USE OF GRASSLAND AVIAN COMMUNITIES TO MONITOR RECLAMATION SUCCESS ON SURFACE MINE LANDS[1]

Shawn M. Rummel and Fred J. Brenner

Abstract. Grassland songbird communities have been on a steady decline for many years throughout their range. Recently, however, it has been discovered that several species of grassland birds are nesting on reclaimed surface mines. The use of surface mines by these species have been shown to be correlated with the size of the grassland, along with habitat characteristics and the dispersal of these habitats upon the landscape. The current paper provides a mechanism to use the structure and composition of avian communities to assess the initial and long term sustainability grassland habitats on reclaimed mined lands. The use of feeding guilds and biotic indices along with species composition and bird density provide a means to rapidly assess the sustainability of these systems. The authors provide several suggestions to enhance the number and diversity of bird species along with other wildlife using grasslands on reclaimed surface mines.

Key Words: Grasslands, bird communities, monitoring

Introduction

Since the passage of the Surface Mining and Control Act (SMCRA, 1977) the majority of surface mines in the eastern United States have been reclaimed as grasslands. Although SMCRA and state regulations provide for mine lands to be reclaimed as wildlife habitat, generally this is not a prime consideration in mine land reclamation. Because of the effect of mining on the topography and land use, their impacts on grassland bird communities has been a concern of wildlife managers for over two decades. Many bird species are considered to be habitat sensitive and, therefore, may be affected by these changes in vegetation and topography.

For over two decades investigators have proposed using avian assemblages as indicators of the impact of habitat disturbances and reclamation of damaged ecosystems (Bradford *et al.*1991;

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[2] Shawn M. Rummel is a senior biology major at Grove City College and Fred J. Brenner is a Professor of Biology, Grove City College, 100 Campus Drive, Grove City, PA

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Bryce *et al.*, 2002; Croonquist and Brooks, 1991; Glooschenko *et al.* 1988; Severinghaus, 1981; Szaro, 1986). In the Forest Preserve District of Dupage County, Illinois, Ludwig *et al.* (1999) compared the composition of avian communities on lands reclaimed as native prairie planted with big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), wild rye (*Emymus canadensis*), switchgrass (*Pa- nicum* and indian grass (*Sorghastrum nutans*) with a forb/grass habitat, comprised of timothy (*Phleum pretense*), ladino clover (*Trifolium hybridum*) and perennial rye (*Lodium pernne*) and a Eurasina meadow dominated by meadow fescue (*Festuca elatior*). Thirty-four bird species were observed using the prairie grasslands compared to 27 and 29 species using the forb/grass meadow and Eurasian grasslands, respectively. Grasshopper spar- rows (*Ammodramus savannarum*) were common inhabitants of all three grasslands (prairie 73%, forb/grass meadows 40%, Eurasian grasslands 41%) whereas; the savannah sparrow (*Passerculus sandwichensis*) preferred the prairie (41%) and Eurasian grasslands (38 %). Eastern meadowlarks (*Sturnella magna*) occurred at 23% of the sampling stations in forb/grass meadows compared with 50% of the sampling points in the Eurasian meadow. Although all these species are considered to be obligate grassland birds, it appears that their habitat preference varies among bird species, and may provide a mechanism to compare different reclamation strategies within or among different geographical regions.

Grasslands on reclaimed surface mines are not only beneficial to avian populations (Brenner and Kelly 1981; Brenner and Sterner, 1988; Wray *et al*., 1978, 1982), but also provide habitat for several species of small mammals, as well as amphibians and reptiles (Brenner *et al*., 1982; Brenner and Hofius, 1990). Although grasslands on reclaimed surface mines tend to be homogenous habitats, they provide the potential to create a variety of wildlife habitats, including those for rare and endangered species (Brenner, 1986, 1990, 2000).

Vegetation Characteristics and Considerations

With the initiation of the SMRCA regulations, surface mines have been reclaimed throughout much of the eastern coal regions using a mixture of cool season grasses and legumes, including fescue (*Festuca arundinacea*), blue grass (*Poa compressa*), timothy (*Phleum pratense*), clovers (*Trifolium pratense, T. repens*) and birdsfoot trefoil (*Lotus corniculatus*). These grasslands often remain dominated by cool season grasses and legumes for at least 20 years (Rummel and

Brenner, 2003) thereby providing habitat for grassland birds during this time frame. But it is has been suggested that the diversity of these grassland communities may be enhanced by using a mixture of warm and cool sea- son grasses and legumes, including big bluestem, little bluestem and indian grass in con- junction with timothy, blue grass and clovers, will benefit a variety of grassland species (Brenner, 2000; Brenner and Clark, 1987).

