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NESTING SUCCESS AND BEHAVIOR OF NORTHERN HARRIERS ON A RECLAIMED SURFACE MINE GRASSLAND IN KENTUCKY

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ABSTRACT.—Grasslands are among the most threatened habitats in North America and populations of many grassland birds, including Northern Harriers (*Circus cyaneus*), are declining. While native grasslands are disappearing, current procedures for reclaiming surface mines have produced large areas of grasslands in the eastern United States. Currently, little is known about the use of such grasslands by raptors. The objective of this study was to examine the nesting behavior of Northern Harriers on a reclaimed surface mine grassland in Kentucky. Over two breeding seasons (April–July 2002–03), 46 harrier nests were located, and young fledged from 10 (21.7%) of these nests. All but one nest were located in dry, upland areas, and the increased vulnerability of nests in such sites to predation may have contributed to this relatively low nesting success. Successful nests were located in denser vegetation than unsuccessful nests, suggesting that greater concealment may reduce predation risk. The percentage of breeding females that were subadults (44.4%) was higher in this Kentucky population than reported elsewhere, although nest success did not differ with female age. Most prey items delivered to nestlings were small mammals (134 of 139; 96.4%), with male harriers capturing most prey and, in aerial exchanges, transferring those prey to females for delivery to the nest. These results suggest that Northern Harriers can breed successfully on reclaimed surface mine grasslands.

KEY WORDS: *Northern Harrier*; Circus cyaneus; *Kentucky*; *nest success*; *provisioning*; *reclaimed surface mine grassland*.

ÉXITO DE NIDIFICACIÓN Y COMPORTAMIENTO DE *CIRCUS CYANEUS* EN PASTIZALES RECUPERADOS DE MINERÍA DE SUPERFICIE EN KENTUCKY

RESUMEN.—Los pastizales son uno de los hábitats más amenazados en Norteamérica y las poblaciones de muchas aves de pastizal, incluyendo a *Circus cyaneus*, están disminuyendo. Mientras que los pastizales nativos están disminuyendo, las prácticas actuales de recuperación de áreas dedicadas a la minería de superficie han producido una gran cantidad de pastizales en el este de Estados Unidos. Actualmente, se sabe muy poco acerca del uso de estos pastizales por aves rapaces. El objetivo de este estudio fue examinar el comportamiento de nidificación de *C. cyaneus* en un pastizal recuperado de minería de superficie en Kentucky. Durante dos épocas reproductivas (abril–julio de 2002 y 2003), se localizaron 46 nidos de *C. cyaneus*, de los cuales 10 emplumaron juveniles (21.7%). A excepción de un nido, todos los nidos estuvieron localizados en tierras altas y secas La mayor vulnerabilidad de los nidos ante depredadores puede haber contribuido al éxito de nidificación relativamente bajo en estos sitios. Los nidos exitosos estuvieron localizados en vegetación más densa que los nidos no exitosos, lo que sugiere que una mayor cobertura del nido reduce el riesgo de depredación. El porcentaje de hembras reproductivas subadultas (44.4%) fue mayor en esta población de Kentucky que el reportado para otras poblaciones, a pesar de que el éxito de nidificación no varió con la edad de las hembras. La mayoría de los ítems presa llevados a los nidos correspondieron a pequeños mamíferos (134 de 139; 96.4%). Los machos capturaron la mayoría de las presas transfiriéndolas en el aire a las hembras, las cuales posteriormente llevaron las presas a los nidos. Estos resultados sugieren que *C. cyaneus* puede reproducirse exitosamente en pastizales recuperados de minería de superficie.

[Traducción del equipo editorial]

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Grasslands are among the most threatened habitats in North America (Jones and Bock 2002), and populations of many grassland birds are declining at rates exceeding those of forest species (Herkert 1994). Populations of Northern Harriers (*Circus cyaneus*) appear to be declining globally (del Hoyo et al. 1995), and harriers are a species of management concern over much of their range in the United States (U.S. Fish and Wildlife Service 1987). Available data suggest that the loss and fragmentation of grassland habitat have been important factors in this decline (Serrentino 1992).

