

Foraging Behavior of Short-eared Owls and Northern Harriers on a Reclaimed Surface Mine in Kentucky

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Abstract - Current procedures for reclaiming surface mines have produced many hectares of open grasslands. *Asio flammeus* (Short-eared Owl) and *Circus cyaneus* (Northern Harrier) are regularly found in such grasslands, but little is known about the suitability of these areas as raptor habitat. Our objective was to quantify the hunting behavior of Short-eared Owls and Northern Harriers, and characterize the vegetation in areas used by foraging Short-eared Owls during the non-breeding season on a reclaimed surface mine in Muhlenberg and Ohio counties, KY, from 1 January–1 May 2002. Northern Harriers and Short-eared Owls foraged in flight during our study, with no instances of perch-hunting observed, and initiated attacks primarily in areas dominated by either *Lespedeza* sp. (sericea) or *Festuca* sp. (fescue). Attack success rates were 7% and 10.9% for Harriers and Short-eared Owls, respectively, both within the range of success rates previously reported. Analysis revealed that areas used by foraging Short-eared Owls had shorter, less-dense vegetation than unused areas. The use of areas with shorter, less-dense vegetation by Short-eared Owls might increase prey detectability and increase attack success. The use of hunting behaviors and attack success rates similar to those reported in previous studies conducted in unmined habitats suggest that reclaimed surface mine grasslands in Kentucky provide suitable habitat for Northern Harriers and Short-eared Owls during the non-breeding season.

Introduction

Grasslands are among the most threatened habitats in North America (Jones and Bock 2002), and many grassland bird populations are declining at rates exceeding those of forest species (Herkert 1994). Populations of two grassland raptors, *Asio flammeus* Pontoppidan (Short-eared Owls) and *Circus cyaneus* Linnaeus (Northern Harriers), have declined over the past several decades (Sauer et al. 2005). Although few investigators have attempted to determine the reasons for this decline, available data suggest that conversion of grasslands to croplands, disrupted fire regimes, and fragmentation of remaining grassland habitats have been important factors (Melvin et al. 1989, Serrentino 1992).

Although native grasslands are scarce, current procedures for reclaiming surface mines in Kentucky have produced many hectares of open grasslands. In western Kentucky, coal-mining activities in the Shawnee Hills (or Western Coal Fields) have converted large areas of upland forest and farmland to grasslands (Palmer-Ball 1996). For example, the Peabody Wildlife Management Area (WMA) in Ohio and Muhlenberg counties comprises roughly

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25,000 ha, with most of the area consisting of reclaimed grasslands. The use of reclaimed surface mines by Northern Harriers was reported in the 1970s in southern Indiana (Palmer-Ball 1996). Recent observations of Northern Harriers and Short-eared Owls indicate that these raptors, and several other species of raptors, occur regularly on reclaimed surface mines during the breeding and non-breeding seasons in Kentucky (Machniak and Elliott 1997, Palmer-Ball 1996) and other locations in the eastern United States (Rohrbaugh and Yahner 1996, Yahner and Rohrbaugh 1998).

Although previous research revealed that Short-eared Owls, Northern Harriers, and other species of raptors use reclaimed surface mines in Kentucky (Palmer-Ball 1996, Vukovich and Monroe 2005), little is known about the suitability of these areas as raptor habitat. Clearly, more information is needed concerning the use of reclaimed surface mines by raptors, such as Short-eared Owls and Northern Harriers, and, specifically, how the hunting behavior of raptors using reclaimed habitats compares to that of raptors in non-reclaimed areas. Our objective was to quantify the hunting behavior of Short-eared Owls and Northern Harriers and characterize vegetation in areas used by these raptors during the non-breeding season.

Methods

We conducted our study on the Peabody Wildlife Management Area (WMA), located in Muhlenberg and Ohio counties of west-central Kentucky. Peabody WMA includes 25,000 ha of reclaimed coal-mined land. The open areas of the Peabody WMA consist primarily of non-native vegetation, including *Lespedeza* sp. (sericea), *Festuca* sp. (fescue), *Coronilla* sp. (crown vetch), and *Lathyrus* sp. (sweet pea).

