Effect of Reclamation Technique on Mammal Communities Inhabiting Wetlands on Mined Lands in East-Central Ohio[1]

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ABSTRACT. **Mammal communities were studied from May through August, 1988 to 1990, at four wetland sites in Coshocton and Muskingum counties, OH. Sites represented varying degrees of disturbance from mining activity and subsequent reclamation techniques, including a wetland constructed to treat mine water drainage. Each site was composed of a series of three cattail (*Typha latifolia*) cells for a balanced experimental design. Mammals were inventoried with snap trap removal grids and midday surveys for signs of activity. Mammal diversity and richness was highest at the constructed wetland and lowest at the site established with traditional reclamation procedures. Predictable patterns of land use disturbance for species presence/absence were observed with some alpha diversity (habitat specific) species being absent (i.e., tree squirrels) and gamma diversity (wide-ranging) species such as mustelids occurring rarely. Beta diversity species (habitat generalists) like woodchucks (*Marmota monax*) and white-tailed deer (*Odocoileus virginianus*) were common at all sites. The white-footed mouse (*Peromyscus leucopus*) was the small mammal captured most frequently, being the most abundant small mammal at the constructed wetland and the undisturbed site, with meadow voles (*Microtus pennsylvanicus*) most prevalent at the remaining sites. These results suggest that a wetland constructed for the treatment of mine water drainage can provide secondary benefits as habitat for a variety of mammal species.**

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INTRODUCTION

Use of reclaimed surface mines by mammals has been the subject of several studies, including some in Ohio (Riley 1954, De Capita and Bookhout 1975, among others). Mammal communities have been examined for the importance of habitat structure on mined lands (Brenner et al. 1982) and selected species evaluated in relation to succession (Hansen and Warnock 1978). With the exception of Brooks and co-workers (1985), studies targeting wetland-associated mammal communities have focused primarily on small mammal populations (McConnell and Samuel 1985, Amrani and Samuel 1988), but to our knowledge no study has examined mammal responses to a wetland constructed for the purpose of abating mine water drainage.

Harris (1988) has projected that species composition and diversity of wetland vertebrates will respond predictably following cumulative impacts from various land use practices. He suggests that wide ranging species (gamma diversity) and area sensitive species (typically referred to as habitat specific species or alpha diversity) will be eliminated with disturbance, only to be displaced by habitat generalists (beta diversity) in the newly formed landscape. The end result will be a more homogeneous species mix, with a loss of unique faunal assemblages.

In the present paper, the ideas of Harris (1988) have been evaluated by examination of mammal communities across a series of wetlands varying in the degree of disturbance from mining activity and accompanied by differing reclamation procedures, including a wetland constructed for the treatment of mine water drainage. The current information available on mammal responses to mine land reclamation is reviewed, with a synthesis of patterns emerging across the studies.

STUDY AREA

All four sites were located within the Wills Creek drainage system in Coshocton and Muskingum counties, OH. The constructed wetland (Simco #4) was established in November 1985 to treat a deep mine discharge containing high levels of iron (Lacki et al. 1990). The wetland surface area was partitioned into three cattail cells totaling 0.3 ha in size, with emergent vegetation dominated by broadleaf cattail (*Typha latifolia*). Specifics for the construction design of this wetland are provided in Stark et al. (1988).

The remaining three sites were selected so that they also would each be partitioned into three cattail cells. This arrangement permitted a balanced experimental design of four sites, each with three cattail cells, allowing for replication within site. The second site was located downstream (Downstream) from the constructed wetland. This site differed somewhat from the constructed wetland by virtue of the presence of ponded water adjacent to two of its three cattail cells and a power line right-of-way neighboring the lower end of the third cattail cell. This site was influenced by historical mining activity on nearby hillsides, but no direct impact in the drainage bottom was evident. Mining activity ceased in the vicinity of the Downstream site in 1961 (T. Romanoski, pers. commun.).

The two remaining sites represented a relatively undisturbed wetland (Volunteer) and a reclaimed strip mine area with a cattail wetland having developed naturally in the drainage bottom (Reclamation). The Volunteer site was enclosed by a forest community more advanced in succession than the three other sites (Lacki et al. In Press)

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and had ponded water next to one of its cattail cells. No ponds were present at the Reclamation site; instead, this area supported large expanses of open grassland habitat in the vicinity of the wetland zones and an abandoned apple orchard next to its upstream cattail cell (Lacki et al. In Press). For additional site information see Lacki et al. (1990).

