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EVALUATION OF WILDLIFE RESPONSE TO A RETAINED MINE HIGHWALL IN SOUTH CENTRAL WYOMING

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Abstract.—From 1984 through 1985 a study was made of the influence of a retained mine highwall on a wildlife community in south central Wyoming. Vegetation species richness and diversity were greater near the highwall compared with two adjacent sites 150 m in front of and behind the highwall. However, vegetation abundance (cover) was greater on the two adjacent sites. Small mammal abundance, richness, and diversity were greater on the highwall than on the two adjacent sites. Male bird abundance, richness, and diversity were greatest in front of the highwall (+50 m to +350 m) compared with the highwall and the area behind the highwall.

Current reclamation law mandates that operators reestablish the approximate original contour of mined lands (Surface Mining Control and Reclamation Act [SMCRA] 1977). Unless otherwise approved, operators are legally bound to regrade rills and gullies over 15.25 cm deep, fill surface depressions, and spread topsoil evenly on all affected lands. These practices result in a moderated topography with only the macrocontours restored (Tessman, Wyoming Game and Fish Department, personal communication). However, wildlife biologists recognize that such conditions may be insufficient to fulfill certain wildlife requirements including cover, shelter, and food. Therefore, some biologists now recommend regrading affected areas into minor hills and undulations sufficient to provide visual barriers, escape corridors, and increased habitat diversity. One reclamation alternative is the permanent retention of a final highwall. As mentioned above, SMCRA presently requires highwalls to be backfilled and leveled. In certain instances, raptors (especially Golden Eagles [*Aquila chrysaetos*] and Redtailed Hawks [*Buteo jamaicensis*]) have constructed nests on highwalls before reclamation was initiated (Fala et al. 1982). This may indicate that highwalls could improve wildlife habitation of an otherwise flat, homogeneous surface.

Considering this potential, the U.S. Office of Surface Mining (OSM) approved (13 May 1983) a variance request by Arch Mineral Corporation to leave a highwall segment on reclaimed surfaces near Hanna, Wyoming. This proposal was closely coordinated with the U.S. Fish and Wildlife Service and Wyoming Game and Fish Department and had the concurrence of both agencies.

The objective of the variance was to develop a study comparing wildlife use of the highwall with that of conventional reclamation from 1983 through 1985.

Study Area

The highwall variance is located in south central Wyoming, 40 km east of Rawlins, Wyoming, and 16 km west of Hanna, Wyoming. This area, referred to as the Hanna basin, ranges in elevation from approximately 1,900 to 2,400 m. Vegetation is typical of the high, semiarid plains where sagebrush (*Artemisia* spp.) and grassland communities dominate. Greasewood (*Sarcobatus* spp.) prevails within ephemeral drainages (Fala et al. 1985). Grassland vegetation in the area includes *Artemisia* spp., *Chrysothamnus* spp., *Koeleria* spp., *Agropyron* spp., *Stipa* spp., and *Carex* spp. Sagebrush communities are composed of *Artemisia* spp., *Chrysothamnus* spp., *Atriplex* spp., *Sarcobatus* spp., *Agropyron* spp., *Poa* spp., *Sitanion* spp., *Carex* spp., *Hordeum* spp., *Elymus* spp., *Juncus* spp., *Oryzopsis* spp., and *Bromus* spp. Topography is gentle with dissecting drainage patterns and numerous rock outcrops. Winds are predominantly west to southwest. Occasional upslope winds from the south or east occur during winter.

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Highwall History

The area in which the highwall now exists was first mined from December 1977 to January 1978. The original highwall was approximately 30 m high and 1,000 m long. Reclamation began in June 1981, and the area was backfilled and regraded by June 1982. Because the highwall variance had not been approved by Wyoming's Department of Environmental Quality (DEQ) or the OSM, no topsoil was applied. On 4 March 1983 the DEQ officially approved the highwall variance, and on 13 May 1983 the OSM concurred. Topsoil was applied in June 1983. Disking, mulching, and seeding were completed the last week of October 1983.

