SHRUB REESTABLISHMENT IN THE MOUNTAIN SHRUB ZONE[1]

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Abstract.--Reestablishing shrubs for deer and elk habitat is a major reclamation objective on mining disturbances in the mountain shrub zone of western Colorado. In this zone, precipitation is generally favorable for establishment of grass which outcompetes shrub seedlings. Research and ongoing reclamation indicate that shrub seedlings can be established when grass competition is controlled.

INTRODUCTION

Mountain shrub is the dominant vegetation type on areas being surface mined for coal in northwest Colorado. Other land disturbances in this vegetation zone are by agriculture, development for oil and gas production, and potentially, for oil shale development. The shrubs, locally dominated by serviceberry but including Gambel oak, chokecherry, big sagebrush, snowberry, and rose are of major importance to deer and elk as food and cover.

The mountain shrub type in northwest Colorado is at elevations of 6500 to 8200 ft. (2000 to 2500 m). Below 6500 ft. big sagebrush is usually the visually dominant vegetation. As elevation increases a mosiac of patches of big sagebrush and patches of serviceberry occur. As elevation increases further, the vegetation is dominated by serviceberry and oak which attain heights of 10 to 15 ft. At about 8200 ft., aspen, Douglas fir, and lodgepole pine become dominant.

Average annual precipitation in the mountain shrub zone is 16 to 22 in. (40 to 56 cm), about half of this is snow. Soils are usually deep and dark with loamy surfaces and clayey subsoils. Parent materials in the coal-producing areas are soft shales and sandstones of the Cretaceous-age Mesa Verde group. The predominant soil is the Work series (fine montmorillonitic Typic Argiboroll).

The objectives of this paper are: 1) to present research findings on shrub reestablishment after 9 to 11 growing seasons in the mountain shrub zone, 2) outline reclamation practices and report preliminary results for shrub reestablishment on a surface coal mine in the mountain shrub zone.

SHRUB REESTABLISHMENT RESEARCH

Revegetation research was started in the summer of 1975 on an 18% north-facing slope at an elevation of 7400 ft (2,250 m). The site is on the Colowyo Cosl Mine which is on the west side of Colorado Highway 13, midway between Craig and Meeker. The site was prepared by pushing off the brush, then stripping off 1 to 2 in. of soil to remove roots, rhizomes and sod. After the stripping operations, the top foot of soil was mixed by removing the soil and then redistributing it back over the research area. The site was fenced to exclude deer, elk and rodents.

Direct Seeding Shrubs

A direct-seeding study was established in the fall of 1975 with shrub seed collected from adjacent stands, with the exception of bitterbrush. Acorns were stored at 2° C to inhibit worm damage prior to seeding. The study

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was a comparison of shrub survival and growth when a mixture of shrubs (bitterbrush 1/2 lb/a = 0.1 seed/ft^2, oak 1 acorn/20 ft^2, serviceberry 1 lb/acre = 1 seed/ft^2, and snowberry 1/2 lb/a = 0.6 seed/ft^2) were seeded alone as compared to seeding the shrubs with grass and forbs. The grasses and forbs were slender wheatgrass 10 lb/a, smooth brome 10 lb/a, penstemon mix 2 lb/a, and Utah sweetvetch 2 lb/a. Seed was hand broadcast on freshly chiseled soil in October and then the soil was lightly raked. Three replications were used in this study. Individual plots were 10 x 20 ft.

The number of shrubs established from seed was nearly an order of magnitude greater where shrubs only were seeded as compared to where a mixture of shrubs, grasses, and forbs were seeded (Table 1). In August of 1976, foliar cover on the shrubs-seeded only treatment was 60%, largely by volunteer broadleaf annuals. Foliar cover on the plots seeded to shrubs + herbaceous species was 75%, largely by slender wheatgrass. On 14 July 1977, foliar cover was 37% (mostly annuals) on the shrub-seeded only treatments and 68% (mostly grass) on the treatments where shrubs, grasses and forbs were seeded. By July 1986, smooth brome had invaded and was the dominant species on all treatments. Despite grass invasion, many more shrubs were present after 11 years on treatments where grass was not initially seeded (Table 1).

Direct seeded serviceberry and snowberry were small after 11 growing seasons (Table 1). Bitterbrush and big sagebrush were considerably taller. In an adjacent nursery the same seed sources were also seeded in 1975 in pure stands and then maintained weed-free the first 4 growing seasons. Here, the mean height of serviceberry was 30 in., snowberry 16 in. and bitterbrush 35 in. after 11 growing seasons.

