Abundance and Habitat Use of Winter Raptors on a Reclaimed Surface Mine in Southeastern Ohio

Danny J. Ingold[1], Department of Biology, Muskingum University, New Concord, OH

Abstract. Numerous studies have documented the benefits of reclaimed surface mines to breeding grassland birds, but few studies have focused on the use of such grasslands by winter raptors. I surveyed birds of prey along a driving transect on and around a 3,700 ha reclaimed surface mine in east-central Ohio from early January through mid-April 2009. My objective was to use these survey data to assess the relative abundance of migratory and winter resident raptors, as well as to examine potential habitat associations, perching preferences and morning versus afternoon activity patterns in each species. I sighted 382 total birds; red-tailed (*Buteo jamaicensis*) and rough-legged hawks (*B. lagopus*) had the greatest index of relative abundance followed by American kestrels (*Falco sparverius*) and northern harriers (*Circus cyaneus*). Numbers of rough-legged hawks, the only purely migratory species in this region, declined from January through April, while numbers of red-tailed hawks and harriers increased. Rough-legged hawks, kestrels and harriers were found in open grasslands at a rate greater than expected by chance alone, whereas red-tailed hawks were found disproportionately more often along forest edges. Most rough-legged hawks and harriers were observed soaring rather than perched, while approximately equal numbers of red-tailed hawks were observed soaring or perched in large trees. Most kestrels were observed on utility wires or in small trees. That moderate to high numbers of obligate grassland raptors were observed in this study, support previous findings that reclaimed surface mines provide important winter habitat for these species.

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INTRODUCTION

Populations of several grassland bird species, including birds of prey, are declining in the eastern United States (Askins 1993, Helzer and Jelinski 1999, Knopf 1994, Swanson 1996, Sauer and others 2008), largely as the result of habitat fragmentation and loss (Askins 2002, Peterjohn 2003, Vickery and others 2005). Reclaimed surface mines, although heavily disturbed ecosystems, provide suitable nesting habitat for several obligate grassland bird species (Monroe and Ritchison 2005, Galligan and others 2006, Vukovich and Ritchison 2006). A growing body of research has focused on the nesting success of several grassland passerine species on reclaimed surface mines (Monroe and Ritchison 2005, Galligan and others 2006, Ingold and others 2010), but little is known about birds of prey, particularly during the winter months. Nesting northern harriers (*Circus cyaneus*) have been reported on reclaimed surface mines in Ohio (Peterjohn and Rice 1991), Pennsylvania (Rohrbaugh, Jr. and Yahner 1996) and Kentucky (Vukovich and Ritchison 2006). Vukovich and Monroe (2005) examined the abundance of winter raptors on reclaimed mined lands in Kentucky, while Vukovich and Ritchison (2008) reported on the foraging behavior of winter northern harriers and short-eared owls (*Asio flammeus*) on a reclaimed surface mine in Kentucky. Beyond this however, little research has focused how winter raptors use reclaimed surface mines during the winter months.

Northern harriers, short-eared owls (*Asio flammeus*) and rough-legged hawks (*Buteo lagopus)* are obligate grassland species during the winter months (Baker and Brooks 1981, Bildstein 1988, Martell 1991, Holt and Leasure 1993), and are heavily reliant upon voles (*Microtus spp.*) for food (Colvin and Spaulding 1983, Village 1987, Grant and others 1991, Korpimaki and Norrdahl 1991, Poulin and others 2001). Both northern harriers and short-eared owls require relatively large, contiguous grassland tracks for hunting during the winter months (Holt and Leasure 1993, MacWhirter and Bildstein 1996, Walk and Warner 1999, Wilson and others 2010), and both have undergone population declines during the past 30 to 40 years in much of their North American ranges largely as the result of habitat loss (Robbins and others 1986, Tate 1986, Holt and Leasure 1993, MacWhirter and Bildstein 1996, Sauer and others 2008). The Wilds, a 3,700 ha reclaimed surface mine in southeastern Ohio, includes about 2,500 ha of open grasslands and brushy areas that attract a variety of raptor species during the winter months including harriers, short-eared owls and rough-legged hawks (pers. ob.). Populations of meadow voles (*M. pennsylvanicus*) on portions of the Wilds have been documented to be robust (Dooley and Murray 2006), and likely serve as an important food source for many of these raptor species.

