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The Value of Bentonite Mine Spoils in Southeastern Montana as Small Mammal Habitat

Abstract

Bentonite mine spoils in southeastern Montana provided foraging sites for some species of small mammals, but failed to provide cover or burrow sites. Habitat conversions resulting from bentonite mining favored foraging by the pioneering species, deer mice (*Peromyscus maniculatus*) and plains pocket mice (*Perognathus flavescens*), but apparently precluded permanent establishment of any small mammal species. These results indicate the importance of inspecting some study sites for burrows before drawing conclusions on small mammal densities.

Introduction

Bentonite has been surfaced mined in the northern Great Plains for more than 60 years, resulting in the formation of small (less than 5 ha) yet numerous and conspicuous spoil piles from adjacent excavated pits. Bentonite, or the "clay of 1000 uses," is used in a variety of household products (i.e., cosmetics, toothpaste, medicines), is a primary component in oil well drilling mud, and is used in foundry bonding sands (Romo 1981). Because the bulk of the world's supply of sodium bentonite is located in the northern Great Plains (Knechtel and Patterson 1962), it is likely that bentonite mining will remain an important industry in this area.

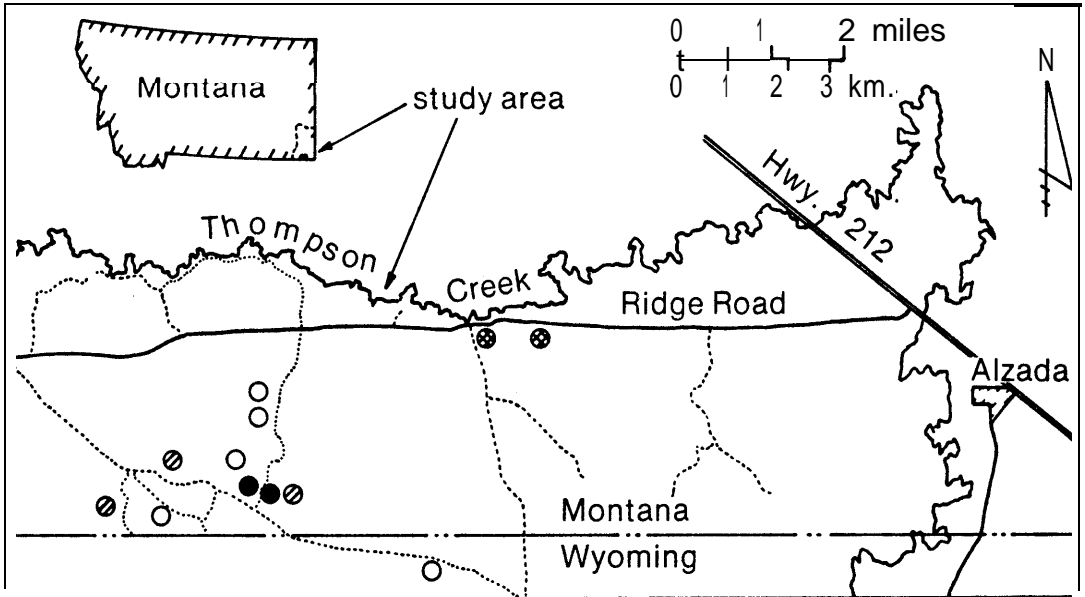
Bentonite mine spoils have proved difficult to revegetate (Sieg et al. 1983). Physical and chemical properties of the spoils materials, sparse and low quality topsoil, low annual precipitation, and livestock grazing hamper natural succession and revegetation efforts. Unreclaimed spoils, even after 30 years, remain steep, barren and sparsely vegetated and early reclamation attempts were only marginally successful (Sieg et al. 1983). Studies designed to enhance reclamation success on bentonite mine spoils have been conducted (Bjugstad 1979; Schuman and Seabrook 1984; Uresk and Yamamoto 1986; Voorhees et al. 1984), but information pertaining to wildlife use is limited to a study of vesper sparrow (*Poocetes gramineus*) densities on bentonite mine spoils by Schaid et al. (1983). The

objectives of our study were to assess the impacts of bentonite mining in southeastern Montana on relative densities of small mammals and to evaluate reclamation attempts in terms of restoring small mammal habitat.