MATERIALS AND METHODS

Surveys for mammal sign were conducted from 19 to 25 May and 10 to 15 June in 1988, 1989, and 1990. In each cattail cell and the surrounding vicinity, all mammal signs, including direct observations, were recorded. A 20 minute search effort by four to five observers was made at every cattail cell in all sampling periods, for a total of 18 surveys per site. All data were collected during afternoon hours.

Snap trap removal grids were set from 6 to 10 August 1988, 1989. A total of 16 mouse traps were placed at every cattail cell and baited with rolled oats, molasses, and peanut butter. Traps were prebaited for one night and set for two consecutive nights thereafter. All animals trapped were aged, sexed, weighed, identified to species, and evaluated for reproductive condition. To examine microsite habitat preferences, all trap sites were assigned to a moisture category and a dominant plant grouping.

Total small mammal population sizes were estimated using Zippin's removal method (Davis and Winstead 1980) and converted to densities by dividing by cattail cell surface areas. Reproductive activity was calculated as the percent of adult females lactating. Microsite habitat preferences were examined using Chi–square tests of independence (Daniel 1974), with moisture categories analyzed independently of dominant plant groupings.

Survey data were evaluated for abundance of mammal sign, species richness, and species diversity, with the latter calculated using the Shannon-Weaver function to the base of the natural logarithms. These three groupings were tested with a balanced, nested analysis of variance (SAS Institute 1982). ANOVAs were treated as mixed effects models, with sites as the fixed, main effect. Cattail cells used as the random effect, nested within sites; thus, cattail mean square was used as the error term for testing site effects. The month and year of sampling were examined for possible interactions with site effects but none were found. For significant models, site means were tested using Tukey's studentized range test. For all tests, outcomes were considered significantly different when $P \leq 0.05$.

RESULTS

A total of 12 mammal species was detected in midday surveys (Table 1). White–tailed deer (*Odocoileus virginianus*) and woodchucks (*Marmota monax*) were the most common mammals recorded, with woodchucks being especially adapted to conditions at Simco #4, the constructed wetland. Trends in abundance were evident for two species, muskrat (*Ondatra zibethicus*) and red fox (*Vulpes vulpes*), with both increasing noticeably at the Downstream site during the third year of sampling. The pattern for muskrat was attributable, in part, to a controlled harvest prior to the start of the study to prevent heavy grazing pressure on the cattails planted in the constructed wetland. A large wetland mammal that was not recorded during surveys was the beaver (*Castor canadensis*). This species was common in lakes formed adjacent to nearby highwalls and was observed using the constructed wetland on one occasion outside the normal survey periods.

Site comparisons with survey data showed significant differences for mammal abundance ($F = 4.75$, $P = 0.01$), species richness ($F = 4.73$, $P = 0.01$), and species diversity ($F = 3.03$, $P = 0.05$). Tests of individual site means found the constructed wetland to support as complex a mammal community as any of the four sites examined (Table 2), with the Downstream site exhibiting comparable values for abundance, richness, and diversity. The simplest overall mammal community occurred at Reclamation, with this site showing the lowest mean values for all three measures of mammal community structure. Because of its sensitivity to the number of species in a sample, the Shannon–Weaver function assumes that all species capable of being detected are actually recorded during sampling. As evidenced by the snap trap results (Table 3), this assumption was violated at least twice. Meadow voles

TABLE 1

List of mammals detected in midday surveys, including numerical abundance, for wetland sites in Coshocton and Muskingum counties, OH, 1988 through 1990.

Species	Simco #4 n	Downstream n	Volunteer n	Reclamation n
Didelphis virginiana	1	–	–	–
Blarina brevicauda	1	2	1	–
Procyon lotor	13	14	2	1
Mustela vison	–	1	–	–
Mephitis mephitis	1	–	–	–
Vulpes vulpes	2	7	2	–
Marmota monax	29	7	5	13
Microtus pennsylvanicus	4	–	3	1
Ondatra zibethicus	2	27	1	1
Napaeozapus insignis	–	–	–	1
Sylvilagus floridanus	–	1	1	–
Odocoileus virginianus	21	25	16	9

TABLE 2

Means and standard deviations for mammal abundance, species richness, and species diversity, for wetland sites surveyed in Coshocton and Muskingum counties, OH, 1988 through 1989.