Another concern among wildlife managers is use of non-native or exotic species in the reclamation of mine lands. Although native grasses may also be used to reclaim surface mines, their establishment depends upon the date of seeding (Brenner, 2000). In North Dakota, Bjugstad and Whitman (1989) reported that within two years following the seeding of native grasses, native forb species (white prairie clover; wild licorice, *Glycyrrhizin lepidota*; prairie coneflower, *Ratibida spp.*; blazing star, *Liatris spp.* and milk vetch, *Astragalus spp.*) demonstrated exceptional emergence and growth; thereby, increasing species diversity.

The diversity of plant communities on mine lands depends at least in part on soil replacement and reconstruction of the mine site during reclamation. For over four decades, the removal, storage and replacement of topsoil has been the accepted practice for the reclamation of mined lands, but Schuman (2002) concluded that the direct placement of topsoil has better physical soil characteristics when compared to stockpiled topsoil. In addition, topsoil has also been shown to be an important seed-bank for achieving the high plant species diversity on reclaimed surface mines (Beauchamp *et al*., 1975; Hodder, 19- 77; Howard and Samuel, 1979; Rice 1989). These seed banks generally contain (a) more annuals than perennials, (b) more forbs than grasses, (c) more legume species, and (d) common weedy species that typically colonize disturbances or gaps in the vegetation (Rice, 1989). But according to Schuman (2002), the stockpiling of topsoil will reduce seed viability and these soils should be spread at a depth of 3-5 cm. Numerous studies have concluded that a shallow layer of topsoil will provide greater species diversity along with increased production of forbs and increased shrub density within 10 years after reclamation (Redente *et al.* 1997). Moreover, Bowen *et al*. (2002) reported that after 24 years, species richness and diversity indices were higher and total canopy cover was lower in areas without topsoil replacement. Based on these studies, the evolution of plant community diversity and density, an essential for erosion control (Miles *et al*., 1969 is dependant on the amount and depth of topsoil replacement during reclamation. Although the increase in diversity

of these reclaimed grasslands will provide additional stability to the systems, their relationship to evolution of avian communities on these sites remains to be determined.

Although native and reclaimed grasslands areas provide a diversity of wildlife habitats, they are rapidly becoming one of the most threatened ecosystems, especially in temperate climates. In addition to birds, these ecosystems also provide habitat for a wide diversity of reptile and mammal populations (Brenner, 2000; Brenner and Hofius, 1990). But to enhance and maintain a high diversity of wildlife species on the grasslands, there must be a specific emphasis on developing diverse plant communities during the reclamation of mine lands.

Methodology to Evaluate Avian Communities

The following methodology is designed to provide a rapid assessment to estimate the size; density, species richness and ecological relationships of grassland bird communities on reclaimed mine lands. The number and density (birds/ha) of each species comprising the bird communities can be estimated by a line transect - $P = n\ f(O)/2L$, where n is the number of animals sighted, L is the length of the transect and $f(O)$ is the estimated distance of sighting or vocalization from the transect line. For this study, the total number of species will be used as representative of species richness among the different years, but species richness (D) may also be expressed as $D = s \sqrt{N}$, where S is the number of species and N is the number of individuals. In addition to the size, density and diversity of avian communities, several authors have suggested using guilds as an additional tool to evaluate the ecological relationships among species as an additional tool to assess the success of reclamation efforts on disturbed lands (Bradford *et al.*, 1988; Brenner and Kelly, 1982; Brenner and Hofius, 1990; Brenner and Sterner, 1988). Previous studies indicate that the majority of birds using these grasslands are primarily ground foraging granivores (GS) with ground feeding insectivores (GI)/carnivores (GC) and omnivores (GO) being a minor component of the grassland bird fauna (Brenner and Kelly, 1981; Brenner and Hofius, 1990, Brenner and Rummel, 2003; Ingold, 2002). Species were then ranked 1 to 5 according to their relative abundance with 1 assigned to a grassland species common in the region and 5 to either a state or federal listed endangered species. A biotic index (BI) was calculated by multiplying the number species in each rank by the rank - ($BI = \sum 3x1+ 2x2+3x3…..2x5$). To assess the changes in grassland bird communities over time was surveyed

on six mine sites at five-year intervals for 25 years. All sites were reclaimed using the standard cool season grasses and legumes mixtures, creating Euroasian meadows as described by Ludwig *et al.* (1999) and were at least 50 ha in size.

Avian Communities as Indicators of Reclamation Success

As a result of habitat loss and fragmentation, grassland species have experienced the most severe, long-term population decline among North American birds (Brauning et al., 2001). However, reclaimed mine lands provide habitat for a diverse array of grassland bird species (Brauning et al., 1994, 2001; Brenner and Clark, 1987; Brenner and Kelly, 1982; Brenner and Hofius, 1990; Brenner and Sterner, 1988; Wray *et al*., 1978, 1982).