Study Area and Methods

Our study was conducted in southeastern Montana, approximately 9 km west of the town of Alzada. Elevations range from 1000 to 1100 m. The predominant vegetation type (75 percent) on the study area is big sagebrush (*Artemisia tridentata*), with an understory of mainly buffalograss (*Buchloe dactyloides*), and western wheatgrass (*Agropyron smithii*) (MacCracken et al. 1983). Scattered bentonite spoil piles and pits constitute approximately 3 percent of the area. The area receives an annual average of 37 cm of precipitation; nearly 50 percent (18 cm) is accumulated between May and July (National Oceanic and Atmospheric Administration 1976). In 1979 and 1980, precipitation during the growing season was 17 percent and 39 percent below normal, respectively.

Twelve 60 x 60-m (0.36-ha) study sites were established: 10 on bentonite mine spoils (ranging in size from 1 to 3 ha) and 2 in adjacent mined vegetation (Fig. 1). The study sites were classified into 4 site types: 1) old mine spoils, 2) reclaimed spoils, 3) semireclaimed spoils, and 4) sagebrush grasslands. All sites were grazed by domestic livestock.



Study sites:

- = Old spoils
- ⊗ = Reclaimed spoils
- ⊗ = Semireclaimed spoils
- = Sagebrush-grass

Figure 1. Map of the study area, with regional orientation, showing locations of the 12 study sites near Alzada, Montana.

Five study sites were located on old mine spoils constructed before reclamation was mandated by law. Total plant canopy cover on old spoils averaged 3 percent, and was comprised mostly of rillscale (*Atriplex suckleyi*) and foxtail barley (*Hordeum jubatum*) (Sieg *et al.* 1983). Big sagebrush with an understory of Sandberg bluegrass (*Poa sandbergii*) and green needlegrass (*Stipa viridula*) grew at the base of a north-facing slope on one of the spoils, but was generally absent from other old spoils.

Three study sites were located on reclaimed mine spoils, 5 to 12 years old, which had been recontoured, covered with topsoil, and seeded with a mixture of wheatgrasses (*Agropyron* spp.) and yellow sweetclover (*Melilotus officinalis*). Total plant canopy cover averaged 12 percent and consisted mainly of rillscale and wheatgrasses (Sieg *et al.* 1983). Shrub cover averaged less than one percent, resulting in little vertical structure of the plant community on these sites.

Two study sites were established on semireclaimed bentonite mine spoils that had

been recontoured and covered with topsoil the year before our study began. One of the two semireclaimed spoils was seeded with mainly wheatgrasses in the fall of the first year of the study, but the steep grade of the other spoil prevented seeding. Plant canopy cover on the semireclaimed spoils averaged three percent over the 2 years, and consisted mainly of rillscale (Sieg *et al.* 1983).

Two sites were established in gently undulating sagebrush-grass rangeland that had not been disturbed by mining. Total plant canopy cover averaged 32 percent on these sites; big sagebrush constituted 19 percent of the total cover, followed by western wheatgrass (7 percent), green needlegrass, and a diverse mixture of other grasses, forbs, and a few other shrubs.

Small Mammals

To estimate relative abundance of small mammals, on each site 36 Sherman live traps (23 x 9 x 8 cm) were arranged in a grid design with 10-m spacing. Trapping grids on mine spoils were

at least 10 m from unmined vegetation on all sides. Trapping began in April of each year and continued at 3-week intervals until October, except in October 1979, when seeding activities precluded trapping on semireclaimed spoils. Each trapping session consisted of one night of prebaiting following by three consecutive nights of trapping. Traps were opened in late afternoon and checked at dawn the next day. A food supply (rolled oats mixed with peanut butter), along with Dacron batting, was placed in the traps. Upon removal from the traps, animals were first classified by species, then assigned a unique four digit number by toe clipping (Blair 1941). Snap traps were used to collect reference mammals. Small mammal scientific nomenclature follows Hall (1981).

Metal can pitfall traps (15 x 15 cm) were used to sample shrew populations. On each site, 12 cans were buried flush with the soil surface in a grid pattern with 15-m spacing. The pitfall traps were opened every three weeks (during small mammal trapping) from April through October for three consecutive nights by placing a 2- to 4-cm block under the edge of a wooden lid.