Although few native grasslands remain, current reclamation procedures for surface mines have converted large areas of upland forest and farmland to grasslands in Kentucky and elsewhere in the eastern United States (Peterjohn and Rice 1991, Palmer-Ball 1996, Rohrbaugh and Yahner 1996). Northern Harriers are known to use these reclaimed grasslands during both the nonbreeding and breeding seasons. For example, Northern Harriers were found nesting on reclaimed surface mines in southern Indiana in the 1970s (Palmer-Ball 1996), and harrier nests were first documented on reclaimed surface mines in Kentucky in 1989 (Palmer-Ball and Barron 1990). Northern Harriers have also been reported nesting on reclaimed grasslands in Ohio (Peterjohn and Rice 1991) and Pennsylvania (Rohrbaugh and Yahner 1996).

Although Northern Harriers are known to use reclaimed surface mines during the breeding season, little is known about the harriers' abundance or about the suitability of these areas for breeding (Rohrbaugh and Yahner 1996). MacWhirter and Bildstein (1996) suggested that efforts were needed to better document the breeding range of Northern Harriers, and to monitor populations at the perimeter of their range. The objective of our study was to examine nest-site selection, provisioning behavior, and reproductive success of breeding Northern Harriers on a reclaimed surface mine in west-central Kentucky.

STUDY AREA AND METHODS

From April–August 2002 and 2003, we attempted to locate all Northern Harrier nests on the Peabody Wildlife Management Area (PWMA), an area with six separate management units encompassing 25 000 ha of reclaimed coal mine land in Muhlenberg and Ohio counties in west-central Kentucky. The open areas of the PWMA consisted primarily of nonnative vegetation, including sericea (*Lespedeza* sp.), fescue (*Festuca* sp.), crown vetch (*Coronilla* sp.), and sweet pea (*Lathyrus* sp.). Native species present include switchgrass (*Panicum* sp.), cattail (*Typha latifolia*), dogbane (*Apocynum* sp.), Indian currant (*Symphoricarpos orbiculatus*), and blackberry (*Rubus* sp.).

Because we did not capture and mark Northern Harriers on the PWMA, the number of breeding individuals in the population could only be estimated. One adult male in 2002 was known to be polygynous because he was observed flying between two nest sites. In addition, based on timing and location of nests, we were relatively certain that some pairs that lost nests to predators or abandoned nests were the same ones that subsequently initiated new nests. However, in other cases, it was not clear whether nests were initiated by the same pair that had earlier lost a nest in the same general area or by a new pair.

The ages of Northern Harriers in our study were categorized as either adult or subadult. Eye color was used to categorize each harrier, with adults having yellow irises and subadults having darker irises (brown, gray, or light gray-brown; Clark and Wheeler 1987). Because it takes from 2–6 yr for iris color to become completely yellow (Clark and Wheeler 1987), the exact ages of harriers in our study were unknown.

We located nests by observing the behavior of adults (e.g., prey exchanges). Once located, nests were monitored to determine clutch sizes, number of nestlings, and nest outcome. To minimize disturbance, we checked nests infrequently (every 7–14 d) and the status of nests was often determined by observing the behavior of adults. Nest contents were often viewed using a telescoping pole (ca. 5 m long) with an attached mirror. Nestlings were already present when some nests were located and, because predators may have taken one or more eggs or nestlings, those nests were not used when determining mean clutch sizes or comparing clutch sizes of adult and subadult females.

Provisioning rates were determined by watching harriers from a distance (≥50 m) or from inside an observation blind (≥20 m) to minimize disturbance. The size of prey delivered to nestlings by adult harriers was estimated by comparing the length of prey items to that of the harriers' bill (bill range = 16.1–19.3 mm [MacWhirter and Bildstein 1996]; we used 17.5 mm as the typical bill length).