Although the number species and the density of birds/ha varied among years, ground foraging species, especially sparrows (GS) along with the red-winged blackbird (*Alelaius phoenicus*) (GO), tended to dominate the avian communities using these reclaimed grass- lands (Table 1). All mine sites supported five of the seven grassland sparrow species for at least 20 years post reclamation and, except for the vesper sparrow (*Pooecetes gramineus*), the other four species occurred on these mines 25 years after the initial establishment of these grassland communities. Henslow's (*Ammodramus henslowii*), grasshopper (*Ammodramus savannarum*) and savannah (*Passerculus sandwichensis*) sparrows were only observed during the breeding season on mines 25 years following reclamation. These three species may be more habitat specific than the other sparrows commonly occurring on reclaimed grasslands. The other ground foraging species using these grasslands were the dickcissel (*Spiza americana*) and the meadowlark (*Sturnella magna*), which were observed on mines 10-15 and <5 and 25 years of age, respectively, and the indigo bunting (*Passerina cyanea*) occurring periodically on grasslands between 10 and 25 years of age. The bobolink (Do*lichonyx oryzivorus*), horned lark (*Eremophia aipestriis*) and upland sandpiper (*Bartrama longicauda*) were the only ground insectivores occurring in these grasslands and all three species were more numerous on mines during the first five years following reclamation. Loggerhead shrikes (*Landius ludovicianus*) and short-eared owls (*Asio flammeus*) occurred on mines 5 and 25 years after reclamation and although loggerhead shrikes and short-eared owls feed on insects, small mammals and birds are a major part of their diet.

The calculated biotic index (BI) varied among years with the highest BI occurring 5 years (BI-26) and 25 years (BI-40) after reclamation (Table 2). The higher BI in both incidences was a result of three state listed endangered species using mine sites during these years. On mines 5

Table 1. Feeding Guilds, Abundance Ranking and Distribution of Grassland Birds occurring on Reclaimed Surface Mines in Northwestern Pennsylvania (GS-Ground Foraging Granivores, GO-Ground Foraging Omnivore. GI-Ground Foraging Insectivore, GC Ground Foraging Carnivore.

			Years Post Reclamation					
Species	Guild	Rank	1	5	10	15	20	25
Song Sparrow *Melospiza melodia*	GS	1	X	X	X	X	X	X
Chipping Sparrow *Spizella passerine*	GS	1	X	X	X	X	X	X
Field Sparrow *Spizella pusilla*	GS	1	X	X	X	X	X	X
Vesper Sparrow *Poocetes gramineus*	GS	1	X	X	X	X	X	
Grasshopper Sparrow *Ammodramus savannarum*	GS	4						X
Henslow's Sparrow *Ammodramus henslowii*	GS	5						X
Savannah Sparrow *Passerculus sandwichensis*	GS	4			X		X	
Indigo Bunting *Passerina cyanea*	GS	3			X		X	
Dickcissel *Spiza Americana*	GS	3			X		X	
Red-winged Blackbird *Agelaius phoeniceus*	GO	1	X	X	X	X	X	X
Eastern Meadowlark *Sturnella magma*	GO	2	X	X	X			X
Bobolink *Dolichonyx oryzivorus*	GI	3	X	X				X
Horned Lark *Eremophilia alpestris*	GI	4	X	X				
Loggerhead Shrike *Lanius ludovicianus*	GI/GC	5		X				X
Upland Sandpiper *Bartramia longicauda*	GI	5	X	X				
Short-eared Owl *Asio flammeus*	GI/GC	5		X				X

years after reclamation, the state listed endangered species were the upland sandpiper, short-eared owl and loggerhead shrike. Twenty-five years following reclamation, the state listed endangered species also included the short-eared owl and loggerhead shrike along with Henslow's sparrow. Overall, the BI increased from 15 in the first year after reclamation 29 in year 5, and then decreased to 13 and 8 for the years 10 to 20 years post reclamation and increasing to 40 after 25 years. But if the endangered species are not included in the BI, the BI would be 14 and 25 for years 5 and 25 following reclamation respectively.

Table 2. The Number of Grassland Bird Species, Abundance Rank, Biotic index and Density (Birds/ha) occurring of Surface Mines in Years Following Reclamation.