One way to obtain abundance and habitat distribution data on winter raptors is through the use of roadside surveys (Fuller and Mosher 1981). Indeed such surveys have been employed to obtain information on raptor relative abundance/density (Eakle and others 1996, Boano and Toffoli 2002, Pearlstine and others 2006), habitat preferences (Bohall and Collopy 1984, Preston 1990, Yahner and Rohrbaugh 1998, Garner and Bednarz 2000, Littlefield and Johnson 2005), perch preferences (Bohall and Collopy 1984, Meunier and others 2000, Leyhe and Ritchison 2004) and activity patterns (Meunier and others 2000). The objectives of this research were to determine: (1) the relative abundance of migratory and resident wintering raptors on a reclaimed surface mine, (2) potential habitat associations of these raptor species, (3) perch preferences of each species, and (4) morning versus afternoon activity patterns of each species.

STUDY AREA AND METHODS

The Wilds (International Center for the Preservation of Wild Animals) which is located in Muskingum, Guernsey and Noble counties in southeastern Ohio (Fig. 1), was initially mined by the Ohio Power Coal Company in the 1940s and 1950s. After a 10 to 15 year hiatus, the land was again mined from 1969-1984 and subsequently converted to mostly hilly grasslands with scattered forest patches and drainage ponds and lakes. Ingold (2002) provides a description of the dominant vegetation types found on the Wilds. A little less than half of the study area incorporates land adjacent to the Wilds along its western, southern and eastern boundaries owned mostly by American Electric Power (AEP), but also includes a few private farms (Fig. 1). The AEP land is reclaimed mine land

[1]Address correspondence to Danny J. Ingold, Department of Biology, Muskingum University, New Concord, OH 43762. Email: ingold@muskingum.edu

FIGURE 1. Thirty-six km driving transect used to survey winter raptors from January through April 2009 on and around the Wilds (white hash marks). The boundry of the Wilds is outlined in white cross bars. The majority of the land along the suvey route but not the Wilds is owned by the American Electric Power Company. There is a small portion of private land at the southwest tip of the survey route (top = north, bottom = south). The lighter shaded areas on the map are reclaimed grasslands or pastures and the darker areas are forests and scrublands.

as well and is similar to the Wilds in species composition but also includes a few scattered patches of Austrian pine (*Pinus nigra*) and green ash (*Fraxinus pennsylvanica*) planted during the last 20 years. The private farm land consists of scattered woodlots and a couple of areas of contiguous forest that were not previously mined.

I established a 36 km driving transect through the study area and used *ArcMap 9.3* and *ESRI, Inc.* global information systems software to estimate the amount of each of ten major habitat categories located within a 500 m buffer on each side of the road (Fig. 1). Raptors were not included in the counts that were clearly outside the bounds of this buffer although in some instances I had to approximate whether this was the case. The habitat categories included open grassland (< 20 percent woody vegetation; 31.5 percent), moderate grassland (20-60 percent woody vegetation; 11.3 percent), heavy autumn olive (*Elaeagnus umbellata*; 7.6 percent), heavy sericea lespedeza (*Lespedeza cuneata* ; 1.7 percent), Austrian pine reclamation (3.8 percent), green ash reclamation (0.4 percent), unmined contiguous forest (21.5 percent), spoils forest (forest that had grown back since reclamation; 8.2 percent), forest edge (50 m zone extending from unmined or spoils forest edge; 11 percent) and water (drainage lakes; 3 percent). The total transect area in which raptors were tallied was approximately 30.8 km^2 (3080 ha).

I conducted two transect surveys weekly, usually three days apart, from early January through mid-April 2009 for a total of 28 surveys (1,008 total km). Surveys were initiated at 1000 and 1400 hours respectively in order to examine for a time of day effect on raptor activity. I started at opposite ends of the transect each week and rotated morning vs. afternoon starts on a weekly basis in order to avoid potential biases (see Bunn and others 1995). I traveled between 30 to 40 km/hour (see Bohall and Collopy 1984) and employed a field assistant so that raptors could be effectively spotted on both sides of the road. Whenever a raptor was spotted within the approximate 500 m buffer zone on either side of the road, I stopped to record the species, habitat type and perch type. If the bird was soaring I recorded the habitat type it was nearest when it was initially observed. Transects were conducted in a variety of weather conditions, but were not conducted during periods of precipitation (rain or snow).