The resulting highwall is approximately 10 m tall at the highest point and 425 m long. The general aspect is 196 degrees (south). Parent material is sandstone. The nearest natural cliffs are 2.7 km east and 4.2 km north.

The area in front of the highwall (south) gently slopes at a rise of 10 degrees in 158 m to the top of a contoured ridge. Immediately to the back side (north) of the highwall is a spoil bank 100 m long and 9 m high with a 25-degree embankment. North of the spoil bank is a contoured ridge that slopes at 6.5 degrees and extends the entire highwall length. Fourteen rockpiles have been placed in the highwall area. Ten of these are located along the base of the highwall. The remaining four rockpiles are dispersed on the upslope to the south. The farthest rockpile is 122 m south. The nearest undisturbed, contiguous sagebrush-grassland habitat is 75 m southwest of the highwall. Small patches of undisturbed vegetation occur in the rimrock 100 m north of the highwall. General drainage flows to the base of the highwall then westward.

The area south of the highwall was seeded in October 1983, and the area to the north was seeded in 1982. Seed was applied using both broadcast and drill methods. Seed that was drilled south of the highwall included (in kg/ha) western wheatgrass (*Agropyron smithii*) (3.93), thickspike wheatgrass (*Agropyron dasystachyum*) (3.93), slender wheatgrass (*Agropyron trachycaulum*) (2.24), bluebunch wheatgrass (*Agropyron spicatum*) (3.37), Indian ricegrass (*Oryzopsis hymenoides*) (1.12), and basin wild-rye (*Elymus* spp.) (1.68). Seed that was broadcast included winterfat (*Ceratoides lanta*) (0.56), rubber rabbitbrush (*Chrysothamnus* spp.) (0.28), and big sagebrush (*Artemisia tridentata*) (0.28). The area to the north was seeded with the same mixtures except that intermediate wheatgrass (*Agropyron* spp.) was substituted for bluebunch wheatgrass.

The area south of the highwall has also had some supplemental seeding. Twenty-three kilograms of sagebrush seed was hand-broadcast along the base and north-facing slope of the highwall. Also, 11 kg each of rabbitbrush and winterfat was broadcast in front of the highwall area.

METHODS

Small mammals were trapped 31 July–2 August 1984 and 28–30 July 1985. The sample design included three pairs of transects, each 210 m long. One pair (nos. 1 and 2) was 150 m in front of the highwall, another pair (nos. 5 and 6) was 150 m behind the highwall, and the third pair (nos. 3 and 4) was directly on the highwall. The pair on the highwall included one transect (no. 3) at the base and another (no. 4) at the top. When highwall ledges were present, traps of transect 3 were placed on the lower half of the highwall face. Similarly, traps of transect 4 were placed on the upper half of the highwall face. Eight trap stations were located at 30-m intervals. Each trap station included two aluminum box traps ($23 \times 9 \times 8$ cm) and two wire mesh traps ($48 \times 15 \times 15$ cm). One of each trap type was baited with sunflower seeds and the other with rolled oats. Traps were left open, baited for three consecutive nights, and checked twice daily—once in the morning (after sunrise) and once in the evening. Each small mammal captured was identified by species, age, and sex; it was then uniquely fur clipped and released. Small mammal abundance (number of newly captured small mammals), species richness (number of species), and species diversity [Shannon-Weiner function (Krebs 1978:455)] were determined for each transect pair.

Birds were sampled from the last week of May through 16 June each summer. One week prior to the sampling period, six 400-m transects were staked out on the study area. Three transects were located in front of the highwall and three behind it at distances of 50 m, 150 m, and 250 m. Wooden stakes were spaced at 100-m intervals along each transect, creating a 400 × 500-m grid. Bird transects were walked once a week for three consecutive weeks in the morning before 1000 hours. Locations of male birds (singing or calling) were plotted on a mylar sheet overlaid upon a schematic drawing of the area. The use of singing or calling males to estimate bird numbers is suited to territorial, noncolonial species (Bull 1981). This index has been used to make comparisons of bird use between areas or between years on the same area. After the field season each mylar sheet was overlaid with a scaled grid (700 × 500 m). All sightings were plotted on the grid, estimated to the nearest meter. Each bird was assigned to one of five quadrats. Quadrats 2 and 6 extended 150 m to 250 m in front of and behind the highwall face, respectively; quadrats 3 and 5 were 50 m to 150 m in front of and behind the highwall face, respectively; and quadrat 4 extended from 50 m in front of to 50 m behind the highwall face. Male bird abundance (total number of male birds counted), species richness (number of species), and species diversity [Shannon-Weiner function (Krebs 1978: 455)] were determined for each quadrat.

