Small Mammal Response to Vegetation and Spoil Conditions on a Reclaimed Surface Mine in Eastern Kentucky

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Abstract - Ecologically effective mine reclamation is characterized by the return of pre-mining floral and faunal communities. Excessive soil compaction typically results in delayed succession and low species diversity on reclaimed mine lands. We compared small mammal abundance and diversity among three levels of compaction in reforestation plots on an eastern Kentucky surface mine during 2004 and 2005. Compaction levels included 1) no compaction (loose-dumped), 2) light compaction (strike-off), and 3) high compaction (standard reclamation). *Peromyscus leucopus* (White-footed Mouse) made up 98% (295 of 300) of all individuals captured. In 2004, loose-dumped plots had more White-footed Mice (n = 108, mean = 36, SE = 0.58) than high-compaction plots (n = 62, mean = 20.6, SE = 3.10). Strike-off plots had more White-footed Mice (n = 59; mean = 19.6, SE = 0.66) than loose-dumped (n = 46, mean = 15.3, SE = 1.45) or high-compaction (n = 20, mean = 6.6, SE = 2.19) plots in 2005. Canopy cover and large rocks that created crevices appear to have been the factors that most influenced White-footed Mouse abundance on our study sites. Low small-mammal species diversity across all treatments was likely due to the presence of low quality habitat resulting from a poorly developed ground layer and soil compared to that found in undisturbed forest. Additionally, an insufficient amount of time since reclamation for small-mammal colonization from surrounding forests and a relatively large matrix of non-forested reclaimed mineland between our plots and potential source habitats may have also limited small-mammal diversity. To promote biodiversity and provide better wildlife habitat, we suggest that mine operators consider using reclamation methods that promote surface and vegetation heterogeneity and connectivity to source habitats.

Introduction

Surface mining and reclamation impacts both plant and animal populations (Holl and Cairns 1994). Since 1984, more than 219,000 ha have been surface mined for coal in Kentucky (Environmental Quality Commission 1997). In eastern Kentucky, botanically and structurally diverse deciduous forests (Braun 1950) have been replaced by reclaimed exotic grasslands with low plant diversity. Several factors such as low soil pH, increased surface temperatures, drought conditions, exotic invasive plant species, lack of nutrients, and soil compaction are thought to contribute to delayed succession and low plant species diversity on reclaimed mine lands (Bendfeldt et al. 2001, Bradshaw 1987). Compaction may be most responsible inasmuch

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as it negatively impacts tree colonization and survival on reclaimed mines (Graves et al. 2000, Torbert and Burger 2000), which in turn limits structural complexity necessary to support a number of terrestrial flora and fauna.

Effective mine reclamation is characterized by the return of pre-mining biotic communities with their attendant structure and function (Steele and Grant 1982). However, reforestation is not a common post-mining land use in the Appalachian Coalfields (Sweigard 1999). This situation is largely due to federal regulations that promote high soil compaction in an attempt to return mined landscapes to their original contour and reduce soil erosion. Reclamation methods that reduce compaction can decrease tree seedling mortality and improve growth (Graves 1999). Although results from compaction reduction research suggest improved plant community development (Graves 1999), the response to such practices by vertebrate communities is unknown.

Reclaimed surface mines provide different habitat and microsite conditions than that which existed prior to mining. We predicted that the distribution and abundance of small mammals on such sites in eastern Kentucky would reflect the simplified topography and vegetative characteristics associated with these areas (Hansen and Warnock 1978, Hingtgen and Clark 1984, Sly 1976). Krupa and Haskins (1996) documented four small-mammal species on reclaimed mines in eastern Kentucky; however, microhabitat relations were not reported. Overall, there is a great paucity of work that has examined small-mammal microhabitat relations on reclaimed surface mines in the central Appalachians (Chamblin 2002, Chamblin et al. 2004). Moreover, no published data exist about small-mammal response to mine reclamation techniques intended to reduce soil compaction. Such studies are needed to evaluate whether such techniques promote the recovery of biodiversity and to make recommendations for their use or their improvement.