	Abundance (N)		Richness (S)		Diversity (H')	
Site*	Mean	SD	Mean	SD	Mean	SD
Simco #4	$12.3^{a,b}$	5.99	4.50^{a}	1.05	1.24^{a}	0.23
Downstream	14.0^{a}	8.53	4.50^{a}	1.22	$1.14^{a,b}$	0.38
Volunteer	$5.17^{a,b}$	2.14	$3.17^{a,b}$	0.98	$1.02^{a,b}$	0.28
Reclamation	4.33^{b}	3.01	2.17^{b}	1.72	0.60^{b}	0.59

[a,b] Means in the same column with common letters are not significantly different at $P \leq 0.05$.

Analyses are based on 18 cattail cell surveys at each site.

TABLE 3

List of small mammals captured, including abundance by sex class, for wetland sites trapped in Coshocton and Muskingum counties, OH, 1988 and 1989.

Species	Simco #4 M(F)	Downstream M(F)	Volunteer M(F)	Reclamation M(F)
Sorex cinereus	–	(1)	(1)	(1)
Blarina brevicauda	–	–	–	(4)
Peromyscus maniculatus	1	1	2	–
Peromyscus leucopus	12(11)	3(4)	6(6)	2(1)
Microtus pennsylvanicus	1(2)	5(3)	9(2)	8(1)
Zapus hudsonius	1(1)	–	–	–

(*Microtus pennsylvanicus*) were not detected in surveys at Downstream but were captured there; short-tailed shrews (*Blarina brevicauda*) were captured only at Reclamation but never detected there in midday surveys. Despite these shortcomings, we believe the different patterns detected across the sites reflect the true conditions present.

Snap trap removals found six species present (Table 3), with four of the species not having been recorded in midday surveys. The white-footed mouse (*Peromyscus leucopus*) was the most common species captured overall, being most frequent at the constructed wetland and the Volunteer site, while the meadow vole was most common at Downstream and Reclamation.

Population densities for small mammals showed that all sites supported comparable abundance levels, except the constructed wetland which had appreciably high numbers in 1988 but declined sharply in 1989 (Fig. 1). We suggest this latter response resulted from haybale dikes being in place in 1988, but rotting significantly by August 1989, with portions of the dikes below water level. Zippin's formula assumes that capture frequency will be highest on the first night of capture only to decline on subsequent trap nights; therefore, it was impossible to derive population totals at Simco #4 and Downstream in 1989 because of greater capture success on the second night of trapping relative to the first night.

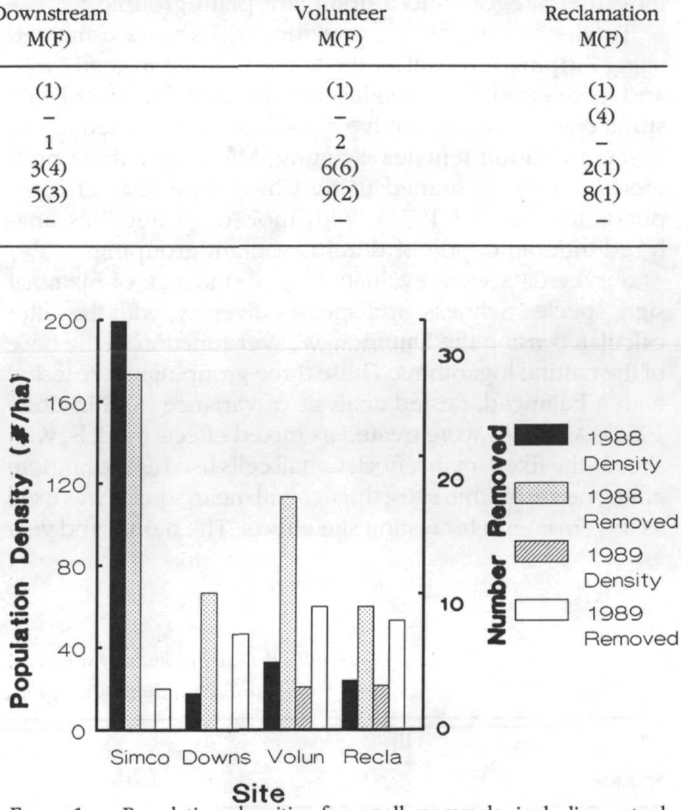

FIGURE 1. Population densities for small mammals, including actual numbers removed, for wetland sites trapped in Coshocton and Muskingum counties, OH, 1988 and 1989. Site abbreviations are as follows: Simco – Simco #4, Downs – Downstream, Volun – Volunteer, and Recla – Reclamation.