Line transects are considered to be one of the most effective techniques used to estimate the relative abundance of raptors (Fuller and Mosher 1987). Although driving transects are typically non-linear, they may be considered equivalent to a line transect when determining the relative abundance of roadside birds (Eakle and others 1996). To estimate the relative abundance of each species, I used a modification of the index developed by Woffinden and Murphury (1977) for diurnal raptors (see also Vukovich and Monroe 2005). This index (linear density) is obtained by dividing the total number of individuals of a single species on all surveys by the total number of km traveled on all surveys multiplied by 100 (i.e., raptors/100 km). The sample size for only four of the nine species observed (red-tailed hawk, *B. jamaicensis*; rough-legged hawk; American kestrel, *Falco sparverius*; and northern harrier) was sufficiently large to include in statistical analyses. I used chi-square tests to examine for differences between habitat use by each species relative to habitat availability. In order to facilitate these analyses, I combined some of the ten habitat categories listed above to form five: grassland (42.8 percent), contiguous forest (29.7 percent), forest edge (11 percent), autumn olive (7.6 percent) and other (8.9 percent). I used a paired t-test to test for time-of-day effects (morning vs. afternoon totals for each week were paired) for each of the four main species. I used a linear regression analysis to determine if there was a relationship between raptor numbers and the progression of time.

RESULTS

I traveled a total of 1008 km and observed nine raptor species (382 sightings); only five species, however, included 15 or more sightings (Table 1). The overall abundance for all species combined was 38.0 raptors/100 km (Table 1). Red-tailed hawks and rough-legged hawks had the greatest relative abundance (17.7/100 km and 11.4/100 km respectively; Table 1). I observed a total of 178 red-tailed hawks, 115 rough-legged hawks, 43 kestrels and 26 harriers (Table 1). Only a single short-eared owl was observed, a species that is typically more common on this study site during the winter months (pers. ob.). The number of rough-legged hawks, a winter migrant to southern Ohio, declined significantly ($F = 14.7$, $P < 0.001$, $df = 27$) from January through April, while the number of northern harriers, a predominately winter resident, increased slightly, but not significantly, during the study ($F = 0.24$, $P > 0.05$, $df = 27$) (Fig. 2). The number of red-tailed hawks, a year-round resident, increased slightly but not significantly across time ($F = 1.70$, $P > 0.05$, $df = 27$), while the number of American kestrels, also a year-round resident, stayed about the same ($F = 2.13$, $P > 0.05$, $df = 27$) (Fig. 3). Ospreys showed up in late March when the lakes were ice free and were seen consistently thereafter on a nest tower near one of the lakes (Table 1). Roughly equal numbers of the four most prevalent species were observed in the mornings and afternoons; paired t-tests revealed no significant time of day effect for any of these species.

The majority of rough-legged hawks, northern harriers and American kestrels were observed in open grass lands, while most red-tailed hawks were observed along forest edges (Table 2). Relatively few sightings of any species occurred in grasslands heavily encroached upon by autumn olive or sericea lespedeza, while about 10 percent of rough-legged hawks, harriers and kestrels were observed on grasslands with planted Austrian pine. Chi-square

Table 1

Total number of each raptor species and the number of raptors/100 km (index of abundance) for each species on a reclaimed surface mine (the Wilds) in Ohio.

Species	Number Observed	Percent of total	Raptors/ 100 km
Red-tail Hawk (*Buteo jamaicensis*)	178	46.6	17.7
Rough-legged Hawk (*B. Lagopus*)	115	30.1	11.4
American Kestrel (*Falco sparverius*)	43	11.3	4.3
Northern Harrier (*Circus cyaneus*)	26	6.8	2.6
Osprey (*Pandion haliaetus*)	15	3.9	1.5
Red-shouldered Hawk (*B. lineatus*)	2	<1.0	0.2
Sharp-shinned Hawk (*Accipiter striatus*)	1	<1.0	0.1
Short-eared Owl (*Asio flammeus*)	1	<1.0	0.1
Golden Eagle (*Aquila chrysaetos*)	1	<1.0	0.1
Total abundance (Linear Density): 38.0/100 km			

analyses revealed that rough-legged hawks, harriers, kestrels and red-tailed hawks all occupied certain habitats (open grassland for the first three and forest edge of red-tailed hawks) in greater proportions than would be expected by chance (rough-leggeds = $X^2 = 26.9$, df = 4, $P < 0.01$; harriers = $X^2 = 54.9$, df = 4, $P < 0.01$; kestrels = $X^2 = 49.4$, df = 4, $P < 0.01$; and red-taileds = $X^2 = 27.0$, df = 4, $P < 0.01$).

The majority of rough-legged hawks and northern harriers were observed soaring rather than perched whereas about equal numbers of red-tailed hawks were observed soaring or perched in large trees (Table 3). The majority of American kestrels were observed on utility wires while most ospreys were seen on a nest platform (Table 3).