We analyzed data collected in reforestation plots on a reclaimed surface mine in eastern Kentucky. Specifically, we examined small-mammal abundance and diversity among three compaction regimes (no compaction, light compaction, high compaction), and looked for relationships between microhabitat characteristics and small-mammal abundance. We selected small mammals as our focal taxa because: 1) much is known about their biology, 2) many species are effective colonizers of vacant habitats, 3) individuals can be easily marked and monitored (Barrett and Peles 1999), and 4) our findings can be compared to studies conducted in adjacent undisturbed forests.

Study Area

Our study was conducted on experimental reforestation plots located on the Star Fire Mine in Perry County, southeastern Kentucky. Elevations ranged from 250–410 m (Krupa and Lacki 2002). Mountain top removal methods were used to extract coal, and subsequent reclamation have converted rugged, forested topography into expansive (up to 5000 ha), level to gently sloping grasslands. Herbaceous plant species commonly found on reclaimed surface mines primarily are exotic to the area and include Kentucky-31 *Festuca elatior* L. (Tall Fescue), *Lespedeza cuneata* G. Don (Chinese Lespedeza), *L. striata* Hook. and Arn. (Japanese Clover), *L. stipulacea* Maxim. (Korean Clover), *Lolium*

multiflorum, Lamarck (Annual Ryegrass), *Lolium perenne* L. (Perennial Ryegrass), *Dactylis glomerata* L (Orchardgrass), and *Trifolium hybridium* L. (Alsike Clover) (Slaski and Fowler 1980). Woody plant species that tend to colonize forest-mineland edge in this part of the Appalachians include *Rubus* spp. (blackberry), *Liriodendron tulipifera* L. (Yellow-poplar), *Robinia psuedoacacia* L. (Black Locust), and *Rhus* spp. (sumac).

Where surface mining is not a factor, mixed-mesophytic forests dominate the region (Krupa and Lacki 2002). Depending on slope and aspect, this forest type is composed of 55 native and six exotic tree species (Braun 1950, Krupa and Lacki 2002). Lower slope and cove sites consist of *Quercus* spp (oaks), *Acer* spp. (maples), Yellow-poplar, *Fagus grandifolia* Ehrh. (American Beech), *Tilia americana* L. (American Basswood), *Rhododendron maximum* L. (Rosebay Rhododendron), and *Tsuga canadensis* (L.) Carr. (Eastern Hemlock). Forests occupying side slopes are dominated by multiple species of oak and *Carya* spp. (hickory), whereas xeric ridgetops, southwestern facing slopes, and areas with rocky shallow soils are dominated by *Q. prinus* L. (Chestnut Oak) *Q. coccinea* Munchh. (Scarlet Oak), *Pinus virginiana* Mill. (Virginia Pine), *P. echinata* Mill. (Short-leaf Pine), and *P. rigida* Mill. (Pitch Pine) (Krupa and Lacki 2002, Leopold et al. 1998).

In adjacent forest habitat, *Peromyscus leucopus* Rafinesque (White-footed Mouse) is the most abundant small mammal in early succession growth (Krupa and Haskins 1996, Krupa and Lacki 2002). White-footed Mice comprised 47% of the small mammals trapped in regenerating clear cuts three years post-harvest (Krupa and Haskins 1996). *Microtus pennsylvanicus* Ord. (Meadow Vole) and *M. pinetorum* LeConte (Pine Vole) were the next most common species, representing 32% and 16% of the total mammals trapped, respectively (Krupa and Haskins 1996).