From 1 January–1 May 2002, the hunting behavior of Northern Harriers and Short-eared Owls was observed 2–3 times a week. Harriers were observed for a total of 35.3 hours and Short-eared Owls for 16.6 hours. Observations began when either a harrier or owl was located, and continued until that focal individual was lost from view. Observations continued when another individual was located. Hunting harriers and owls were observed from distances ranging from 5–300 m. Spotting scopes were used for some long-distance observations (>200 m). For Harriers, if a “new” individual at a particular location was thought to be one observed previously on that day (e.g., a male Harrier observed on consecutive days at the same location), we either waited until another bird came into view or moved to a different location before resuming observations. All observations were made either from a vehicle or from an elevated area.

During each observation of a Northern Harrier or Short-eared Owl, we noted (1) the amount of time spent perched, hunting in flight, soaring, hovering (Clark 1975), carrying prey, and feeding; (2) the method of hunting; (3) the distance flown between successive pounces or touchdowns; (4) the number of pounces and whether pounces were successful; and (5), if possible, the prey species captured. Hunting methods were categorized as hook pounces, hover

pounces, straight pounces, touchdowns, or bird chases (Bildstein 1987). In addition, flights were categorized as quartering, transect flights, border following, soaring, or direct flights (Bildstein 1987). If a focal bird remained on a perch for more than 0.5 h, the observation period was ended.

In November 2003, we identified 10 areas where Short-eared Owls had been observed foraging on the Peabody WMA. In those areas, a 50-m circular plot was established, with the plot center being the approximate spot where an owl had initiated one or more attacks. Vegetation in these plots and at 10 randomly selected, apparently unused sites was sampled following methods described by James and Shugart (1970). Random sites were selected by randomly picking two digits from a random number table. We then used numbered grid maps of the Peabody WMA to determine the location of random sites. At 10-m intervals along transects radiating from a plot center in the four cardinal directions, we measured: (1) foliage cover (any stem or leaf within 0.1 m of a vertical rod) at vertical intervals of <0.5 m, 0.5–1 m, and 1–2 m; (2) percent cover of plants (grass, herbaceous vegetation, shrubs, or trees) and bare ground (determined using a densiometer); (3) litter depth; (4) height of tallest grass or herbaceous vegetation; and (5) lateral, or vertical, cover at vertical intervals of < 0.5 m, 0.5–1 m, and 1–2 m. Lateral cover was recorded at five points in each cardinal direction using a canvas cloth (0.5 m wide x 2 m high) divided into a grid of 49 squares. An observer, viewing the cloth from 2 m above ground, noted the number of squares at least half obscured in each of the three vertical sections (Noon 1981). From the center of each plot, the distances to the closest shrub, tree, and edge (boundary zone between fields and woodlots) were also measured. Approximate distances from plot centers to the nearest gravel road, state (paved) road, and permanent water were determined using ArcMap 8.1. The location of state roads was determined using information from the Kentucky Transportation Cabinet (KYGEONET 2000).

Because individuals were not marked and could not be identified and because many individuals (based on marked variation in numbers of Northern Harriers and Short-eared Owls present on the Peabody WMA over the duration of our study; Vukovich and Monroe 2005) were apparently transients, we assumed, for purposes of statistical analysis, that all observations of foraging Harriers and Short-eared Owls made during different observation periods were independent (i.e., different individuals). However, because Northern Harriers may occupy winter ranges for periods ranging from several hours to more than 15 days (Bildstein and Collopy 1985) and Short-eared Owls may use communal roost sites for several days (G. Ritchison, pers. observ.), some individuals may have been observed on more than one occasion.

Possible differences between Short-eared Owls and Northern Harriers in foraging behavior were examined using chi-square tests for categorical variables and Wilcoxon tests for continuous variables (SAS Institute 1999). Possible differences in the foraging behavior of male and female Northern Harriers, as well as the foraging behavior of adult and subadult Northern Harriers were also examined using chi-square and Wilcoxon tests

(SAS Institute 1999). Finally, the characteristics of foraging areas used by Short-eared Owls and randomly selected, unused sites were compared using multivariate analysis of variance. Stepwise discriminant analysis (backward procedure) was used to identify variables that best discriminated ($P < 0.05$; SAS Institute 1989) between nests (successful vs. unsuccessful) and sites (used vs. unused). A cross-validation procedure was used to assess the effectiveness of the discriminant functions. This procedure classifies each observation in the data set using a discriminant function computed from other observations in the data set, but excluding the observation being classified (SAS Institute 1999). Cohen's *Kappa* and its *Z* value were calculated to test model performance (Titus et al. 1984). Values are presented as means \pm one standard error.

