils than where it had not (Table 2). Except for some-spreading-type species, such as smooth bromegrass, stand counts declined from 1974 to 1976. Spreading species tend to have higher plant counts in later years because the spreading rhizomes of a single plant can establish and appear as another plant. By 1976, average plant count for each group of species was essentially equal on topsoil and untreated spoil plots. Stand counts at Mandan increased for most species between 1975 and 1976 because weed competition decreased as the forage plants gained vigor. Weed competition was considerably less at the mine site than at Mandan.

Even though plant counts declined on topsoil to equal those on untreated spoil, plants remained more vigorous and produced better on topsoil (Table 3). For all groups of species, and for both treatments at the mine site, 1976 yields were considerably less than 1975 yields. This yield decline for 1976 may be attributable to lack of precipitation. Forage yields at Mandan tended to be higher in 1976 than in 1975, because these plots received supplemental irrigation late in the growing season.

When comparing a large number of species, it is easier to discuss general trends of plant establishment and forage yield rather than each individual species. However, the species are listed individually and in detail in the tables for the benefit of the reader. In general, the grasses usually recommended for dryland seeding (wheatgrasses and wildryes) provided the best stands and had the highest forage yields. Smooth bromegrass and alfalfa also produced exceptionally well, but their decrease in productivity on mine plots as compared to agricultural lands was proportionately greater than that of the wheatgrasses. Warm-season species were very difficult to establish and, even once established on spoil material, their survival was poor.

The ability of individual species to establish, survive and produce should be carefully considered when selecting the composition of a species mix for seeding. Some species respond differently to different spoil treatments, and these differences should be considered in view of the reclamation goal desired. Unless seeded under ideal conditions, mixtures containing species performing similar to the warm-season grasses listed in the tables would be less economical than mixtures containing only species with prime ability to establish and produce.

The results presented here are not a basis for far-reaching recommendations, but rather serve as a starting point for learning the differences among species. Considerably more data are needed on response of species to seeding in varying climatic conditions experienced from year to year, on different mining sites, and under different spoil-topsoil combinations. To help us gain more information on the latter point, a study has been initiated to determine several species' response to various depths of topsoil covering high-sodium spoil.

Reference

Barker, R.E., J.J. Bond, and L.G. Zachmeier. 1976. **Equipment for seeding experimental plots of small grains, grasses, and legumes.** Agron. J. 68:141-142.

Table 1. Common names, scientific names, varieties, and seed sources of revegetation study materials.

Common Name	Scientific Name	Variety	Source[1]
Cool-season Grasses			
Wheatgrasses	*Agropyron*		
Montana	*albicans*	ND-316	SCS Bismarck, ND
Fairway	*cristatum*	Parkway	CA Saskatoon, Sask.
Crested	*desertorum*	Nordan	ARS Mandan, ND
Tall	*elongatum*	Orbit	CA Swift Current, Sask.
Intermediate	*intermedium*	"Commercial"	Pri. Co. Bismarck, ND
Pubescent	var. *trichophorum*	Mandan 759	ARS Mandan, ND
Slender	*trachycaulum*	"Native"	Pri. Co. Healy, KS
Streambank	*riparium*	Sodar	Pri. Co. Healy, KS
Western	*smithii*	Mandan 456	ARS Mandan, ND
Wildryes	*Elymus*		
Altai	*angustus*	—	CA Swift Current, Sask.
Canada	*canadensis*	Mandan wildrye	ARS Mandan, ND
Basin	*cinereus*	ND-718	SCS Bismarck, ND
Mammoth	*giganteus*	Volga	ARS Mandan, ND
Russian	*junceus*	Vinall	ARS Mandan, ND
Beardless	*triticoides*	P-15594	SCS Bridger, MT
Miscellaneous Cool-season Grasses			
Creeping foxtail	*Alopecurus arundinaceus*	Garrison	ARS Mandan, ND
Smooth bromegrass	*Bromus inermis*	Mandan 404	ARS Mandan, ND
Prairie sandreed	*Calamovilfa longifolia*	ND-95	SCS Bismarck, ND
Hard fescue	*Festuca ovina* var. *duriuscula*	Durar	SCS Bismarck, ND
Indian ricegrass	*Oryzopsis hymenoides*	Mandan 57-2	ARS Mandan, ND
Nuttail alkaligrass	*Puccinellia nuttalliana*	SD-214	SCS Bismarck, ND
Reed canarygrass	*Phalaris arundinacea*	Castor	CA Beaverlodge, Alta.
Alkali sacaton	*Sporobolus airoides*	ND-264	SCS Bismarck, ND
Green needlegrass	*Stipa viridula*	Lodorm	ARS Mandan, ND
Mandan ricegrass	*X Stiporyzopsis caduca*	Mandan ricegrass	ARS Mandan, ND

Table 1. (Continued)