We live-trapped small mammals in nine 1-ha plots (70 m x 155 m) that were established in 1997 as part of a study on compaction effects on forest regeneration (Thomas 1999). All nine plots were located on relatively flat, high elevation (≈300 m) mine land originally reclaimed to hay/pastureland during the late 1980s. Treatment plot layout was constrained by mining activity and regulations, and as a result, distance between plots varied between 70 m and 500 m. Our treatments included 1) standard (high compaction), 2) strike-off (light compaction), and 3) loose-dump (no compaction). High-compaction plots were graded until smooth using a bulldozer to remove all existing vegetation and then compacted to the industry standard (bulk density = 1.73 g/cm^3). High-compaction plots were level and exhibited no visible surface variation. Lightly compacted (strike-off) plots were created by dumping spoil into piles then leveling with one or two passes of a bulldozer. Strike-off plots exhibited more surface variation than the high-compaction treatment. Loose-dump plots exhibited the highest degree of surface variation (i.e., rocks up to 2 m in diameter with shaded recesses). A standard mixture of Q. *alba* L. (White Oak), *Fraxinus americana* L. (White Ash), *Pinus strobus* L. (Northern White Pine), *Q. rubra* L. (Northern Red Oak), *Juglans nigra* Thunb. (Black Walnut), *Paulownia tomentosa* Thunb. (Royal Paulownia), and yellow-poplar seedlings was planted in each plot. Additionally, all plots were hydro-seeded

to a standard mixture of low stature, non-aggressive grasses and legumes to limit erosion (Thomas 1999). This mixture included *Secale cereale* L. (Annual Rye), Perennial Rye, Orchardgrass, *Lotus corniculatus* L. (Birdsfoot Trefoil), and Chinese Lespedeza.

Methods

We used Sherman traps (7 cm x 9 cm x 23 cm) to capture small mammals during May 2004 and 2005. We trapped in May because small mammal abundance and trapping success is the highest locally during the spring (Krupa and Haskins 1996). We randomly placed trapping grids (50 m x 50 m; 0.25 ha) in each plot. Our traps were placed every 10 m, with a total of 36 traps per grid. In 2004, we trapped in compacted and loose-dump plots. In 2005, we were made aware of strike-off plots and incorporated this treatment during the second field season.

Each trapping bout lasted 3-days. We trapped one replicate of each treatment each night, and our trapping bouts were spaced 4 days apart. We baited traps with oats; cotton batting was added for bedding. We set traps in the late afternoon and checked them each morning starting at 0600 to ensure all animals were processed before temperatures became too high for the captured individuals. We determined species identity and applied a uniquely numbered ear tag to each individual prior to on-site release. Our small-mammal handling procedures were approved by University of Kentucky Institutional Animal Care and Use Committee (IACUC) protocol 00695A2004.

We did not establish study plots in adjacent forests as we were primarily interested in evaluating the effectiveness of each reclamation method relative to each other rather than adjacent forests. From an experimental design perspective, we considered our high-compaction plots to be homologous to control plots because this treatment type is the standard method used for surface mine reclamation throughout Appalachia. We measured habitat characteristics within 20 randomly placed 1-m^2 plots throughout each trapping grid. Within each 1-m^2 plot, we measured vegetation height, and estimated % woody canopy cover, % grass, % forbs, and, % bare ground. In each trapping grid, we also measured the number of woody stems <2 cm dbh, number of woody stems >2 cm dbh, and number of rocks >20 cm across in 10 randomly placed 5-m radius circular plots (Bonham 1989). We counted rocks if they had the potential to provide cover for small mammals (i.e., bare rocks flush to the soil surface were not counted). To reduce observer variability, one researcher conducted all habitat measures and estimates.

We compared species diversity and abundance among treatments using 95% confidence intervals (Johnson 1999). Statistical similarity was indicated if confidence intervals overlapped. We analyzed habitat variables using general linear models (PROC GLM; SAS 2000). If the overall model for a particular variable was significant, we preformed mean separation using least-square means (LSMEANS; SAS 2000) to determine which treatments were responsible for the differences. We arcsin square root transformed all percentage data prior to analysis. We accepted significance at an alpha of 0.05.