Within 4 d after nests failed or young fledged, we characterized nest-site vegetation using methods described by James and Shugart (1970). In addition, we randomly selected and characterized the vegetation at paired sites where no nesting occurred. Random sites were identified either using a grid map and random number table or by choosing a random number or angle and measuring 25 m from the nest site. At both nest sites and randomly-selected sites, vegetation within an 11.3-m radius (0.04 ha) of the plot center was characterized. Within these plots, we counted the number of shrubs, the number of trees <8 cm diameter breast height (DBH), and the number of trees >8 cm DBH. In addition, four transects extending from the plot center in the four cardinal directions were established and, at 2.25-m intervals along each transect as well as at the plot center, we measured litter depth and maximum foliage height, and noted the type of ground cover (bare ground, grass, herbaceous, or shrub). At these same points, we also determined foliage cover at three height intervals (<0.5 m, 0.5–1 m, and >1 m) by counting the number of stems within 4 cm of a 2-cm diameter pole. Vertical cover was determined using a white canvas cloth (0.5 m wide and 2 m high) on which three grids (below 0.5 m, 0.5–1 m, and 1–2 m) each consisting of 49 equal-

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sized squares (grids below 0.5 m and from 0.5–1 m) or rectangles (from 1–2 m) were drawn. This cloth was placed at the edge (11.3 m from the plot center) of each plot in each of the four cardinal directions and, at each of these four positions, the number of squares or rectangles at least half obscured by vegetation (as viewed from the plot center and the observer's eyes 1 m above ground) was determined (Noon 1981). In addition, distances from the center of plots to the nearest roads and nearest permanent water were determined from aerial photographs of the study area.

Data Analysis. Possible differences in nest success between years, among months and different nest substrates (i.e., the vegetation under and immediately adjacent to the nest), and between female Northern Harriers of different age categories (adult vs. subadult) were examined using chi-square tests. Possible differences between adult and subadult female harriers in clutch sizes and number of fledglings per successful nests were examined using Wilcoxon tests (SAS 1999).

Characteristics of nest sites and randomly-selected sites, and those of successful and unsuccessful nest sites, were compared using multivariate analysis of variance (MANOVA). If, based on the location and timing of a second nest, we believed that a pair re-nested after losing a nest to predation or abandoning a nest, only one of the two nests (randomly-selected) was used for these analyses. In addition, harriers generally exhibit low fidelity to breeding sites (MacWhirter and Bildstein 1996), so, for these analyses, we assumed that different pairs were observed in 2002 and 2003. Because we characterized vegetation shortly after nests failed or young fledged and, for successful nests, young may remain on or in the vicinity of the nest for more than 4–5 wk (MacWhirter and Bildstein 1996), successful nests were typically characterized later in the breeding season than unsuccessful nests ($\bar{x}$ = 13 June for unsuccessful nests and 14 July for successful nests). To eliminate the effects of seasonal changes in vegetation height and density, only nests that failed or succeeded after 15 June were included in our analysis of possible differences between successful and unsuccessful nests. For those nests, there was no difference ($z = 0.56$, $P = 0.57$) in the mean date on which vegetation was characterized ($\bar{x}$ = 11 July for failed nests and 14 July for successful nests). When multivariate analysis revealed significant differences, stepwise discriminant analysis was used to identify variables that best discriminated between sites (SAS 1999).

The provisioning rates of adult male and female Northern Harriers were compared using Wilcoxon tests. The possible effect of brood size on provisioning rates and the size of prey delivered to nestlings was examined using repeated measures analysis of variance. All analyses were conducted using the Statistical Analysis System (SAS 1999). Values are presented as means ± standard error and significance was accepted at $P \leq 0.05$.

RESULTS

Forty-five nests were located on the Peabody WMA during 2002 (N = 27 nests representing 18–24 pairs plus one polygynous male with two females and two nests) and 2003 (N = 18 nests representing 12 or 13 pairs), and one nest (2002) was located on a privately-owned reclaimed area adjacent to the WMA. Ten of the 46 nests (21.7%) were successful (i.e., fledged young). Of the 36 nests that failed, 33 (91.6%) were apparently destroyed by predators (with remains of either young or eggs present or, in some cases, the nest found empty) and three were abandoned (two probably because we inadvertently visited nests during egg-laying; one for unknown reasons). Most nests that apparently failed due to predation were lost during the nestling period (N = 31; 93.9%). For nests located on the Peabody WMA, and excluding abandoned nests (N = 3), 10 of 42 (23.8%) of nests were successful. Nest success did not differ between years ($\chi^2 = 0.49$, df = 1, $P = 0.48$). At least six pairs of Northern Harriers apparently renested (N = 1 in 2002 and N = 5 in 2003) after either losing a nest to predation or abandoning a nest, with a mean distance between initial nests and replacement nests of 139 ± 108 m.