Three times during each year, in late spring, midsummer and late summer, the study sites were inspected for small mammal burrows. The number of burrows found along three permanent line transects, 50 m in length and 1 m wide, was recorded for each study site.

Statistical Analyses

One-way analysis of variance and Tukey's multiple comparison procedure (Hull and Nie 1981) were used to compare relative numbers of individual small mammals captured between years and among site types. Bartlett's Box F test was used to test for homogeneity of variances. Data with heterogeneous variances were log transformed. Chi-square contingency tables and Spearman's rank order correlation coefficient (Snedecor and Cochran 1973) were used to compare small mammal composition between years.

Results

Small Mammals

The number of small mammals captured on all study sites was 677 and 347 during 1979 and 1980, respectively. Trap mortality was two per-

cent in 1979 and three percent in 1980. Deer mice were the most abundant mammal, constituting 94 percent of the 1979 captures and 90 percent of the 1980 captures (Table 1). The 49 percent decline ($P < 0.001$) in small mammal captures from 1979 to 1980 was associated with a significant ($P < 0.001$) change in small mammal species composition. Sagebrush voles (*Lagurus curtatus*) were not captured in 1980; however, plains pocket mice (*Perognathus flavescens*) increased ($P = 0.15$) during the second year (Table 1). Dwarf shrews (*Sorex nanus*), masked shrews (*Forex cinereus*), other shrews (*Sorex* spp.), and thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) were captured approximately as often in both years.

TABLE 1. Total numbers of small mammals on bentonite mine spoils and sagebrush-grass rangelands in 1979 and 1980, near Alzada, Montana.

Species	Individuals captured	
	1979	1980
<i>Lagurus curtatus</i>	22 ^a (3%) ¹	0 ^b (0%) ¹
<i>Peromyscus maniculatus</i>	636 ^a (94%)	311 ^b (90%)
<i>Perognathus flavescens</i>	10 ^a (1%)	23 ^a (7%)
<i>Sorex</i> spp.	2 ^a (1%)	5 ^a (1%)
<i>Spermophilus tridecemlineatus</i>	7 ^a (1%)	8 ^a (2%)
Total	677 ^a (100%)	347 ^b (100%)

¹Percent of total capture.

^{ab}Numbers in rows followed by same superscript were not significantly different at $\alpha = 0.05$.

Small mammal species richness was low on both mined and unmined habitats. Five species were captured on old bentonite mine spoils; four species were captured on reclaimed and semireclaimed bentonite mine spoils and on sagebrush grasslands (Table 2). Deer mice were the most common species on all study sites. Pocket mouse numbers were low, but similar among mine spoil types, and generally higher on these sites than on sagebrush grasslands. Numbers of thirteen-lined ground squirrels were higher on sagebrush grasslands than on other sites, but ground squirrels were found on mine spoils. Sagebrush voles were captured on all site types, but showed a tendency toward higher

TABLE 2. Two-year average relative abundance (no. individuals/1000 live-trap nights \pm SE) of small mammal species captured on bentonite mine spoils and sagebrush grasslands near Alzada, Montana.

Species	---Bentonite mine spoils---			Sagebrush grasslands
	Old	Reclaimed	Semireclaimed	
<i>Lagurus curtatus</i>	0.8 \pm 0.8 ^a	0.2 \pm 0.2 ^a	0.4 \pm 0.4 ^a	3.8 \pm 3.8 ^a
<i>Petognathus flavescens</i>	2.4 \pm 0.8 ^b	1.6 \pm 1.5 ^b	0.4 \pm 0.4 ^{ab}	0 ^a
<i>Peromyscus maniculatus</i>	39.4 \pm 4.7 ^a	62.5 \pm 9.4 ^b	29.4 \pm 6.4 ^a	41.0 \pm 6.3 ^{ab}
<i>Sorex</i> spp.	0.7 \pm 0.7 ^a	0 ^a	0 ^a	1.2 \pm 0.1 ^a
<i>Spermophilus tridecemlineatus</i>	0.1 \pm 0.1 ^a	0.2 \pm 0.2 ^a	0 ^a	2.9 \pm 0.2 ^b

^{ab}Numbers in rows followed by same superscript were not significantly different at $\alpha = 0.05$.