Another direct seeding shrub study was initiated on an area that had been seeded to grass in 1975 and supported a foliar cover of 63% grass in August 1977. The soil was rototilled and seeded on 28 September 1977. The shrubs seeded were serviceberry 2 lb/a, snowberry 1 lb/a, bitterbrush 1 lb/a, oak 1 acorn/10 ft^2, chokecherry 2 lb/a (0.2 seed/ft^2) and rose 1 lb/a (1 seed/ft^2). Birds were observed eating emerging chokecherry seedlings in the spring of 1978. From 1978 through 1986 these plots supported a moderate (about 50% foliar cover) stand of slender wheatgrass and smooth brome. In the ninth growing seasons (1986) the shrub density was 1280 serviceberry/a, 640 snowberry/a, 140 rose/a, 1100 big sagebrush/a (volunteer), 20 bitterbrush/a and no chokecherry or oak. Average height after 9 growing seasons was serviceberry 6 in., snowberry 5 in., rose 10 in., big sagebrush 9 in. and bitterbrush 12 in.

In summary, these direct seeding studies indicate that stands of some shrub species (e.g. serviceberry and snowberry) can be established if grass competition during the first growing season is nil (1975 study) or moderate (1977 study). However, these shrubs are still very small after 9 to 11 growing seasons. Oak and chokecherry were not established by direct seeding in these studies.

Table 1. Number of shrubs present 1, 2, and 11 growing seasons after seeding as affected by seed mixture.

	Seed Mixture and Growing Season						
	Shrubs + herbaceous species			shrubs only			
	1st	2nd	11th	1st	2nd	11th	11th Season mean ht.
Seeded Shrubs	number of shrubs/acre						--- in. ---
Bitterbrush	800	230	20	6,400	2,700	400	22
Oak	0	0	0	270	9	0	--
Serviceberry	2,700	450	40	11,400	3,200	770	8
Snowberry	0	450	0	300	680	230	4
Total	3,500	1,130	60	18,370	6,589	1,400	
Volunteer Shrub							
Big sagebrush	2,700	1,360	860	12,800	6,800	3,600	20

Transplanting Seedling Shrubs

Shrub seedlings were transplanted in the spring of 1976, 1977, and 1978. Both bare-root and containerized seedlings were planted. Most of these seedlings were purchased from commercial growers. In general, the bare-root stock was dormant and the containerized stock in leaf when planted. Each seedling was watered with about one liter of water when planted.

Overall survival of planted seedlings was 8% after 9 to 11 growing seasons. Survival on bare root stock was 7% (598 planted, 43 survived). Survival on containerized stock was 8% (873 planted, 73 survived). On shrubs of major interest, survival was fair (21%) on chokecherry, low (6%) on serviceberry and nearly nil on oak (Table 2). Grass growing in these plantings ranged from none to abundant the first growing season. Grass, predominately smooth brome, was present in moderate to abundant amounts in all plantings by 1986. Mean height of serviceberry and chokecherry was 15 in. after 9 to 10 growing seasons. Comparable heights were reported for these species 10 years after planting in the Black Hills (Dietz et al., 1980).

Table 2. Seedling shrub transplant survival and height after 2 and 9 to 11 growing seasons.

Species	Number planted	Survival 2 seasons	Survival 9-11 seasons	Height after 9-11 seasons range	Height after 9-11 seasons mean
		%	%	in.	in.
Chokecherry	300	35	21	4-35	15
Oak	350	19	0.3	--	3
Serviceberry	510	23	6	4-50	15

Mature Shrub Transplants

Clumps of mature serviceberry, oak, chokecherry and snowberry were individually dug and transplanted into the revegetation test plot. A backhoe with a 30 in. bucket used for transplanting extracted a root ball about 24 in. in diameter and 20 in. deep. All shrubs were pruned so 6 in. or less of stem remained.

Survival of the mature transplants after 10 to 11 growing seasons was high for serviceberry and snowberry, low on chokecherry, and nil on oak (Table 3). Watering when transplanting had no effect on survival. Use of a slow release fertilizer (1 lb magnesium ammonium phosphate/shrub) was detrimental to survival of transplanted serviceberry. Time of pruning apparently had little effect upon survival or growth of spring transplanted serviceberry.

Much larger-scale front-end loader transplanting of mature mountain shrubs has resulted in an overall survival one to 5 years after transplanting of 85% for serviceberry, 37% for oak, and 88% for chokecherry (Carlson et

Table 3. Survival and size of mature shrub transplants in research planting.