Most female harriers (25 of 46; 56.5%) in the breeding population were adults, with 20 (43.5%) subadults and the age of one female not determined. In contrast, 44 of 45 male harriers (97.8%) were adults. The single subadult male was paired with a subadult female, and their clutch of eggs was lost to predation. For female harriers, nest success did not differ with age ($\chi^2 = 1.39$, df = 1, $P = 0.24$). Adult females did initiate nests earlier than subadult females ($\chi^2 = 8.96$, df = 2, $P = 0.0114$), with more adult (13 of 23; 56.5%) than subadult females (3 of 18; 16.7%) initiating nests in April. However, the month of nest initiation had no effect on nesting success ($\chi^2 = 4.21$, df = 2, $P = 0.12$).

The mean dates for initiation of egg laying by female Northern Harriers in our study were similar in 2002 ($\bar{x}$ = 6 May; range = 1 April–17 June) and 2003 ($\bar{x}$ = 7 May; range = 4 April–20 June). For nests with clutches known to be complete (N = 34), mean clutch size was 5.07 ± 1.0 eggs, and mean clutch size did not differ between years ($z = 1.30$, $P = 0.19$). However, clutch sizes did differ with age ($z = 4.10$, P = 0.0003), with mean clutch sizes of 5.4 ± 0.8 for adult females (N = 21) and 4.3 ± 0.8 for subadult females (N = 13), respectively.

Overall, 40.3 ± 11.0% of nestlings fledged (N = 14 nests), with no difference either between adult and subadult females ($z = 0.21$, $P = 0.83$) or between years ($z = 0.74$, $P = 0.46$). Overall, mean brood size was 4.29 ± 1.0 (N = 14), with no difference either between years ($z = 0.68$, $P = 0.49$) or between adult and subadult females ($z = 0.28$, $P =$

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Table 1. Variables permitting best discrimination between nest sites of Northern Harriers and randomly-selected sites.

	NEST SITES		RANDOM SITES	
VARIABLE[a]	MEAN	SE	MEAN	SE
Distance to nearest tree (m)	32.5	5.6	28.2	4.8
Distance to nearest water (m)	139.6	13.1	166.7	15.2
Distance to nearest shrub (m)	8.38	1.47	14.31	2.29
Number of trees <8 cm[a]	0.75	0.32	0.87	0.37
Percent tree cover[a]	1.14	0.46	0.66	0.47
Foliage cover[a,b], 0.5–1 m	4.22	0.23	3.25	0.19

[a] Number of trees, percent tree cover, and foliage cover determined for 0.04 ha area.

[b] Foliage cover was measured as the total number of stems within 0.1 m of a 2-cm diameter pole placed at the center of a nest.

0.78). Similarly, we found no difference between adult and subadult female Northern Harriers in the mean number of young fledged per successful nest ($z = 1.60$, $P = 0.11$).

Northern Harrier nests were constructed on and in several different species of vegetation, but the most frequently used nest substrates were sericea ($N = 21$) and blackberry ($N = 11$). Nest substrate (native vs. nonnative) did not influence nesting success ($\chi^2 = 0.04$, df = 1, $P = 0.83$).

Multivariate analysis of variance revealed no difference in the vegetation characteristics of successful (fledged young) and unsuccessful harrier nests (Wilk's lambda = 0.02, $F_{18,2} = 5.33$, $P = 0.17$). However, we found a significant difference between the vegetation characteristics of nest sites and random sites (Wilk's lambda = 0.67, $F_{17,64} = 1.85$, $P = 0.041$). Stepwise discriminant analysis revealed six variables that best differentiated between nest and random sites (Table 1). Classification analysis using these six variables correctly classified 30 of 38 (80%) random sites and 32 of 42 (76.2%) nest sites (55% better than by chance alone; Cohen's *Kappa* $Z = 4.93$, $P < 0.0001$). Areas used as nest sites by Northern Harriers were closer to water and shrubs in areas with fewer small trees and more tree and foliage cover (Table 1).