TABLE 3. Average relative abundance (no. individuals/1000 trap nights \pm SE) of *Peromyscus maniculatus* on bentonite mine spoils and sagebrush-grass rangelands in 1979 and 1980, near Alzada, Montana.

	1979	1980	2-Year \bar{x}
Old spoils	52.2 \pm 5.7 ^a	26.6 \pm 3.0 ^{ab}	39.4 \pm 4.7 ^a
Reclaimed spoils	90.0 \pm 10.1 ^{b*}	35.0 \pm 7.6 ^b	62.5 \pm 9.4 ^b
Semireclaimed spoils	46.9 \pm 8.5 ^a	16.3 \pm 6.2 ^a	29.4 \pm 6.4 ^a
Sagebrush-grasslands	61.2 \pm 5.5 ^a	20.8 \pm 4.6 ^{ab}	41.0 \pm 6.3 ^{ab}

^{ab}Numbers in columns followed by same superscript were not significantly different at $\alpha = 0.05$.

*Different from sagebrush-grasslands at $\alpha = 0.10$.

numbers on sagebrush grasslands. Shrews were limited to sagebrush-grass rangelands and old bentonite mine spoils, but captures were not different ($P > 0.1$) among site types.

The average number of deer mice captured (no./1000 live-trap nights) in 1979 ranged from 52 on old mine spoils to 90 on reclaimed mine spoils; in 1980, captures ranged from 16 (semireclaimed spoils) to 35 (reclaimed spoils) (Table 3). In 1979, deer mouse captures were higher ($P < 0.05$) on reclaimed mine spoils than on all other sites. Relative densities were similar on old spoils, semireclaimed mine spoils, and sagebrush grasslands. However, in 1980, numbers of deer mice were higher ($P < 0.05$) on reclaimed spoils than on semireclaimed spoils, but were similar to captures on old spoils and sagebrush grasslands. Captures were also similar on old and semireclaimed spoils and on sagebrush-grass sites. For the two years combined, captures were higher ($P < 0.05$) on reclaimed bentonite mine spoils than on old spoils and semireclaimed spoils, but were similar to captures on sagebrush

grasslands. Average two-year captures of deer mice on old spoils and semireclaimed spoils did not differ significantly ($P > 0.01$).

Burrow Transects

Small mammal burrows were limited to sagebrush-grass rangelands. An average of 50 burrows per hectare were found on the sagebrush-grass sites, whereas small mammal burrows were absent from the bentonite mine spoil habitats.

Discussion

Bentonite mining in southeastern Montana resulted in habitat conversions that generally precluded establishment of small mammal populations, but provided foraging sites for at least deer mice. Although numbers of deer mice were often higher on reclaimed spoils than on other sites, this adaptive rodent was the most common species on all study sites. Deer mice are abundant in a variety of habitats throughout the

United States, and their ability to colonize mine spoils is well documented (e.g. Verts 1959, Kirkland 1976, Steel and Grant 1982). Deer mice were more common on reclaimed coal mine spoils than on unmined sagebrush-grass rangeland in Wyoming, and consumed a variety of plants that grew on mine spoils (Hingtgen and Clark 1984). In our study area, rillscale seeds and bromegrass (*Bromus* sp.) were preferred foods of deer mice captured on the study area (Sieg et al. 1986), and the dominance of rillscale in the vegetative cover on the mine spoils likely explained the high use of these sites by deer mice. Greater numbers of deer mouse captures on reclaimed bentonite mine spoils was attributed to higher production of rillscale and slightly greater plant cover on these sites, when compared to old and semi-reclaimed spoils.

Sparsely vegetated mine spoils also provided foraging sites for plains pocket mice. Hispid pocket mice (*Perognathus hispidus*) readily invaded Texas lignite spoils and were captured in low numbers in adjacent abandoned fields (Van Waggoner 1978). The attraction of plains pocket mice to bentonite mine spoils was attributed to the abundance of rillscale seeds, particularly on reclaimed spoils (Sieg et al. In press). However, the absence of sandy soils for both burrowing and dust-bathing (e.g. Kritzman 1974) likely prevented the pocket mice from establishing permanent residency on bentonite spoils.