Based on trapping data, *P. leucopus* was the only small mammal species found to be reproductively active at the constructed wetland, with 66.6% of the adult females showing evidence of lactation. However, a meadow vole nest site was uncovered in shale debris approximately 1 m from the edge of cattail cell 2 at the constructed wetland, indicating that this species was probably also reproductively active in the area. The Volunteer site also supported a reproductively active population of *P. leucopus*, with 80% of the adult females lactating. Of the remaining five species, only meadow voles and masked shrews (*Sorex cinereus*) showed any signs of lactation, but these represented isolated individuals.

Microhabitat preferences were determined solely for *P. leucopus*, as this species was the only one captured at sufficient frequency for analysis. Tests for both moisture category ($X^2 = 9.80$, $P = 0.01$) and dominant plant group ($X^2 = 7.40$, $P = 0.03$) were found to be significant. *Peromyscus leucopus* were captured most frequently at trap sites that were dry (Fig. 2), with this category contributing 72.2% to the total Chi–square score. Examination of plant groupings showed *P. leucopus* to prefer woody stems and to avoid cattail–dominated microsite locations (Fig. 3). These represented 52.4% and 46.2% of the contributions to the total Chi–square score, respectively. Woody plant species most frequently found in the vicinity of trap sites were black willow (*Salix nigra*), multiflora rose (*Rosa multiflora*), blackberry and raspberry (*Rubus* spp.), and staghorn sumac (*Rhus typhina*).

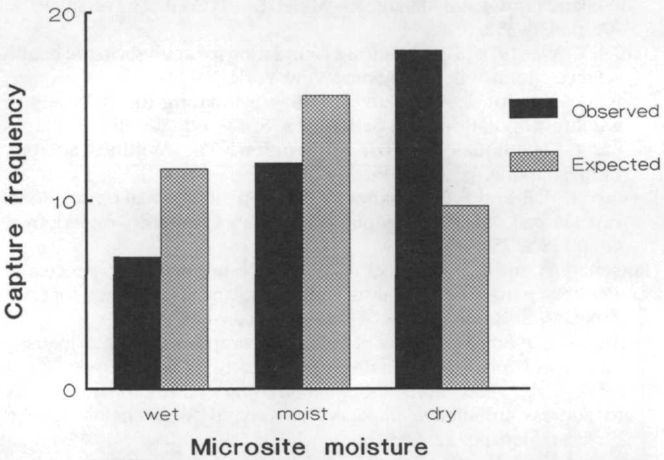

FIGURE 2. Observed and expected capture frequencies for white-footed mice across degrees of microsite moisture availability.

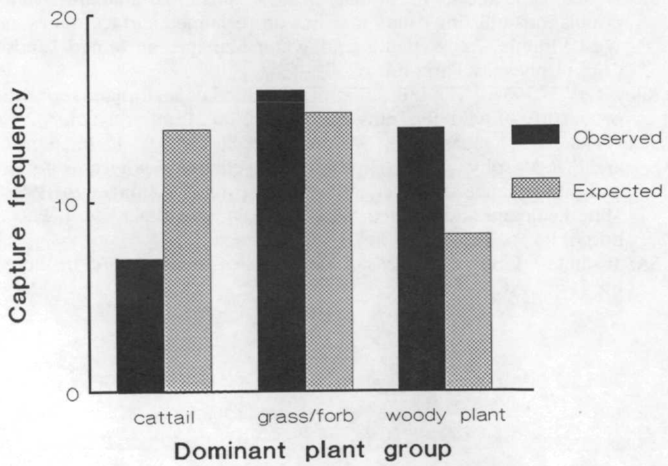

FIGURE 3. Observed and expected capture frequencies for white–footed mice across microsite differences in dominant plant groups.

DISCUSSION

The constructed wetland supported a mammal community equal in complexity or more complex than any of the sites evaluated, suggesting that this reclamation technique, designed for water quality improvement, can have secondary benefits by providing habitat for a wide range of mammals. We found the Reclamation site to have the poorest mammalian fauna; this was not necessarily attributable to the reclamation procedures alone, but was also a function of proximity to other wetlands. Compared with the other three sites, Reclamation was relatively isolated from similar wetland areas and contained no pooled bodies of water in the vicinity of the cattail cells. Klopatek (1988) has suggested that spatial distributions among wetlands may be important in sustaining wetland food chains and, thus, complex species communities.