	Number of Species/Rank						
Age	1	2	3	4	5	Biotic Index	Density-Species/ha
1	5	1	1		1	15	12
5	5	1	1	1	3	29	15
10	5	1	2			13	4
15	5		1			8	7
20	5		1			8	6
25	5	3	2	2	3	40	3

The structure of grasslands on mine sites affects the size and density of avian communities using these habitats, as well as the individual species inhabiting these grasslands (Brenner and Kelly, 1982; Rummel and Brenner, 2003). The area coverage and structure of vegetative cover have been shown to be major factors affecting the number and density of breeding bird species using grasslands on reclaimed mine sites. (Chapman *et al.*, 1978; Madden *et al.*, 2000; Rummel and Brenner, 2003). Chapman *et al.* (1978) reported that the number of breeding species was associated with the percentage of vegetative cover in the 0-1 m layer. Likewise, Powell and Steidl (2000) indicated that the majority of nests occurred within a meter of the ground in a variety of cover types (Powell and Steidl, 2000). But in addition to area coverage of vegetation, plant height has also been shown to be correlated with the abundance of breeding bird populations (Rummel and Brenner, 2003; Madden *et al*., 2000). Of the nesting species that use reclaimed surface mines, grasshopper sparrows have the greatest overall success on reclaimed plots with a success percentage of 46% with the majority of nest predation occurring during incubation (Dixon, 1978). Therefore, grasshopper sparrow numbers should be increasing assuming that the majority of birds survive beyond fledging. Other species with high nesting

success include the red-winged blackbirds and eastern meadowlarks (Ingold, 2002), but it was not a dominant species in our studies.

Many of these grassland bird species are habitat specific, especially during the breeding season (Guerrieri *et al.*, 1992). Rummel and Brenner (2003) indicated that Henslow's sparrows, a state listed endangered species in Pennsylvania, may be an indicator species for evaluating the success of reclamation in terms of providing nesting cover for habitat specific bird species. The status of Henslow's sparrows and other grassland species may depend, in part, on the extensive grasslands being created on reclaimed mine sites throughout their range (Rummel and Brenner, 2003).

Because of the habitat specificity of the Henslow's sparrow, it may be an indicator species to evaluate reclamation success. For example, according to Swanson (1996), Henslow's sparrows prefer tall, dense vegetation characteristic of unmowed, ungrazed, and unburned areas, and Bajema *et al*. (2001) concluded that grasslands on reclaimed mined lands in the Midwestern United States supported abundant populations of Hens- low's Sparrows. These sparrows are also an area sensitive species (Swanson, 1996). The results of these studies suggest that reclamation efforts should strive to achieve a high degree of vegetative cover, increase the amount of ground layer vegetation, and provide for the future development of higher vegetational strata, while delaying canopy closure as long as possible (Chapman *et al*., 1978).

Herkert *et al*. (1993) suggested that to enhance the availability of grassland habitats that four management strategies should be developed: 1 preserve/restore large blocks of habitat, 2) create and maintain a mosaic of structural habitats, 3) remove/control woody encroachment into grasslands and 4) manage grasslands with periodic disturbance (i.e. fire, mowing, etc.), but previous studies indicate that mowing may be detrimental to grassland birds including Henslow's sparrows (Brauning *et al.*, 2001; Brenner and Rummel, 2003; Ingold, 2002). Also as beneficial as these practices may be to enhance and maintain the grassland habitats on abandoned mine lands, it may not be practical unless these lands are being managed by wildlife agencies or private conservation organizations.

Conclusions and Recommendations

Based on this and previous studies, obligate grassland birds may be used as indicators of long-term reclamation success. Although the development of bird assemblages may vary among different geographic regions, they should include both common and rare obligate grassland species. For the northeast, these assemblages should include common habitat generalists (i.e. song sparrow, field sparrow), as well as more habitat specialists (grasshopper sparrows, bobolinks), including at least one or more state or federal listed endangered species. Because of the correlations between the amount and structure of grassland plant communities and the size and diversity of grassland bird communities, these characteristics may be used as indicators of reclamation. In general, passerine birds prefer areas with tall vegetation and extensive vegetative cover, which decreases nest predation, thereby increasing breeding success. In addition to these characteristics, the patch size has also been shown to be an important feature in grassland habitats (Ribic and Sample, 2001). Horn et al. (2000) also concluded that passerines, the Henslow's sparrow in particular, were positively correlated with field size and, according to Bajema and lima (2001), these sparrows have the tendency to avoid habitat edges and are a landscape in- sensitive species.

Based on numerous previous studies, the following set of minimal habitat requirements of passerine birds may be used as indicators of reclamation success for mined lands: 1) the vegetation height should be at least 1 meter in height with a percent cover of 40-85% (Chapman *et al*. 1978), 2) canopy cover of 40% or less, and 3) adequate patch size to reduce interactions between territorial species. With the availability of GIS technology (Lauver *et al.*, 2002), the disposition of grasslands upon the landscape could be incorporated into life history models for individual species or communities as a further aid to resource mangers and planners. Further studies are necessary in order to estimate the critical field size for grassland birds but available data suggest a patch size of at least 50 ha to maximize the distance from the edge habitat. Reclaimed surface mines, as well as other disturbed lands, have a tremendous potential to increase species diversity and should be managed to insure the continual availability of grassland habitats for vast array of species that use these ecosystems for the various phases of their life histories.

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