Transplanting Date Species Treatments	Number of Transplants	Number of surviving transplants 1976	1977	1978	1979	1986	1986 measurements on survivors, ave. Spread	Height
							in.	
1975, 27 Oct.								
Oak	15	15	14	0	0	0	--	--
Serviceberry								
No fertilizer	15	15	15	15	14	13	56	39
MgAmp	15	15	14	13	11	8	38	32
Snowberry	15	15	15	15	15	15	25	45
1976, 26 May								
Serviceberry								
fall pruned	15	15	15	15	15	13	66	36
spring pruned	14	14	14	14	14	13	55	39
1976, 2 Nov.								
Oak	15	--	15	0	0	0	--	--
Serviceberry	15	--	15	15	15	14	55	40

al., 1982; Crofts and Carlson, 1982). Plummer et al. (1968) rated ease of transplanting serviceberry as fair, oak as very poor, chokecherry as fair, and snowberry as very good.

MINE PROGRAM FOR SHRUB REESTABLISHMENT

The purpose of this section is to address Colowyo Coal company's reclamation practices to reestablish shrub densities to meet state criteria for bond release.

Background

Mining started at the Colowyo surface mine in early 1977. The first large-scale reclamation planting was in the fall of 1978 on the 3:1 slope of the Streeter Canyon valley fill. After regrading spoil, approximately 18 in. of topsoil was spread by scrapers, hay mulched, chiseled, and drill seeded with a mixture of 17 grass, 10 forb, and 5 shrub species.

The next spring (1979), 3540 seedling shrubs were planted onto the reclaimed slope. Subsequent shrub plantings were made in 1980 and 1981 for a total of 18,700 transplants.

The seeding was a success in establishing herbaceous cover, dominated by wheatgrasses and smooth brome, to control erosion. However, overall shrub survival was only 7% when a complete shrub count on the 21 acre site was made in August 1983 (Table 4). All shrubs counted were considered to be transplants, although the possibility exists that some of the shrubs were established from drill seeding, or seed and vegetative materials in the topsoil. This survival data (Table 4), therefore, contains an inherent error which would favor a higher shrub transplant survival rate.

Table 4. Survival after 2 to 5 growing seasons of seedlings planted on 21 acre valley fill.

Species	Total Planted 1979-1981	Survival Aug. 1983
		----%----
Bitterbrush	3,200	1.6
Chokecherry	3,950	7.9
Oak	1,460	4.7
Rose	3,270	19.8
Serviceberry	3,990	1.3
Skunkbush	450	0
Snowberry	2,410	7.9

Generally, the surviving shrubs exhibited limited growth and low vigor. Many of the shrubs were no larger than when planted. The low survival and vigor was attributed to competition from wheatgrasses and smooth brome, and from depredation by deer and elk.

During the time that these Colowyo shrub plantings were being monitored, the shrub reestablishment research plots (1st section in this paper) were also being monitored by Colowyo personnel. It became apparent that efforts to establish shrubs by seeding with grasses or by planting seedlings in vegetation dominated by grasses would not meet the required success criteria within the minimum time period.

Coincidently, a shrub density standard for the Colowyo permit was being negotiated between the Colorado Division of Wildlife, Colorado Mined Land Reclamation Division, and Colowyo Coal Company. The Colorado Division of Wildlife recognized that in this particular region returning shrubs to their overall pre-mining densities is less desirable than reestablishing shrubs in clumps.

Based on recommendations of the Colorado Division of Wildlife, the lack of success in establishing shrubs by seeding with grasses or transplanting seedlings subject to grass competition in the research plots, the previous Colowyo mine reclamation, and reclamation efforts at other northwest Colorado mines (Crofts and Carlson 1982; K. A. Crofts, personal communication on shrub establishment by direct-hauling topsoil), the following shrub density standard has been established for the Colowyo Mine:

1. The shrub density standard for the mine has been set at 1,000 stems per acre for all portions of the reclaimed area. Perimeter areas which are steeper than 5:1 and are adjacent to undisturbed, native areas will have no density standard requirement. No density standard will be applied to these perimeter slopes due to the fact that shrub cover is provided by the adjacent undisturbed habitat.

2. Of the remaining areas, a minimum of 20% will be set aside as shrub establishment areas. The areas selected are generally 2 to 5 acres in size with less than 5% slopes. Within these areas, one or more of the following techniques will be used to establish shrubs:

   (a) Direct-hauled topsoil will be used, with emphasis on placing 6 in. of topsoil on the reclaimed surface.

(b) A shrub and forb seed mixture (Table 5) has been developed for these areas. The mixture contains no grasses and is hand broadcast onto these areas after seed bed preparation. The seed bed is first fertilized with 75 to 100 lbs. P_2O_5/acre, chisel plowed, and then contour furrowed.

(c) Containerized tube pack and bare root shrubs will be transplanted onto these areas. Approximately 6 to 10 species, primarily natives to the area, will be planted. It is anticipated that since grass is not planted into these areas the shrubs will have more opportunity to become established.

(d) Some mature shrubs will be transplanted in clumps within the shrub establishment areas. This technique has proven to be very expensive due to the 2 mile haul from the borrow area to the transplant sites. However, this technique shows merit in providing "instant" cover for wildlife.