Common Name	Scientific Name	Variety	Source[1]
Warm-season Grasses			
Big bluestem	*Andropogon gerardi*	NDG-4	SCS Bismarck, ND
Little bluestem	*Andropogon scoparius*	ND-387	SCS Bismarck, ND
Sideoats grama	*Bouteloua curtipendula*	Killdeer	SCS Bismarck, ND
Blue grama	*Bouteloua gracilis*	—	ARS Mandan, ND
Deertongue	*Panicum clandestinum*	NY-1325	SCS Bismarck, ND
Switchgrass	*Panicum virgatum*	Mandan 98	ARS Mandan, ND
Legumes			
Crownvetch	*Coronilla varia*	Emerald	SCS Bismarck, ND
Flatpea	*Lathyrus sylvestris*	Wagner	SCS Bismarck, ND
Birdsfoot trefoil	*Lotus corniculatus*	ND-610	SCS Bismarck, ND
Alfalfa	*Medicago sativa*	Semipalitenske	ARS Mandan, ND
Yellow sweet-clover	*Melilotus officinalis*	Yellow Blossom	Pri. Co. Bismarck, ND

[1]*ARS=Agricultural Research Service*
SCS=Soil Conservation Service
CA=Canada Agriculture
Pri. Co.=Private Company

Table 2. Seeding rates and established plant counts of forage grasses and legumes.

Species	Seeding rate		Untreated Spoil			6 in. Surface Soil			Mandan	
			1974	1975	1976	1974	1975	1976	1975	1976
	lb/A	viable seeds/yd	plants/yd							
Cool-season grasses										
Wheatgrasses										
Steambank	25	183	40.2	30.6	19.2	59.4	37.5	23.8	14.6	21.9
Slender	33	122	48.9	45.7	18.7	73.6	35.7	19.7	30.2	14.6
Crested	22	122	62.6	39.3	15.5	57.5	26.5	16.5	23.3	15.1
Pubescent	36	122	31.1	27.4	12.3	68.6	37.5	15.5	24.2	25.1
Western	37	122	18.7	21.0	10.1	58.5	46.2	15.5	7.8	27.9
Fairway	16	122	27.4	29.7	11.9	48.5	32.5	12.8	16.5	13.3
Montana	37	122	8.7	13.7	17.8	25.1	16.0	12.3	1.8	8.9
Tall	47	122	22.4	18.7	12.3	32.0	30.6	11.9	8.2	7.8
Intermediate	30	122	29.3	26.5	10.5	35.7	28.8	11.0	13.7	16.0
Average			32.1	24.7	14.2	51.0	32.4	13.7	15.6	16.7
Wildryes										
Russian	25	122	56.7	40.7	17.4	59.4	34.3	19.7	20.1	13.7
Altai	42	91	2.7	23.3	0.9	45.7	26.5	14.2	3.7	11.4
Canada	31	122	31.1	26.1	12.3	48.9	26.5	9.6	14.2	9.1
Basin	27	122	11.9	17.4	0.5	46.6	35.2	7.8	0.5	0.0
Beardless	51	122	2.7	5.5	8.2	11.0	4.6	4.1	0.0	7.3
Mammoth	44	91	29.3	22.4	11.4	33.4	8.7	3.2	0.5	0.0
Average			22.4	22.6	8.5	40.8	22.6	9.8	6.5	6.9
Miscellaneous										
Smooth bromegrass	26	122	36.6	38.7	33.4	54.4	42.1	28.8	33.4	120.7
Reed canarygrass	9	81	7.3	3.2	1.8	30.6	15.5	17.4	0.0	17.4
Hard fescue	12	183	0.5	0.0	0.0	31.5	28.3	16.5	0.9	0.9
Green needlegrass	31	122	45.3	38.4	15.1	47.5	31.5	13.7	11.0	7.8
Creeping foxtail	8	183	11.9	17.8	7.8	17.8	15.1	11.0	1.8	18.3
Mandan ricegrass	96	60	37.0	36.6	19.2	27.9	18.3	8.7	16.5	8.7
Nuttall alkaligrass	14	366	42.5	38.9	16.0	23.8	13.7	5.0	2.3	0.0
Prairie sandreed	36	183	6.4	0.0	0.5	17.4	0.9	4.1	0.0	0.0
Indian ricegrass	92	102	63.1	56.7	12.8	54.4	14.6	3.2	0.5	22.9

Table 2. (Continued)