The mean provisioning rate of Northern Harriers during the 2002 and 2003 breeding seasons was 0.94 items/hr (160.8 hr of observation at 12 nests). Most prey delivered to nestlings by harriers were small mammals ($N = 134$ of 139; 96.4%). Males delivered most prey items ($N = 132$ of 167 prey items; 79.0%), but only 23.4% of prey ($N = 39$ of 167) were presented to nestlings by males. Prey brought to nest sites by male harriers were usually delivered to females during an aerial exchange ($N = 96$ of 132 prey items; 72.7%), and females then delivered the prey to nestlings. In contrast, all 35 prey items captured by female harriers were also delivered to nestlings by these females. Female harriers captured more prey when nestlings were ≥2 wk old (14–28 d post-hatching). For nests with young 1–13 d post-hatching, female harriers captured only four prey items. However, during observation periods when nestlings were 14–28 d post-hatching, females captured 31 prey items.

Overall, the mean length of prey delivered by harriers to nestlings was 39 ± 1 mm ($N = 163$ prey items). The size of prey delivered by male and female harriers did not differ ($F_{2,6} = 0.24$, $P = 0.8$), with a mean length of 36 ± 3 mm ($N = 35$ prey items) for prey delivered by females and 40 ± 2 mm ($N = 129$ prey items) for prey delivered by males. Similarly, neither the size of captured prey ($F_{13,3} = 3.53$, $P = 0.16$) nor the size of prey actually delivered to the nest ($F_{13,3} = 2.56$, $P = 0.24$) varied with nestling age. Brood size also had no apparent effect on prey size, with neither the size of captured prey ($F_{4,4} = 1.74$, $P = 0.3$) nor the size of prey delivered to nestlings ($F_{4,4} = 2.06$, $P = 0.25$) varying with number of nestlings.

DISCUSSION

Nesting success of Northern Harriers on the Peabody WMA (21.7%) was lower than that reported at most other locations. In North Dakota, Hammond and Henry (1949) reported that 18% of harrier nests were successful. At other locations, nest success for Northern Harriers varied from 38% (Michigan; Craighead and Craighead 1956) to 79% (New Hampshire; Serrentino 1987).

MacWhirter and Bildstein (1996) suggested that ground moisture had a significant effect on the nesting success of Northern Harriers, with success

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higher in the wetter sites and lower in drier sites. Similarly, Simmons and Smith (1985) found that harrier nests located in wet sites were more successful than nests in dry sites, perhaps because there were fewer predators in wet areas. Simmons (2000) suggested that mammalian predators may hunt less in wet habitats because scents are harder to follow in such areas. Northern Harriers in North America breed primarily in wetland habitats (MacWhirter and Bildstein 1996), and reduced predation rates in such areas may contribute to this apparent preference. All but one nest in our study were located in dry, upland areas and, as a result, may have been more vulnerable to predation.

We found no difference in the characteristics of successful and unsuccessful harrier nests, with nest plots in both categories similar in the number of shrubs and trees present, vegetation height, foliage cover, and vertical cover. Both successful and unsuccessful nests appeared well concealed, with mean vertical cover of 99.8% and 98.0%, respectively, below 0.5 m and mean vertical cover of 94.5% and 84.3%, respectively, between 0.5–1 m. Other investigators have noted that harrier nests in areas with less vegetation cover were more likely to be unsuccessful (Hamerstrom 1969, Watson 1977). MacWhirter and Bildstein (1996) suggested that nest concealment might be an important factor in determining nest success for Northern Harriers in drier habitats. While differences in vegetation cover and concealment among nest sites may have influenced nest success, our results indicated that even apparently well-concealed nests may be destroyed by predators. Investigators have reported similar results, with no differences between the characteristics of successful and unsuccessful nest sites, in other species of birds (Filliater et al. 1994, Ricketts and Ritchison 2000). Filliater et al. (1994) suggested that environments with a variety of predators, each using a different search strategy, may eliminate predictably safe nest sites. For Northern Harriers, dry, upland locations, such as our study area, may represent such an environment, with a variety of potential predators, including coyotes (*Canis latrans*), bobcats (*Felis rufus*), gray (*Urocyon cinereoargenteus*) and red (*Vulpes vulpes*) foxes, striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), and Great Horned Owls (*Bubo virginianus*), and, in contrast to nests in wet habitats, such as marshes, relatively accessible nests.