We used program R v. 4.2.1 to generate multiple regression models that indicated habitat variables important for distinguishing between plots with high and low White-footed Mouse abundance (R Development Core Team 2004). We created a customized script file to test all possible subsets of our habitat variables. We limited our models to incorporate up to two habitat variables to prevent over-parameterized results due to small sample size (n = 9 plots). We calculated Akaike's Information Criterion values corrected for small sample sizes (AICc), differences in AICc values (ΔAICc), likelihood values, and Akaike weights (ω) for each variable combination. We averaged competing models (<2 AICc units from the best model) that best predicted White-footed Mouse abundances (Burnham and Anderson 2002). If there was a potential for a quadratic relationship between a habitat variable and White-footed Mouse abundance, we then performed a quadratic transformation on that variable (Zar 1996). Additionally, we standardized all data prior to generating multiple regression models (Burnham and Anderson 2002).

Results

In 2004, we trapped 648 trap-nights (324 trap-nights x 2 treatments) and captured 170 different individuals but only of one species, the White-footed Mouse. Loose-dump plots had more White-footed Mice (n = 108, mean = 36, SE = 0.58) than compacted plots (n = 62, mean = 20.6, SE = 3.10; Table 1).

In 2005, we added the strike-off treatment and trapped 972 trap-nights (324 x 3 treatments) and captured 130 individuals of 4 species that included White-footed Mouse (n = 125), *P. maniculatus* Wagner (deer mouse; n = 2, *Mus musculus* L. (House Mouse; n = 2), and Meadow Vole (n = 1). Species richness was three (Meadow Vole, White-footed Mouse, and Deer Mouse), two (White-footed Mouse and house mouse), and two (White-footed Mouse, and Deer Mouse) for strike-off, compacted, and loose-dump plots, respectively. White-footed Mice made up 98% (295 of 300) of all individuals captured during both years combined. Because we captured so few individuals of other species, we limited subsequent analyses to measures of White-footed Mouse

Table 1. White-footed mouse abundance in each of three spoil reclamation treatments during the May 2004 and 2005 sampling periods on a reclaimed strip mine in eastern Kentucky. Note: means with different superscripted letters within each year were not significantly different (P > 0.05).

	Treatment				
	2004		2005		
Replicate	Compacted	Dumped	Compacted	Dumped	Strike-off
Grid 1a	18	37	5	15	19
Grid 1b	27	36	11	13	19
Grid 1c	17	35	4	18	21
Total	62	108	20	46	59
Mean	20.6^{A}	36^{B}	6.6^{A}	15.3^{B}	19.6^{C}
Std Error	3.10	0.58	2.19	1.45	0.66
95% CI	14.4–26.8	34.9–37.1	2.3–10.9	12.5–18.2	18.4–20.9

abundance. Among the treatments that were sampled in both years of this study (compacted and loose-dump) we captured fewer White-footed Mice in 2005 (n = 66) than in 2004 (n = 170) (Table 1). Loose-dumped plots had more White-footed Mice (n = 46, mean = 15.3, SE = 1.45) than compacted plots (n = 20, mean = 6.6, SE = 2.19), and strike-off plots (n = 59, mean = 19.6, SE = 0.66) had more White-footed Mice than both compacted and loose-dump plots (Table 1).