Sagebrush voles, thirteen-lined ground squirrels, and shrews were associated with sagebrush grasslands. Although captures of sagebrush voles were not significantly higher in sagebrush grasslands than on mine spoils, these voles were captured only in sagebrush communities on north-facing slopes of old bentonite mine spoils, or within 10 m of undisturbed sagebrush grassland on other mine spoils. Sagebrush voles, reported to be among the less common microtines in Montana, are found in close association with big sagebrush (Hoffmann and Pattie 1968).

Two thirteen-lined ground squirrels were captured on bentonite mine spoil habitats: one on the perimeter of an 11-year-old reclaimed spoil, and one in sagebrush habitat on an old spoil. They generally burrow in well-drained soil (Jones et al. 1983), and therefore their expansion onto spoils may be limited by their inability to burrow in the spoils material. Further, the near ab-

sence of grass cover on the mine spoils may have prevented colonization by ground squirrels inhabiting adjacent sagebrush grasslands. Thirteen-lined ground squirrels were captured in grass, sagebrush, and riparian habitats on our study area and were associated with grass cover among other variables (MacCracken et al. 1985b).

Shrews captured on old bentonite mine spoils were within 20 m of native sagebrush-grass vegetation. Litter cover and moist microhabitats associated with dense vegetation have been cited as critical elements in shrew distribution on our study area (MacCracken et al. 1985a), and the lack of litter and dense vegetation on the bentonite mine spoils likely explains the general absence of shrews on these sites.

The significant decline in small mammal captures and change in species composition from 1979 to 1980 was attributed to a scarcity of food resources induced by drought. Other authors have attributed changes in small mammal densities (Spevak 1983), species composition (Brown 1973), and restricted breeding activity (Taitt 1981) to food shortages and water stress resulting from annual droughts. In our study, reduced plant canopy cover and aboveground biomass (Sieg et al. 1983), as well as lower captures of ground-dwelling macroarthropods (Hull 1981) in 1980 were evidence of diminished food supplies, which undoubtedly influenced small mammal survival.

On mine spoils in Florida (Frohlich and Marion 1984) and in Colorado and New Mexico (Steele and Grant 1982), diverse topography and resulting diverse flora on unreclaimed mine spoils supported a greater number and variety of wildlife species than did reclaimed spoils of relatively uniform topography and vegetative cover. In our study, topographic relief was greater on old (unreclaimed) spoils than on reclaimed sites, but plant species richness, canopy cover, and aboveground biomass were higher on reclaimed spoils than on old spoils (Sieg et al. 1983). Further, associated numbers of small mammals were higher on reclaimed bentonite spoils than on old spoils. However, the growth of big sagebrush on steep, north-facing slopes on some old spoils indicates that topographic variations may enhance the growth of some plants, and therefore encourage coloniza-

tion by animals associated with sagebrush grasslands. Therefore, future attempts to reclaim bentonite spoils may be more successful by designing topographic relief into the post-mining landscape.

Successful reclamation of mine spoils for wildlife implies that the reclaimed area provides the basic components necessary for a given species to survive and reproduce. Reclaimed bentonite spoils provided food for at least deer mice (rillscale seeds); however, these sites typically lacked vertical plant structure necessary to provide cover and the spoils materials were apparently impenetrable, based on the absence of small mammal burrows and high penetrometer readings previously reported for these sites (Sieg et al. 1983). The value, therefore, of reclaimed bentonite mine spoils as small mammal habitat appears to be as foraging sites. The small size of the spoils results in an "edge effect," which favors pioneer species like the deer mouse. However, in areas where a high percentage of sagebrush grassland is disturbed by numerous

bentonite pits, the overall effect on small mammal populations will likely be a decrease in numbers of species such as sagebrush voles, shrews, and thirteen-lined ground squirrels, and a loss of burrow sites for animals adapted to foraging on mine spoil habitats, such as deer mice and pocket mice. Our results also indicate the importance of establishing the presence of burrows before making implications about small mammal population densities on sites adjacent to undisturbed vegetation.

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