A large mix of mammal species was recorded across the four sites studied (Tables 1, 3). No eastern chipmunks (*Tamias striatus*) or tree squirrels were recorded and only once was evidence found of mink (*Mustela vison*) and striped skunk (*Mephitis mephitis*). Surveys of the literature show a stronger representation of sciurids on other reclaimed mine sites (Brenner 1973, De Capita and Bookhout 1975, Brenner et al. 1982, Brooks et al. 1985) but, in every case, common species were absent and no species was recorded in great abundance. The absence of mast producing trees or well developed stands of conifers following initial phases of reclamation is probably responsible for the paucity of tree squirrels in surveys of abandoned mine lands. The poor representation of tree squirrels on abandoned mine lands would support Harris' (1988) suggested loss of alpha species with habitat disturbance. An absence or limited use of habitats following reclamation by mustelids would constitute a loss of gamma or wide–ranging species (Harris 1988). As reported for sciurids, mustelids have been documented as using abandoned mine lands, but at relatively low frequencies (Brenner 1973, De Capita and Bookhout 1975, Brenner et al. 1982, Brooks et al. 1985).

Of the mammals present in our surveys, white–tailed deer, woodchucks, and raccoons (*Procyon lotor*) were detected most consistently. Each of these species has proven widely adaptable to man–altered landscapes, and their presence on the study areas was not surprising. Because of their adaptability to a variety of habitat types, these species are habitat generalists and, thus, represent the beta diversity species component. Harris' (1988) suggestion that beta species would be strongly associated with habitat disturbance was supported by our findings. This study did not evaluate volant mammals, so no direct inference can be made concerning these species; however, bats were frequently observed in the twilight hours at all four sites, and the likelihood of multiple species was high.

Peromyscus leucopus was the most common species of small mammal in the sites we examined and was the most dominant small mammal on abandoned mine lands surveyed by De Capita and Bookhout (1975) and Brenner et al. (1982). For other localities, the deer mouse (*P. maniculatus*) (Brenner 1973) and meadow vole (McConnell and Samuel 1985) were the most frequently trapped small mammal species, the latter occurring in cattail marsh habitats. Meadow voles were recorded most frequently at two of the four wetlands trapped in this study (Table 3). Amrani and Samuel (1988) observed *Peromyscus* to be the most common small mammal in cattail marshes. They did not differentiate between *P. leucopus* or *P. maniculatus*, however.

Cattail marshes on abandoned mine land were found to support breeding populations of meadow voles and *Peromyscus* (Amrani and Samuel 1988). Evidence for meadow vole reproductive activity was anecdotal, but data for *P. leucopus* showed this species to use the constructed wetland as breeding habitat.

Hansen and Warnock (1978) found *P. leucopus* and *P. maniculatus* to shift in abundance in relation to the stage of succession on abandoned mine lands, with *P. maniculatus* more frequent early in succession, and *P. leucopus* predominating in later seral stages. Present data were in agreement with this trend as *P. leucopus* was the most common small mammal at Volunteer. The habitat adjacent to the wetland at this site was furthest along in successional development. Conversely, *P. leucopus* were scarce at Reclamation where open grass areas persisted (Lacki et al. 1991). *Peromyscus leucopus* were also found to preferentially select microhabitats dominated by woody plant species, as opposed to cattail or grass/forb locations (Fig. 3). In contrast, Amrani and Samuel (1988) demonstrated a preference by *Peromyscus* for cattail habitats over grassy areas. Assuming the avoidance of cattails by *P. leucopus* in our study is a characteristic behavior of this species, we suspect but cannot be sure that most of the *Peromyscus* in the Amrani and Samuel (1988) study were *P. maniculatus*. *Peromyscus maniculatus* were trapped too infrequently at our sites to render any direct comparisons.

Brenner and co-workers (1982) found that small mammals, grouped according to feeding strategy, shifted in abundance with changes in structural properties of the habitat, such as woody stem diameter and height. They observed that insectivore abundance remained relatively constant, while grazers decreased with increasing stem diameter and height, being displaced by omnivores and granivores. At Reclamation, where woody stems were infrequent and grasses dominant near the wetland, meadow voles (grazers) were most common and *P. leucopus* (granivores) were rare. At the constructed wetland, where *P. leucopus* were most abundant, meadow voles were infrequent. Thus, similar patterns were observed, with the possible exception of several meadow voles trapped at Volunteer where open grass areas were present at only one of three cattail cells.

Findings from this study and those reported in the literature suggest that mammals are adaptable to habitat conditions present on reclaimed mine lands. Predictable patterns of species occurrence and abundance were evident and demonstrate the importance of plant species composition, age, and structure for mammalian use of mine lands. Successional changes in plant communities with increased time since initial reclamation can be expected to be accompanied by shifts in mammal species and abundance. Future reclamation attempts oriented toward the creation of wildlife habitat as a long-term land use objective need to consider these trends to achieve diverse assemblages of mammal species.

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