DISCUSSION

The combined abundance of raptors in this study as a measure of linear density (38 raptors/100 km) was lower than what Vukovich and Monroe (2005) reported for raptors on a reclaimed surface mine in west-central Kentucky (86.5/100 km). Conversely, my findings were greater than those reported by Sferra (1982) in central Kentucky (24.6 raptors/100 km) and Bildstein (1987) in central Ohio (8.4 raptors/100 km), although these studies were not conducted on reclaimed surface mines. I observed roughly the same percentage of red-tailed hawks (46.6 percent) as reported by Vukovich and Monroe (2005) (39.4 percent) and Yahner and Rohrbaugh, Jr. (1998) on a reclaimed surface mine in Pennsylvania (45.7 percent). However, I observed a higher percentage of rough-legged hawks (30.1 percent vs. 2.8 percent) and lower percentage of northern harriers (6.8 percent vs. 32.9 percent) than Vukovich and Monroe (2005). The density of harriers reported by Vukovich and Monroe (2005) is high (28.5/100 km) relative to what I observed for this species on this study site (2.6/100 km). Nonetheless, the harrier density I report here is greater than those reported by Andres (1994), Bildstein (1987) and Sferra (1982). Both Vukovich and Monroe (2005) and Yahner and Rohrbaugh, Jr. (1998) observed a higher percentage of American kestrels than I report here (17.3 percent and 43.4 percent respectively vs. 11.3 percent in this study). Yahner and Rohrbaugh, Jr. (1998) did not report seeing any short-eared owls and Vukovich and Monroe (2005) reported seeing only two individuals (< 1 percent), while I observed only a single individual (< 1 percent). Winter densities of rough-legged and red-tailed hawks as well as kestrels and short-eared owls have been reported to be positively associated with vole numbers (Baker and Brooks 1981; Village 1982, 1987; Poulin and others 2001). It is possible that lower-than-average vole densities on this study site (although I have no direct evidence for this since I did not trap voles) could help to explain the low numbers of short-eared owls I observed, as well as modest numbers of harriers and kestrels. Poulin and others (2001) reported that short-eared owls in their study were nomadic and showed up only during the year when vole densities were high. Potentially low vole densities however, might also be expected to result in low densities of rough-legged hawks, which was not the case in this study. Unlike the other raptors in this study, rough-legged hawks are strictly an arctic tundra-nesting species (Bechard and Swem 2002), and as such are perhaps more likely to seek out more extensive open areas (e.g. grasslands and wetlands) than harriers and kestrels during the winter months. Bosakowski and Smith (1992) suggested that wintering rough-legged hawks in New Jersey were attracted to open wetlands because of the structural similarity between these wetlands and the arctic tundra. Perhaps, independent of vole numbers, rough-legged hawks may be attracted to reclaimed surface mines during the winter months because these extensive grass and shrublands are also structurally similar to the arctic tundra.

Of the four predominate species reported here only rough-legged hawks declined significantly from January through mid-April. Red-tailed hawks and kestrels are year-round residents in Ohio (Peterjohn and Rice 1991) and northern harriers, although predominately a wintering species in southern Ohio, have been reported to nest on reclaimed grasslands in the south-central portion of the state (Peterjohn and Rice 1991). Conversely, rough-legged hawks are strictly a winter resident in Ohio (see Bechard and Swem 2002) and thus it is not surprising that their numbers declined from winter to early spring in this study.

Northern harriers, rough-legged hawks and American kestrels along my transect route were observed proportionally more frequently in open grasslands versus other habitats. Vukovich and Monroe (2005) reported observing harriers, kestrels and red-tailed hawks more frequently in tall grass habitats during winter while Yahner and Rohrbaugh, Jr. (1998) observed more harriers and kestrels on reclaimed grasslands than expected by chance. I observed more red-tailed hawks along forest edges than any other habitat type whereas Vukovich and Monroe (2005) reported seeing more red-taileds in tall grass habitats. This, however, could be a reflection