Results

Northern Harriers used five types of hunting flights, with quartering flights ($N = 222$ of 344 , or 64.5%) and transect flights ($N = 114$ of 344 , or 33.1%) used most often. Harriers rarely hunted by soaring ($N = 3$) or by border flights ($N = 2$) and direct flights ($N = 3$). Short-eared Owls used primarily quartering flights ($N = 175$ of 182 , or 96.2%). Other types of hunting flights used by Short-eared Owls included soaring ($N = 3$), transect flights ($N = 3$), and direct flights ($N = 1$). Male and female Northern Harriers differed in types of flights used when foraging ($\chi^2_1 = 9.6$, $P = 0.002$), with females using quartering flights ($N = 138$ of 187 , or 73.8%) more often than transect flights ($N = 49$ of 187 , or 26.2%), and males using quartering flights ($N = 43$ of 79 , or 54.4%) and transect flights ($N = 36$ of 79 , or 45.6%) to similar degrees.

Differences between Northern Harriers and Short-eared Owls in mean distance flown between successive pounces or touchdowns were not significant ($z = 1.65$, $P = 0.099$). Harriers flew a mean distance of 74.0 ± 7.8 m ($N = 342$ observations) between pounces or touchdowns, and Short-eared Owls flew a mean distance of 58.3 ± 7.0 m ($N = 243$ observations).

We found that 7% of all attacks ($N = 183$) by hunting Northern Harriers ($N = 792$ observations) were successful, and 10.9% (14 of 128 attacks) of attacks by Short-eared Owls ($N = 505$ observations) were successful. There was no difference between male and female Northern Harriers in success rates ($\chi^2_1 = 0.12$, $P = 0.73$), with attacks by females successful 8.5% (8 of 94) of the time and attacks by males successful 6.8% (3 of 44) of the time. Both species used straight pounces ($N = 63$, or 34% , for Northern Harriers; and $N = 43$, or 32.5% , for Short-eared Owls) more often than other types of attacks (Figs. 1 and 2). Hook and hover pounces were more successful for Short-eared Owls (6 of 14 successful attacks, or 42.8%), whereas hover pounces (6 of 33 successful attacks, or 18.2%) were more successful for Northern Harriers. Neither species pursued birds.

The vegetation at locations where attacks occurred was identified when possible ($N = 51$ for Northern Harriers and $N = 41$ for Short-eared Owls). For both species, most attacks were initiated in areas consisting primarily of

sericea ($N = 32$ of 51, or 62.7% for Harriers and $N = 22$ of 41, or 53.6% for Short-eared Owls). For both Northern Harriers ($N = 18$ of 51, or 35.2%) and Short-eared Owls ($N = 17$ of 41, or 41.4%), most of the remaining attacks were initiated in areas dominated by fescue. Female Northern Harriers initiated attacks primarily in areas dominated by sericea (16 of 25 attacks, or 64%). For male Northern Harriers, 4 of 5 attacks were initiated in areas dominated by fescue. In addition, all attacks (25 of 25) by female harriers were in areas with tall vegetation (height of >0.5 m), whereas 2 of 5 attacks by male harriers were in short vegetation (height of <0.5 m) and 3 of 5 in tall vegetation.

Multivariate analysis of variance revealed significant differences between the vegetation characteristics of sites used by foraging Short-eared Owls and randomly selected, apparently unused sites (Wilk's lambda = 0.09, $F_{18,1} = 3.37$, $P = 0.023$). Stepwise discriminant analysis revealed 11 variables that permitted best discrimination between foraging sites and apparently unused sites (Table 1). Classification analysis using these variables correctly classified nine of 10 (90%) foraging sites and eight of 10 (80%) randomly selected, apparently unused sites (70% better than by chance alone; Cohen's Kappa $Z = 3.15$, $P = 0.0017$). Short-eared Owls foraged in areas that had fewer shrubs and shorter, less dense vegetation (dominated by grass rather than herbaceous vegetation) than unused areas (Table 1).