Vegetation was sampled at each small mammal trapping station. A 1-m^2 sampling frame partitioned by 25 evenly spaced points was randomly placed. The substrate directly under each of the 25 points was recorded. Soil was recorded as bare ground and vegetation was recorded by species. Vegetation abundance (number of plants counted) was tallied within each transect. Percentages of grasses, forbs, shrubs, and bare ground were calculated within each transect. Vegetation abundance, species richness (number of plant species), and species diversity [Shannon-Weiner function (Krebs 1978:455)] were determined for each transect pair.

RESULTS

Small mammal abundance and diversity were greatest on transect pair 3 and 4 compared with transect pairs 1 and 2, and 5 and 6 (Table 1). However, species richness was similar on all three transect pairs in 1984 and only slightly higher on transect pair 3 and 4 in 1985. Deer mice (*Peromyscus maniculatus*) were twice as abundant on transect pair 3 and 4 compared with transect pair 1 and 2, and 1.5 times more abundant compared with transect pair 5 and 6 (Table 2). Only one least chipmunk (*Eutamias minimus*) was captured each year. This species is diurnal and not susceptible to night trapping. Many were observed near transect pair 3 and 4, while none was observed near transect pairs 1 and 2, and 5 and 6.

On three occasions in 1984 and 1985 during small mammal trapping, a total of four pronghorned antelope (*Antilocapra americana*) were observed at the base of the highwall feeding or drinking from an intermittent pond that formed after heavy rainstorms. Numerous (~100) striped skunk (*Mephitis mephitis*) scats were found under three of the rockpiles, indicating use for cover.

Male bird abundance was generally greatest in front of the highwall on quadrats 2, 3, and 4 (Table 3). Species richness and species diversity were consistently greatest in quadrat 3, decreasing in quadrats 2, 4, 5, 6, respectively. Interestingly, a species composition shift appeared to occur from quadrat 2

TABLE 1. Average small mammal characteristics from 1984 and 1985.

	Transect pairs		
	1 and 2	3 and 4	5 and 6
Abundance	19.5	45.0	28.5
Richness	2.0	3.5	2.5
Diversity	0.12	0.18	0.13

TABLE 2. Small mammal species captured in 1984 and 1985. Numbers in parentheses represent 1985.

	Transect pairs		
Species	1 and 2	3 and 4	5 and 6
Deer mouse	17 (19)	36 (45)	19 (34)
Bushy-tailed woodrat		4 (1)	
Least chipmunk		1 (1)	
Silky pocket mouse			1 (2)
Striped skunk	0 (2)	0 (2)	1 (0)
White-tailed jackrabbit	1 (0)		

TABLE 3. Average male bird characteristics for 1984 and 1985.

	Quadrat number				
	2	3	4	5	6
Abundance	12.0	12.0	10.5	8.0	10.0
Richness	4.0	6.5	3.5	2.0	1.5
Diversity	0.47	0.75	0.42	0.16	0.05

TABLE 4. Male bird species observed in 1984 and 1985. Numbers in parentheses represent 1985.

Species	Quadrat number				
	2	3	4	5	6
Horned Lark	5 (9)	2 (2)	3 (8)	7 (7)	4 (15)
Mourning Dove	3 (2)	4 (1)	0 (1)	1 (0)	
Rock Wren	1 (0)	1 (3)	3 (4)		
Says Phoebe	1 (0)	3 (1)			
American Kestrel		1 (0)			
Brewer's Sparrow		0 (2)			
Mountain Bluebird	0 (2)	0 (1)	0 (1)	0 (1)	0 (1)
Brewer's Blackbird		0 (2)			
Sage Thrasher		0 (1)			
Violet-green Swallow		0 (1)			
Northern Harrier			0 (1)		

TABLE 5. Vegetation characteristics for transect pairs in 1985.