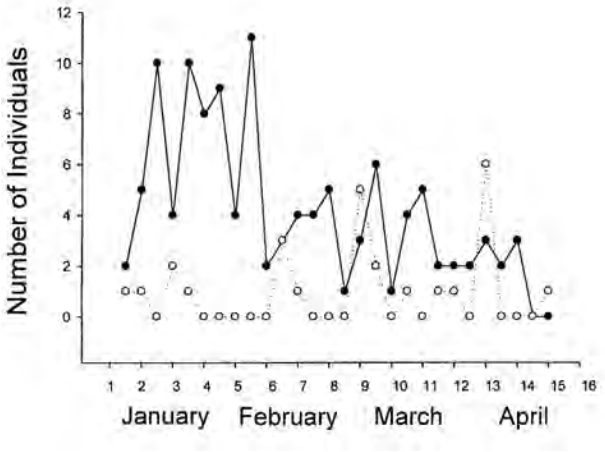

Figure 2. Numbers of rough-legged hawks (solid lines) and northern harriers (hashed lines) seen on 28 transect surveys from 5 January through 16 April 2009. Numbers on x axis represent weeks.

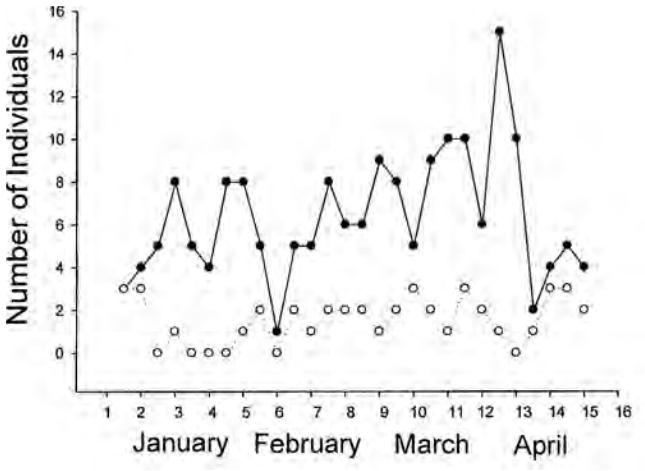

Figure 3. Numbers of red-tailed hawks (solid lines) and American kestrels (hashed lines seen on 28 transect surveys from 5 January through 16 April 2009. Numbers on x axis respresent weeks.

of a higher percentage of forest and forest edge habitat in this study (~40 percent) relative to the area surveyed by Vukovich and Monroe (2005) which is described as primarily open grassland. Yahner and Rohrbaugh, Jr. (1998) observed red-taileds on mined grasslands in northwestern Pennsylvania at rates greater than predicted by chance. These habitat associations, particularly those for harriers and rough-legged hawks, are not surprising given that these species are obligate grassland specialists during the winter months (Baker and Brooks 1981, Bildstein 1988, Bechard and Swem 2002). The number of red-tailed hawks I observed in open grasslands gradually declined with time as birds began initiating nesting in late March. Nonetheless red-tailed hawks and kestrels, both resident species, used open grasslands extensively during this study as well, which was likely at least in part a reflection of food availability.

I did not detect a time-of-day effect for any of the four most common species in this study. Ferguson (2004) reported seeing more raptors between 1000 to1400 h than during any other time of day, with the exception of northern harriers, most of which were seen after 1400 h. Bildstein (1987) reported more activity for red-tailed and rough-legged hawks and kestrels on grasslands after 1100 h, whereas harriers were more active during the early morning and later afternoon hours. My transect surveys occurred from 1000 to1200 and 1400 to1600 hours, the approximate time period during which Ferguson (2004) reported his highest raptor activity. Because I did not run transects during the early morning or late afternoon hours, I may have missed the peak activity period for northern harriers. My observations do suggest that the most common raptors in this study were equally conspicuous on perches and on the wing, both in the mornings and afternoons.

The vast majority of northern harriers I observed (93 percent) were in flight, a finding similar to that reported by Bohall and Collopy (1984) for harriers in Florida (99 percent). Bildstein (1979), Ferguson (2004), and Pearlstine and others (2006) all reported that about 60 percent of the harriers they observed were in flight. The perching percentage of red-tailed hawks in this study (57 percent) is slightly higher than that reported by Bohall and Collopy (1984) (48 percent), but lower than reported by Ferguson (2004) (70 percent). The number of forest patches and amount of edge in this study provided an abundance of suitable natural perch sites for red-tailed hawks, the majority of which were observed in large trees along forest edge. Fifty-two percent of the rough-legged hawks I observed were perched, mostly in isolated large trees surrounded by open grasslands. Ferguson (2004) reported that about 70 percent of the rough-legged hawks he observed were perched, but in contrast to my findings, mostly on power poles and fence posts. The majority of kestrels I observed (46 percent) were perched on utility wires, although 19 percent were observed in small trees. Pearlstine and others (2006) reported that 97 percent of the kestrels they observed were on utility wires or poles, while Ferguson (2004) noted that 86 percent of the kestrels he observed were on utility wires. Certainly the frequency of perching versus soaring in winter raptors, as well as the choice of perches, is influenced by the availability and types of perch sites in a given area. In this study, the number of isolated trees scattered in open grassland, likely provided a suitable perch alternative for both kestrels and rough-legged hawks, in addition to wires and power poles.