Species	Seeding rate		Untreated Spoil			6 in. Surface Soil			Mandan	
			1974	1975	1976	1974	1975	1976	1975	1976
	lb/A	viable seeds/yd	plants/yd							
Alkali sacaton	7	364	0.5	0.5	0.9	26.5	0.0	3.2	0.0	0.0
Average			25.1	23.1	10.8	33.2	18.0	11.2	6.6	19.7
Warm-season grasses										
Blue grama	25	366	1.4	10.5	1.4	16.5	0.5	5.0	4.1	8.2
Sideoats grama	6	174	11.0	6.9	3.7	27.0	10.1	4.6	11.9	11.4
Deertongue	51	183	6.4	10.5	3.7	7.3	4.6	2.3	1.4	0.5
Big bluestem	26	122	6.4	10.1	5.9	31.1	0.5	1.4	4.1	6.9
Little bluestem	53	183	2.3	7.3	3.7	1.8	0.5	0.5	0.0	4.1
Switchgrass	14	183	26.5	0.0	0.0	32.5	0.0	0.5	0.0	11.4
Average			9.0	7.6	3.1	19.4	2.7	2.4	3.6	7.1
Legumes										
Alfalfa	14	122	7.3	4.6	6.4	14.2	7.8	5.0	14.2	11.0
Crownvetch	36	122	0.5	5.5	0.9	13.7	0.0	4.1	0.5	8.2
Sweetclover	20	122	13.7	5.9	2.3	21.0	10.1	2.3	16.9	0.0
Flatpea	48	20	0.9	0.0	0.0	5.5	0.0	0.9	0.5	0.0
Birdsfoot trefoil	12	122	15.5	1.8	4.1	22.4	0.0	0.5	26.1	11.9
Average			7.6	3.6	2.7	15.4	3.6	2.6	12.5	6.2

Table 3. Dry matter yields of forage grasses and legumes.

Species	Untreated Spoil			6 in. Surface Soil			Mandan		
	1975	1976	Ave.	1975	1976	Ave.	1975	1976	Ave.
Cool-season Grasses									
Wheatgrasses									
Slender	1.11	.27	.69	2.39	.93	1.66	1.44	2.14	1.79
Crested	.63	.08	.35	1.70	1.00	1.35	1.34	2.64	1.99
Fairway	.90	.30	.60	1.77	.30	1.04	1.18	2.31	1.74
Intermediate	.90	.27	.59	1.18	.61	.89	1.53	2.17	1.85
Pubescent	1.13	.16	.64	1.04	.49	.76	2.00	3.29	2.64
Tall	.59	.23	.41	.91	.43	.67	.37	1.66	1.01
Streambank	.54	.13	.34	.95	.34	.65	.33	1.04	.68
Western	.21	.10	.15	.42	.70	.56	.15	1.00	.57
Montana	.04	.10	.07	.21	.22	.22	.05	.26	.16
Average	.67	.18	.43	1.17	.56	.87	.93	1.83	1.38
Wildryes									
Canada	.42	.15	.29	1.09	.63	.88	.69	2.79	1.74
Russian	.28	.17	.23	.66	.21	.43	.09	1.14	.62
Altai	.35	.31	.33	.50	.36	.43	.00	.02	.01
Basin	.19	.08	.13	.36	.15	.26	.00	.00	.00
Mammoth	.13	.08	.11	.07	.08	.08	.00	.04	.02
Beardless	.00	.06	.03	.00	.11	.06	.00	.10	.05
Average	.23	.14	.19	.45	.26	.36	.13	.68	.41
Miscellaneous									
Smooth bromegrass	.62	.15	.39	1.18	.30	.74	.68	2.11	1.40
Nuttall alkaligrass	.84	.14	.49	.82	.21	.52	.06	.00	.03
Creeping foxtail	.18	.06	.12	.65	.27	.46	.03	.46	.25
Green needlegrass	.16	.12	.14	.40	.30	.35	.20	1.08	.64
Hard fescue	.01	.05	.03	.22	.24	.23	.02	.98	.50
Mandan ricegrass	.10	.07	.09	.30	.13	.21	.06	.10	.08
Reed canarygrass	.02	.10	.06	.20	.08	.14	.02	.12	.07
Indian ricegrass	.03	.04	.04	.00	.08	.04	.00	.02	.01
Alkali sacaton	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 3. (Continued)

Species	Untreated Spoil 1975	Untreated Spoil 1976	Untreated Spoil Ave.	6 in. Surface Soil 1975	6 in. Surface Soil 1976	6 in. Surface Soil Ave.	Mandan 1975	Mandan 1976	Mandan Ave.
Prairie sandreed	.00	.00	.00	.00	.00	.00	.00	.05	.03
Average	.20	.07	.14	.38	.16	.27	.11	.49	.30
Warm-season Grasses									
Sideoats grama	.00	.00	.00	.00	.06	.03	.00	.05	.02
Big bluestem	.00	.00	.00	.00	.05	.02	.00	.02	.01
Switchgrass	.00	.00	.00	.05	.00	.02	.00	.06	.03
Deerstongue	.00	.00	.00	.01	.00	.01	.00	.01	.00
Little bluestem	.00	.02	.01	.00	.00	.00	.00	.00	.00
Blue grama	.00	.00	.00	.00	.00	.00	.00	.02	.01
Average	.00	.00	.00	.01	.02	.01	.00	.03	.01
Legumes									
Birdsfoot trefoil	.00	.10	.05	.23	.96	.60	1.09	2.44	1.77
Alfalfa	.09	.30	.20	.60	.54	.57	2.45	2.53	2.49
Sweetclover	.47	.00	.23	1.02	.00	.51	3.76	.06	1.91
Flatpea	.00	.00	.00	.00	.00	.00	.00	.01	.00
Crownvetch	.00	.00	.00	.00	.00	.00	.00	.85	.42
Average	.11	.08	.10	.37	.30	.34	1.46	1.18	1.32