	Transect pairs		
	1 and 2	3 and 4	5 and 6
Abundance	281	162	209
Richness	3	10	5
Diversity	0.83	2.20	1.40

to quadrat 6 (Table 4). Although male bird abundance remained similar from quadrats 2 through 6, species richness decreased. Only one species [Horned Larks (*Eremophila alpestris*)] comprised the majority of birds seen on quadrat 6.

During the 1985 breeding season, one pair each of Mountain Bluebirds (*Sialia currucoides*), Violet-green Swallows (*Tachycineta thalassina*), Rock Wrens (*Salpinctes obsoletus*), and Mourning Doves (*Zenaida macroura*) nested in the highwall. However, we could document only that the Mountain Bluebirds and Mourning Doves successfully fledged young. One pair of American Kestrels (*Falco sparverius*) attempted to nest on the highwall in 1984, but a skull and bones found at the base indicated that one of the adults either was preyed upon or died of unknown causes.

Vegetation abundance (cover) was highest on transect pair 1 and 2 (Table 5). This was due primarily to the abundance of Russian thistle (*Salsola* spp.). Species richness and diversity were greatest on transects 3 and 4. Transect pair 3 and 4 also exhibited greatest evenness of thistle, grasses, and forb cover. The area with transect pair 5 and 6 was seeded one year before the other areas with transect pairs 1 and 2, and 3 and 4 (Table 6). Consequently, grasses were more established on transect pair 5 and 6, resulting in greater grass cover and reduced Russian thistle and hay cover. Seeding mixtures and planting techniques were similar on all three areas; therefore, similar revegetation trends should occur in future years. During rainstorms, we noticed that run-off accumulated at the base of the highwall. Vegetation response was visually apparent. Grasses, forbs, and some sagebrush seedlings had readily established in these areas compared with transect pair 1 and 2, which was planted at the same time.

DISCUSSION

Male bird diversity and small mammal diversity were greater nearer the highwall than the other two outlying areas sampled. This was both a direct and indirect result of the highwall's presence. Directly, the highwall provided secure nesting sites for at least five bird species (Rock Wren, Mourning Dove, Violet-green Swallow, Mountain Bluebird, and American Kestrel) and three den sites for mammal species [bushy-tailed woodrat (*Neotoma cinerea*), least chipmunk, and striped skunk]. Although the three mammal species, Rock Wren, and Mourning Dove are also found denning/nesting on other substrates (rimrock), the Violet-green Swallow, Mountain Bluebird, and American Kestrel would have been absent had the highwall been completely backfilled.

Biologists have documented other bird species nesting on unreclaimed highwalls, including Say's Phoebes (*Sayornis saya*) (Steele

TABLE 6. Vegetation composition of the highwall area in 1984 and 1985.

	Halogeton %	Thistle %	Grass %	Forbs %	Hay %	Soil %	Shrub %	Rock %
Transects 1 and 2								
1984	2.8	50.4	1.6	0.0	16.8	28.4	0.0	0.0
1985	0.3	58.2	5.0	0.0	6.8	29.7	0.0	0.0
Transects 3 and 4								
1984	6.0	40.7	3.6	0.0	0.0	49.7	0.0	0.0
1985	0.0	21.0	16.8	2.5	0.0	57.2	0.0	2.5
Transects 5 and 6								
1984	12.0	23.4	17.3	0.0	1.3	46.0	0.0	0.0
1985	9.5	0.0	42.5	0.0	0.0	47.5	0.5	0.0

and Grant 1982), Barn Swallows (*Hirundo rustica*) (Curtis et al. 1978, Northern Rough-winged Swallows (*Stelgidopteryx serripennis*) (Crawford et al. 1978), Eastern Phoebes (*Sayornis phoebe*) (Allaire 1978), Golden Eagles (*Aquila chrysaetos*) (Fala 1982), Prairie Falcons (*Falco mexicanus*) (Postovit and Postovit 1987), Great Horned Owls (*Bubo virginianus*) (Postovit and Postovit 1987), and Ferruginous Hawks (*Buteo regalis*) (Postovit and Postovit 1987).