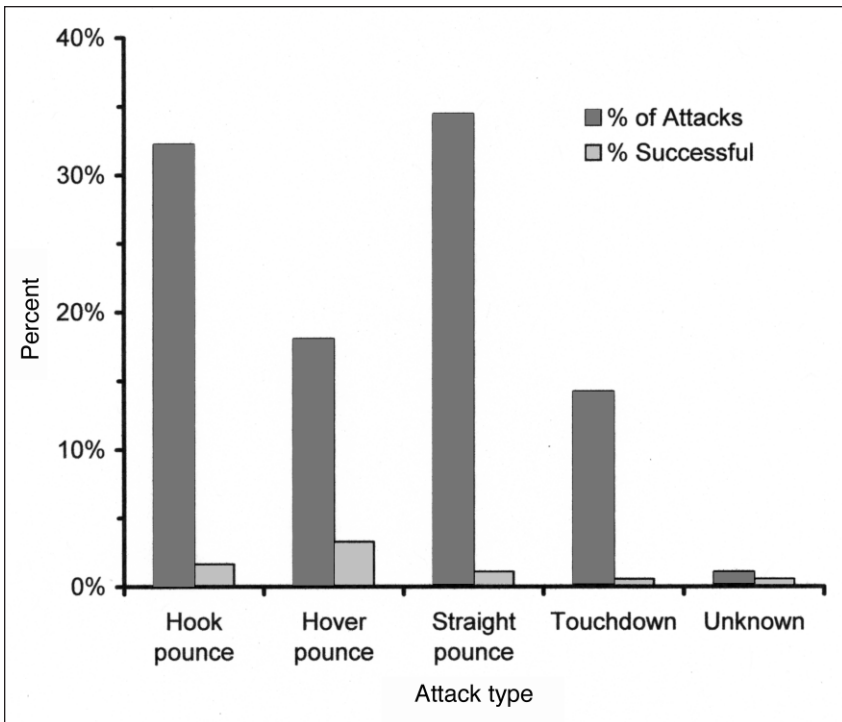


Figure 1. Types of attacks and attack success rates for Northern Harriers on a reclaimed surface mine grassland in Kentucky ($N = 183$ attacks).

Discussion

Northern Harriers and Short-eared Owls foraged on the wing during our study, with no instances of perch-hunting observed. Similarly, MacWhirter and Bildstein (1996) noted that harriers “virtually always” hunt on the wing, and Holt and Leasure (1993) reported that Short-eared Owls hunted “primarily on the wing.” Toland (1986) reported that Northern Harriers in Missouri “hunted from a slow coursing and quartering flight more than 96% of the time.”

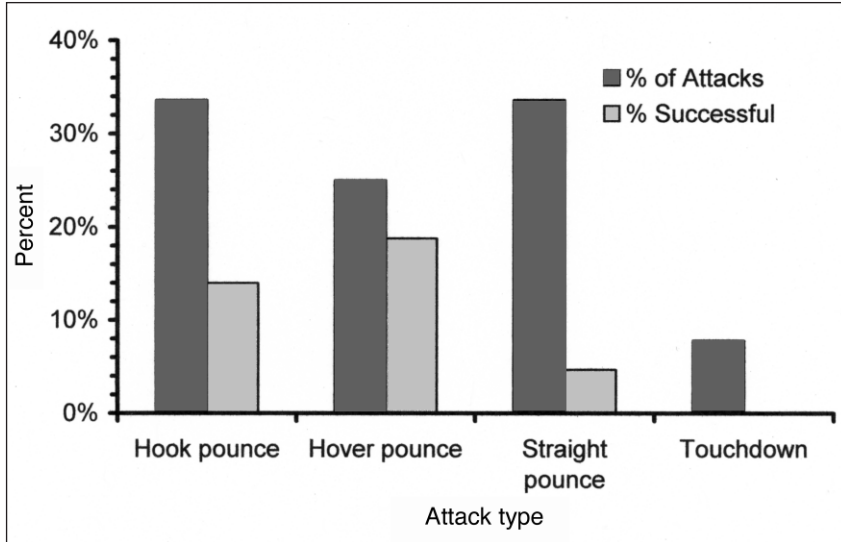


Figure 2. Types of attacks and attack success rates for Short-eared Owls on a reclaimed surface mine grassland in Kentucky (N = 128 attacks).

Table 1. Variables permitting best discrimination between foraging areas of Short-eared Owls and randomly-selected, unused areas on a reclaimed surface mine grassland in west-central Kentucky.

Variable	Used areas (N = 10)		Unused areas (N = 10)	
	Mean	SE	Mean	SE
Nearest shrub (m)	27.4	7.6	9.4	2.0
Nearest edge (m)	768.5	150.9	464.5	95.9
Nearest water (m)	284.7	42.0	242.7	33.6
Number of shrubs in circle	10.7	4.71	50.2	19.0
Trees >8 cm in circle	0.1	0.1	0.0	0.0
% herbaceous vegetation	22.9	7.2	66.8	8.9
Vertical height (cm)	24.3	2.8	55.6	5.6
% foliage cover ^A , <0.5 m	5.8	0.4	7.8	0.4
% foliage cover ^A , 0.5–1.0 m	0.3	0.2	2.1	0.5
% vertical cover ^B , <0.5 m	29.6	2.0	44.6	1.1
% vertical cover ^B , 0.5–1.0 m	9.8	1.6	29.4	3.3

^APercentage of the occurrence of foliage within a radius of 0.1 m of the stick.