We found overall differences in % grass cover (F = 13.73, P < 0.001), % forbs cover (F = 5.99, P < 0.001), % bare ground (F = 14.96, P < 0.0001), % woody canopy cover (F = 4.06, P < 0.0002), % litter cover (F = 4.77, P < 0.0001), number of woody stems >2 cm dbh (F = 11.23, P < 0.001), and number of rocks >20 cm in diameter (F = 113.26, P < 0.001) among treatments (Table 2). Bare ground was highest in loose-dump plots (mean = 0.76, SE = 0.04), followed by strike-off plots (mean = 0.32, SE = 0.04), and lowest in compacted plots (mean = 0.17, SE = 0.04) (Table 2). Loose-dump and strike-off plots had greater canopy cover (mean = 0.29 with SE = 0.03, and mean = 0.24 with SE = 0.03, respectively) than compacted plots (mean = 0.06, SE = 0.03) (Table 2). Strike-off plots contained more litter (mean = 0.85, SE = 0.04) than loose-dump plots (mean = 0.65, SE = 0.04) (Table 2). Compacted and strike-off plots had more forb cover (mean = 0.52 with SE = 0.03, and mean = 0.52 with SE = 0.03, respectively) than loose-dump plots (mean = 0.27, SE = 0.03) (Table 2). Grass cover was highest in compacted plots (mean = 0.51, SE = 0.03), followed by strike-off plots (mean = 0.24, SE = 0.03), and lowest in loose-dump plots (mean = 0.06, SE = 0.03) (Table 2). Number of rocks >20 cm in diameter differed among all treatments, with highest values in loose-dump plots (mean = 100.0, SE = 2.38), followed by strike-off plots (mean = 26.2, SE = 2.38), and lowest in compacted plots (mean = 3.7, SE = 2.38) (Table 2). Loose-dump and strike-off plots had more woody stems >2 cm dbh (mean = 12.1 with SE = 0.87, and mean = 11.2 with SE = 0.87, respectively) than compacted plots (mean = 2.6, SE = 0.87). No differences were found among treatments for vegetation height (F = 0.91, P = 0.51) or number of woody stems <2 cm dbh (F = 1.24, P < 0.29).

Table 2. Habitat characteristics in each of three spoil reclamation treatments on a reclaimed strip mine in eastern Kentucky, 2004–2005. Note: Means in same column with different superscripted letters were significantly different at alpha = 0.05.

Treatment	% grass mean (SE)	% forbs mean (SE)	% bare mean (SE)	% litter mean (SE)	% canopy mean (SE)
Compacted	0.51^{A} (0.03)	0.52^{A} (0.04)	0.17^{A} (0.04)	0.77^{AB} (0.04)	0.06^{A} (0.03)
Strike-off	0.24^{B} (0.03)	0.52^{A} (0.04)	0.32^{B} (0.04)	0.82^{A} (0.04)	0.25^{B} (0.03)
Dumped	0.06^{C} (0.03)	0.28^{B} (0.04)	0.76^{C} (0.04)	0.65^{B} (0.04)	0.29^{B} (0.03)

	# of woody stems		# of	Vegetation
Treatment	(>2 cm dbh) mean (SE)	(<2 cm dbh) mean (SE)	large rocks mean (SE)	height (m) mean (SE)
Compacted	2.6^{A} (0.9)	8.3^{A} (3.1)	3.7^{A} (2.4)	0.15^{A} (0.02)
Strike-off	11.2^{B} (0.9)	9.1^{A} (3.1)	26.2^{B} (2.4)	0.13^{A} (0.02)
Dumped	12.1^{B} (0.9)	8.6^{A} (3.1)	100.0^{C} (2.4)	0.12^{A} (0.02)

We screened for correlation among habitat variables and eliminated % bare ground, % herb, % grass, % forb, % water, and number of woody stems >2 cm dbh; ($r^2 \geq 0.6$). The remaining habitat variables—% litter, % woody canopy, vegetation height, number of woody stems <2 cm dbh, and number of rocks >20 cm across—were analyzed with respect to White-footed Mouse abundance via multiple regression. Our analysis of these data resulted in two competing models that both included the variable % woody canopy (Table 3). After model averaging, based on coefficient estimates for each variable, % woody canopy (*t*-value: 2.40) accounted for the most variation in our data and gave our models better predictive power when included (Table 3). The quadratic transformation for number of large rocks was included in the 2nd competing model, but this variable's effect was indistinguishable from zero (t-value: 0.63).