The highwall in our study also provided cover to birds during adverse weather conditions. Shortly after a severe rainstorm, a pair of American Kestrels and one Great Horned Owl were flushed from the highwall, indicating that these two species used the highwall for protection. During the winter months two Golden Eagles and a Great Horned Owl frequently used the highwall for roosting (Ward and Anderson 1985).

Few studies have quantified use of highwalls by small mammals. However, numerous reports from Wyoming and Montana mines note mammal use of highwalls (D. Trueblood, Powder River Coal Company, Gillette, Wyoming, personal communication). Species and uses include: mule deer (*Odocoileus hemionus*) fawning, shade utilization, bedding, refuge from disturbance, and drinking; pronghorned antelope fawning and drinking; bushy-tailed woodrat, mountain cottontail (*Sylvilagus nuttalli*), and deer mice colonization; and red fox (*Vulpes fulva*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*) hunting and denning (D. Trueblood, Powder River Coal Company, Gillette, Wyoming, personal communication).

Bird and mammal diversity were also increased indirectly by the highwall. Typically, reclamation returns the land surface to "approximate" original contour, yielding a relatively flat topography. The highwall increased topographic diversity, thereby influencing surrounding soil, plants, and wildlife communities. Ward (1987) found more diverse soils and vegetation in areas associated with natural cliffs compared to flat, homogeneous, short-grass prairie. The diverse soils and vegetation afforded more habitat types, thereby supporting more bird and small mammal species. Grant et al. (1982) found that grassland small mammal community composition was determined by structural attributes. Grant et al. (1982) noted that as vegetation cover went from high to low on ungrazed grasslands, small mammal composition also decreased. Stah (1980) studied vertical structure of vegetation and coexistence of two *Peromyscus* species. She determined that because of the vertical stratification of the nesting location of these two species, there was enough niche separation to allow coexistence in the same habitat.

Anderson (1979) stated that habitat structure is the primary reason for the presence of birds in an open area. Bird species select habitats based on, among other things, the structural character of vegetation (Cullen 1957). Many preference studies have shown that height profile, or vertical structure, of vegetation is the primary predictor for bird species diversity (Cullen 1957, MacArthur and MacArthur 1961, Martin 1960, Krebs 1978). Horizontal stratification (patchiness) has been shown to be more important in determining bird species diversity in shrub and grassland habitat than in forested areas (Krebs 1978). However, Roth (1976) stated that bird species diversity may be predicted more accurately from a knowledge of both horizontal and vertical structure in the vegetation. Our results support Roth's findings. The highwall transects were characterized by greater vertical and horizontal structure and supported greater bird species diversity.

Management Recommendations

Before a mine manager proposes that a highwall be left as wildlife habitat, at least four questions must be addressed concerning the requirements of the wildlife species. (1) For what species of wildlife will the reclaimed area be managed? Some species (e.g., sage grouse, (*Centrocercus urophasianus*) may be adversely affected by the presence of a highwall. (2) Would the highwall provide habitat that is limiting to a target species? For example, scarcity of suitable nesting sites limits the local Golden Eagle population in the Hanna basin (Fala et al. 1985). Providing additional nest substrate could potentially increase the eagle population. (3) Are the target wildlife species found in the surrounding area? Birds will probably colonize a reclaimed highwall more readily than will mammalian species. For example, if there is not a local population of a particular small mammal in the area, the probability that this species will find and colonize the highwall is low. (4) If a highwall is designated for a particular species, can the design be altered to benefit other wildlife species without adversely affecting the targeted species. Data from other studies (Mosher and White 1976, McGahan 1968) indicate that Golden Eagles prefer south-exposed cliffs compared to north exposures, especially in cooler climates. Altering this exposure to benefit other wildlife species that prefer another exposure without adversely affecting the Golden Eagles may be possible.

Other questions to be addressed include the stability of the highwall's parent material, the landowner's desire or nondesire to have a highwall on his property, the safety considerations for humans and wildlife, and effects the highwall will have on aesthetics.

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