The moderately high densities of obligate grassland raptors, (rough-legged hawks and northern harriers) on this study transect, relative to those reported by Sferra (1982) and Bildstein (1987) (and relative to adjacent areas in this region of Ohio), suggest that this reclaimed surface mine is providing valuable habitat for these species. Although only 43 percent of this study transect is

Table 2

Percent of total raptor individuals observed in each of the 10 habitat categories on the Wilds. Only the five most prevalent species are shown here. RTH = Red-tailed Hawk, RLH = Rough-legged Hawk, AMK = American Kestrel, NHA = Northern Harrier and OSP = Osprey. The habitat categories listed below were combined into five larger categories in order to facilitate chi-square analyses on habitat assocciations. These categories included grassland (open and moderate grassland; 42.8 percent) contiguous forest (unmined forest and spoils forest; 29.7 percent), forest edge (11.0 percent), autumn olive (7.6 percent) and other (lespedeza, ash and water; 8.9 percent)

Habitat Type (percent of total)	RTH	RLH	AMK	NHA	OSP
Open Grassland (31.5%)	31.0	61.0	76.0	82.0	7.0
Moderate Grassland (11.3%)	3.0	10.0	5.0	3.5	0.0
Autumn Olive (7.6%)	2.0	3.0	0.0	0.0	0.0
Sericea Lespedeza (1.7%)	1.0	1.5	2.3	0.0	0.0
Austrian Pine (3.8%)	3.0	10.0	10.0	11.0	0.0
Green Ash (0.4%)	0.0	0.0	2.3	0.0	0.0
Unmined Forest (21.5%)	18.0	5.0	2.3	0.0	0.0
Spoils Forest (8.2%)	0.0	0.5	0.0	0.0	0.0
Forest Edge (11%)	42.0	9.0	2.1	3.5	0.0
Water (3%)	0.0	0.0	0.0	0.0	93.0*

*Ospreys observed on nest tower beside drainage lake surrounded by Open grassland.

Table 3

Percent of total raptor individuals observed on each of eight perch types on the Wilds. Only the five most prevalent species are show here. RTH = Red-tailed Hawk, RLH = Rough-legged Hawk, AMK = American Kestrel, NHA = Northern Harrier and OSP = Osprey. Since many observations occurred of birds in flight, soaring is included as a category here.

Perch Type	RTH	RLH	AMK	NHA	OSP
Large Tree (> 5 m in height)	40.0	26.0	5.0	0.0	0.0
Small Tree (< 5 m in height)	3.0	15.0	19.0	0.0	0.0
Fence Post	0.0	2.0	0.0	7.0	0.0
Utility Pole	0.5	6.0	0.0	0.0	6.7
Utility Wire	1.0	2.0	0.0	0.0	0.0
Ground	1.0	2.0	0.0	0.0	0.0
Hay Bale	0.5	0.0	2.0	0.0	0.0
Nest	11.0	0.0	0.0	0.0	80.0
Soaring*	43.0	48.0	28.0	93.0	13.3

comprised of open grasslands, the majority of raptors (with the exception of red-tailed hawks) were observed on these grasslands where populations of small mammals, particularly meadow voles, serve as an important food source during the winter months. Indeed the amount of contiguous grasslands on a reclaimed surface mine is likely to be an important factor that influences raptor abundance during the winter months. However, as Vukovich and Monroe (2005) pointed out, other factors including prey availability, weather conditions (see also Grove 2010) and natural year-to-year variation in raptor abundance, probably also contribute to the variation in winter raptor abundance on different grassland sites. Nonetheless, in order to sustain viable populations of winter raptors in this region (especially obligate grassland species), it will be important to maintain at least some of the open integrity of reclaimed surface mines. Although some raptors in this study were observed in tracts of young Austrian pine and to a lesser extent, autumn olive, it is probable that as these patches mature and spread, obligate grassland raptors will use them less frequently. If a long-term management goal on reclaimed surface mines is to maintain healthy populations of winter raptors, it will be important to control the encroachment of woody vegetation, particularly autumn olive, which reproduces asexually and spreads rapidly.

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