Discussion

White-footed Mice occur most often where a combination of vegetative canopy, rocks, and course woody debris is present (Barry and Franq 1980)—conditions typically found in central Appalachian forest settings (Hamilton and Whitaker 1979). Kirkland et al. (1996) suggested that the accumulation of coarse woody debris facilitated White-footed Mouse recolonization of oak forests in Pennsylvania five months after it burned, whereas Krupa et al. (2005) attributed persistence of the species in recently burned forests in Eastern Kentucky to the presence of sheltering emergent rock. Typical mine reclamation compacts soils and thereby creates conditions which not only inhibits woody plant establishment and growth, but leaves a resultant substrate devoid of large surface rocks and course woody debris. In contrast, the two other reclamation techniques used in this study create uncompacted, structurally diverse surface conditions that appear to promote White-footed Mouse abundance, a finding congruent with studies conducted on surface mines elsewhere. Complex topography of mine spoils in Colorado supported diverse vegetation and more small mammals than compacted spoils (Steele and Grant 1982). Bramble and Sharp (1949) concluded that bare spoil on a

Table 3. Multiple regression results showing only competing models (Δ AICc < 2) with associated habitat variables that influenced White-footed Mouse abundance on a reclaimed strip mine in eastern Kentucky, 2004–2005.

ΔAICc[A]	ω[B]	% canopy	Rocks^2
0	0.673	2.439 ± 0.065[C]	-
1.442	0.327	5.309 ± 1.370	-2.257 ± 1.370
Model average estimates[D]	3.377 ± 1.407	-0.738 ± 1.165	
t-values[E]	2.40	-0.633	

[A]Difference of the "best" model's AICc (corrects for small sample size) value and competing model's AICc value.
[B]AICc weight, the probability that a model is indeed the "best" model.
[C]Coefficient and standard error.
[D]Average coefficient and standard error for individual habitat variables.
[E]Associated *t*-values for individual habitat variables based on a significance of 1.96.

Pennsylvania surface mine offered numerous crevices for small mammals, and that such habitats were more heavily used than had been thought.

Strike-off and loose-dumped plots had more White-footed Mice than standard plots. This finding supports the hypothesis that structural heterogeneity at the ground surface primarily influenced small-mammal relative abundance (Steele and Grant 1982). Strike-off plots may have offered a more optimal combination of vegetation and surface structure compared to loose-dump plots, and this difference may have been the reason we observed slightly higher White-footed Mouse abundance in strike-off plots compared to loose-dumped plots. Alternatively, this finding may have been a result of a low treatment replication. Although % woody canopy cover and number of large woody stems did not differ between strike-off and loose-dump plots, strike-off plots had more litter, grass, and forbs (Table 2). These three habitat features are found within the 0–7.6 cm vegetation stratum which is thought to be the habitat zone that primarily influences White-footed Mouse abundance (M'Closkey and Lajoie 1975). Further, habitats supporting dense mats of grass provided *Peromyscus* spp. with cover for travel and feeding (Wirtz and Pearson 1960). Additionally, our multiple regression models suggest that the presence of a woody canopy is a good predictor of White-footed Mouse abundance on these mined sites.

Loose-dump and strike-off treatments had higher White-footed Mouse abundance than the compacted treatment. However, these treatments all had lower species diversity than in adjacent forests (Krupa and Lacki 2002). The low species richness (n = 4) on our sites is a result consistent with the findings from studies conducted on coal surface mines elsewhere in the United States (Bramble and Sharp 1949, DeCapita and Bookout 1975, Hingtgen and Clark 1984). For example, the White-footed Mouse was the only species captured on surface mines in Pennsylvania (Bramble and Sharp 1949). In Colorado, rodent species richness and diversity also were lower on reclaimed mine spoils than in surrounding natural habitats (Steele and Grant 1982). In two previous small-mammal studies adjacent to our study site, at least half as many small-mammal species were recorded on reclaimed mines versus forests and low-elevation clearings (Krupa and Haskins 1996, Krupa and Lacki 2002). Moreover, none of the species observed during these studies were unique to reclaimed habitat (Krupa and Haskins 1996, Krupa and Lacki 2002). All of the species observed in our study, with the exception of the Deer Mouse, were found in grassy openings in a forest adjacent to our study sites (Krupa and Lacki 2002). Yet species found in grassy openings in the adjacent forests such as *Synaptomys cooperi* Baird (Southern Bog Lemming), *Blarina brevicauda* Say (Northern Short-tailed Shrew), Pine Vole, and *Reithrodontomys humulis* Audubon and Bachman (Eastern Harvest Mouse) were not captured in our study. We suggest that their absence in loose-dump and strike-off plots was influenced more by the distance from a source population (>800 m) rather than a lack of suitable habitat (Gottfried 1982). For example, forest gaps created by group selection timber harvest that were closer to existing oldfield habitats exhibited increased small-mammal richness of early-successional species in the Coastal Plain of South Carolina (Menzel et al. 2005). Within the central Appalachians of West Virginia to the northeast of our study site, Francl et al.