^BPercentage of squares at least half obscured.

Northern Harriers and Short-eared Owls in our study initiated attacks primarily in areas dominated by either sericea or fescue. Although based on small sample sizes, these results suggest that female Northern Harriers initiated more attacks in areas dominated by tall stands of sericea, and males initiated more attacks in shorter vegetation and areas dominated by fescue. Sericea typically forms a denser cover than fescue (M. Vukovich and G. Ritchison, pers. observ.), suggesting that female Northern Harriers may hunt in areas with denser vegetation than males. Previous investigators have also reported that female harriers hunt more in taller and denser vegetation than males (Bildstein 1987, Preston 1990, Temeles 1987). Temeles (1986) suggested that areas with taller vegetation (height of >0.5 m) represented preferred foraging habitat for Northern Harriers and, further, that females used such areas more often than males because dominant females caused males to forage in less-preferred areas with low-growing vegetation. However, because female harriers have darker plumage than males and contrast more sharply against the sky (Preston 1990), they might benefit more than males by foraging in denser vegetation where prey would be less likely to detect them (Preston 1990, Schipper et al. 1975)

Overall, Northern Harriers in our study most often used quartering flights (powered flight back and forth over short distances, with many sharp turns). In contrast, Bildstein (1987) reported that Northern Harriers in Ohio used transect flights most often (58% of observations), with quartering flights used 22% of the time. Foraging methods used by Northern Harriers are apparently influenced by the characteristics of the vegetation. For example, Brown and Amadon (1968) suggested that harriers adjusted their speed relative to the visibility of prey in different habitats, and flew faster over areas with less cover. Thus, differences in foraging methods used by Northern Harriers in different locations may, in part, be due to differences in habitat. Harriers in our study often initiated attacks in areas dominated by dense stands of sericea and, in such areas, slower, quartering flights may improve the chances of locating prey.

The attack success rate for Northern Harriers on the Peabody WMA (7%) was within the range of rates previously reported. For example, MacWhirter and Bildstein (1996) reported that prey-capture success by harriers was highly variable (5–35%) and influenced by habitat and prey type. Temeles (1986) reported capture success rates of 6.25% (8 of 128) for harriers attacking rodents and 0% ($N = 20$) for harriers attacking birds in a California population. Northern Harriers on the Peabody WMA preyed primarily on small mammals (G. Ritchison, unpubl. data). Success rates when hunting agile prey such as small mammals are typically lower than when hunting less agile prey such as amphibians and reptiles (Toland 1986). In addition, as suggested by Martin (1987), Northern Harriers foraging in tall, dense vegetation (e.g., areas on the Peabody WMA dominated by sericea) may have difficulty capturing prey and, therefore, have lower attack-success rates.

Analysis revealed that areas used by foraging Short-eared Owls in our study had shorter, less dense vegetation than unused areas. Short-eared Owls

likely use both acoustical and visual cues to detect prey (Holt and Leasure 1993). However, lab experiments indicated that attack success for these owls increases with increasing illumination (Clarke 1983). Such results suggest that vision may play an important role in prey detection. The use of areas with shorter, less dense vegetation by Short-eared Owls might increase prey detectability and, perhaps, increase attack success. Previous studies revealed that many species of raptors preferentially forage in areas with reduced vegetation density, even when such areas have lower prey density, because such areas improve the chances of detecting prey (Bechard and Swem 2002, Preston and Beane 1993).

In summary, the foraging behavior of Northern Harriers and Short-eared Owls on a reclaimed surface mine in Kentucky was similar to that reported at other locations, and attack-success rates, although low, were comparable to those reported previously at other locations. Although we did not determine prey densities, other investigators have reported that *Microtus pennsylvanicus* Drummondi (meadow voles) can be abundant on reclaimed surface mines (Alberici et al. 1989, Chamblin 2002, Yahner and Rohrbaugh 1998). Our study and others (Chamblin 2002) suggest that reclaimed surface mine grasslands provide suitable habitat for Northern Harriers and Short-eared Owls during the non-breeding season.

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