Table 5. Seed mixture for shrub reestablishment areas.

Shrubs	Seeding rate lb pls/acre
Big sagebrush	1/32
Bitterbrush	1/2
Fourwing saltbush	1
Rose	1/4
Serviceberry	1/2
Snowberry	1/4
Half Shrubs	
Fringed sagebrush	1/32
Louisiana sagebrush	1/32
Winterfat	1/2
Forbs	
Cicer milkvetch	1
Lewis flax	1/4
Palmer penstemon	1/8
Rocky Mtn. penstemon	1/4
Yarrow	1/16
Total	5

Preliminary Results

The shrub establishment techniques were initiated during the 1985 field season, which was also the first year that more than just a few acres of area with 5:1 or flatter slopes were reclaimed. The following summaries describe some of the sampling techniques and data collected. Since this is only the second growing season the data must be regarded as preliminary.

Seeded and Seedling Shrub Transplant Areas

A total of ten acres was seeded to the shrub and forb mixture (Table 5) in the fall of 1985. In addition, 11,000 containerized seedlings were planted within the 10 acres. These seedlings consisted of 1000 bitterbrush, 1000 chokecherry, 1000 fourwing saltbush, 1500 fringed sage, 1000 oak, 1500 rose, 2000 serviceberry, and 2000 snowberry. In late July 1986, 35 belt transects (each 3 x 100 ft) were randomly made within these areas to determine the number of living shrub seedlings (Table 6). Long-term sampling will be necessary to determine the success of these plantings.

Table 6. Number of shrub seedlings in July 1986 on mined area seeded and planted to shrubs the preceeding fall.

Species	Stems/acre
Big sagebrush (volunteer)	30
Bitterbrush	27
Chokecherry	60
Fringed sagebrush	3,980
Fourwing saltbush	38
Oak	73
Louisiana sagebrush	17
Rose	128
Serviceberry	171
Snowberry	134

Mature Shrub Transplant Areas

Unpruned mature shrubs transplanted as a pad with a front-end loader in late 1984 and early 1985 had good survival of serviceberry and snowberry (table 7). Permanent 3 ft wide belt transects have been established in these plantings. Data are collected which compares live and dead stems, by species, on a year-to-year basis. The emphasis is to monitor the expected mortality of mature stems in the early years and later the basal sprouting as the transplants reestablish in the reclaimed areas.

Table 7. Live stems during the first and second growing season within pads of mature shrubs transplanted into reclaimed areas.

Species	Sampling Date			
	June 1985	Aug. 1985	June 1986	Aug. 1986
	stems/acre			
Big sagebrush	377	274	207	602
Chokecherry	775	319	463	360
Oak	74	31	42	10
Rabbitbrush	219	47	0	0
Rose	0	2	17	0
Serviceberry	5040	4090	5760	5290
Snowberry	6190	3170	3600	5250

SUMMARY

Establishment and growth of shrub seedlings is severely limited by competition from grass in the mountain shrub zone. The current reclamation program at the Colowyo mine is to intensively manage to establish shrubs on 2 to 5 acre parcels within 20% of the reclaimed areas with 5:1 slopes or flatter. Intensive management for shrub establiahment includes: direct-hauling topsoil, seeding with a shrub and forb mixture, planting shrub seedlings, and transplanting a limited amount of mature shrubs. Grasses are not seeded within the shrub establishment parcels.

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SCIENTIFIC NAMES OF PLANT SPECIES

Aspen	*Populus tremuloides*
Big sagebrush	*Artemisia tridentata*
Bitterbrush	*Purshia tridentata*
Chokecherry	*Prunus virginiana*
Cicer milkvetch	*Astragalus cicer*
Douglas fir	*Pseudotsuga menziesii*
Fourwing saltbush	*Atriplex canescens*
Fringed sagebrush	*Artemisia frigida*
Gambel oak	*Quercus gambelii*
Lewis flax	*Linum lewisii*
Lodgepole pine	*Pinus contorta*
Louisiana sagebrush	*Artemisia ludoviciana*
Palmer penstemon	*Penstemon palmeri*
Rabbitbrush	*Chrysothamnus nauseosus*
Rocky Mtn. penstemon	*Penstemon strictus*
Rose	*Rosa woodsii*
Serviceberry	*Amelanchier alnifolia*
Skunkbush	*Rhus trilobata*
Slender wheatgrass	*Agropyron trachycaulum*
Smooth brome	*Bromus inermis*
Snowberry	*Symphoricarpos oreophilus*
Winterfat	*Ceratoides lanata*
Utah sweetvetch	*Hedysarum boreale*
Yarrow	*Achillea lanulosa*