(2004) emphasized the importance of the configuration and type of surrounding habitats along with the small-mammal species pool for understanding species colonization responses to disturbance.

We cannot, however, rule out the possibility that the low small-mammal diversity and skewed relative abundance of captured individuals was the result of trap bias as we used only Sherman traps. For example, in the central and southern Appalachians, pitfalls were much more effective at capturing extant shrew species compared to other methods (Ford et al. 1997), whereas Moriarty (1982) found that White-footed Mice were especially susceptible to being caught with snap traps. Accordingly, had our animal care and use protocol allowed methods other than Sherman traps, it is possible we might have observed a greater diversity of small-mammal species on our plots.

Small mammals are an important part of terrestrial ecosystems and drive a variety of ecosystem processes (Brady and Weil 2002). Small mammals serve as prey for a variety of mammalian, avian, and reptilian predators (Mindell 1978, Yearsley and Samuel 1980). As such, their return to post-mining landscapes should be an important biodiversity consideration for reclamation goals. Conversely, small mammals can modify plant community composition and species distribution (Siege 1988) through foraging and burrowing in a manner that has landscape-level implications (Hole 1981, Taylor 1935). For example, Hingtgen and Clark (1984) suggested that small mammals influenced vegetation community development on reclaimed mines. Their roles as seed predators, herbivores, detritivores, and seed dispersers affect plant distribution and succession (Chamblin 2002), with Bramble and Sharp (1949) observing White-footed Mice seed predation causing failed Northern Red Oak establishment on Pennsylvania surface mines. Though not a concern in our study plots because seedlings were planted, a recent project to establish blight resistant *Castanea americana* Rafinesque (American Chestnut) on uncompacted mine spoil in eastern Kentucky failed due to seed predation by small mammals (C. Barton, University of Kentucky, Lexington, KY, pers. comm.).

Our findings suggest that loose-dump and strike-off plots are the best for White-footed Mouse abundance, as Graves (1999) found with increased tree productivity. Low small-mammal diversity, regardless of reclamation treatment, was likely due to the presence of low-quality habitat due to a poorly developed ground layer and soil compared to that found in undisturbed forest. Small-mammal diversity may have also been limited by 1) an insufficient amount of time since reclamation for some small mammal species to have colonized from surrounding forests, and 2) a relatively large matrix of non-forested reclaimed mine land between research plots and source habitats. We suggest that mine operators use reclamation methods that promote surface and vegetation heterogeneity and connectivity to source habitats to promote colonization and to meet the life requisites of a more diverse small-mammal community (Menzel et al. 2005). Additionally, until forest communities have been established on reclaimed mine land, it could become necessary for land managers to find ways to mitigate negative impacts small mammals have on seed survival if the establishment of ecologically and economically valuable oak species using acorns is planned. Alternately, it may be beneficial

to place oak regeneration plots on portions of reclaimed mines beyond the immediate dispersal capabilities of small mammals or that are surrounded by compacted mine spoil that inhibits small-mammal colonization. Therein, limited depredation of acorns by small mammals could promote oak regeneration success. Ultimately, a patch work of planted oak stands intermixed with naturally invading vegetation such as Black Locust, Yellow-poplar, *Rubus* spp., and associated grasses and forbs will result in the development of more diverse small-mammal communities on reclaimed surface mines in the region.

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