Our results did reveal differences in the characteristics of nest sites and random sites, with nest sites in areas with more foliage cover. Similarly, Sutherland (1987) found that nest sites in North Dakota had taller vegetation and more cover than random sites. This apparent selection for nest sites that provide more cover suggests that Northern Harriers select sites that provide concealment. However, as noted previously, even well-concealed nests are subject to predation in dry, upland locations.

The percentage of breeding females that were subadults on our study area (44.4%) was among the highest reported in either North America or Great Britain. In Wisconsin, only 16% of 268 breeding females were subadults (Hamerstrom et al. 1985), while, in New Brunswick, 23% of 116 females in the breeding population were subadults (MacWhirter and Bildstein 1996). Watson (1977) reported that the proportion of first-year female harriers in a breeding population in Great Britain was 13%, but this did not include older subadult females. One factor possibly contributing to the relatively high number of breeding subadult females in our study was the relatively low density of breeding females. For example, the average distance between harrier nests on two management units of the Peabody WMA where most nests were located (33 of 45; 73.3%) was about 1600 m. In contrast, MacWhirter and Bildstein (1996) noted that the median internest distance for Northern Harriers at seven locations was 430 m. Male and female harriers are intolerant of conspecifics near nests (MacWhirter and Bildstein 1996) and, at high densities, dominant adult females might prevent subadult females from establishing nesting territories. Watson (1977) also suggested that social behavior apparently excluded some younger harriers from breeding. The relatively low density of breeding harriers on the PWMA may have been related to some unknown feature(s) of habitat quality or may simply be an artifact of the location of the area at the extreme southern edge of the breeding range of harriers.

Adult female Northern Harriers in our study had significantly larger clutches than subadult females. Simmons et al. (1986) reported that clutch sizes of adult female harriers ($\bar{x} = 4.4$, $N = 42$) were marginally larger than those of subadult females ($\bar{x} = 4.2$, $N = 17$). While few investigators have reported clutch sizes of adult and subadult female Northern Harriers, older females produce larger clutches in other raptors (Newton 1986, Smallwood and Bird 2002). These differences might be the result of age-related differences in foraging abilities or in acquiring good quality territories (Newton 1986).

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Such differences could, in turn, contribute to differences in the physical condition of females and differences in energy available to produce a clutch of eggs.

Adult female Northern Harriers in our study initiated nests earlier than subadult females. Similarly, MacWhirter and Bildstein (1996) reported that laying dates of older female Northern Harriers (≥3 yr old) preceded those of younger ones by a mean of 6 d. As with clutch size, the earlier nesting of adult females may be related to age-related differences in physical condition. However, another factor may have been the time of arrival on the breeding grounds. Adult Northern Harriers generally arrive on breeding areas before subadults (Hamerstrom 1969, Bildstein and Hamerstrom 1980), and earlier arrival may permit earlier pairing and initiation of egg-laying.

Although adult female Northern Harriers in our study initiated egg-laying before subadult females and produced larger clutches, we found no differences between adult and subadult females in either nest success or number of fledglings per successful nest. Similarly, Hamerstrom et al. (1985) examined the breeding biology of Northern Harriers in Wisconsin and found few age-related differences. One possible explanation for the absence of differences in the nesting success of adult and subadult female Northern Harriers in our study was that our sample size was quite small, but another was that all but one male were adults, and their experience and food-provisioning skills may have contributed to the success of subadult females. Simmons et al. (1986) suggested that reproductive success of Northern Harriers was related to the food-provisioning rates of males.

Male Northern Harriers in our study provided most of the prey delivered to nestlings, with females providing prey primarily when nestlings were 14–28 d old. Similarly, Simmons et al. (1987) reported that adult female harriers rarely began food provisioning until nestlings were 14–20 d old, and MacWhirter and Bildstein (1996) noted that male harriers provide virtually all food until nestlings are 10–14 d old.

The size of prey delivered to nestlings by adult Northern Harriers in our study did not vary with either nestling age or brood size. MacWhirter and Bildstein (1996) reported that prey size increased with nestling age at some locations, but not others. The absence of variation in the size of prey delivered to broods of different sizes or ages in our study may have been due, in part, to limited variation in brood sizes. Most successful nests ($N = 10$) in our study fledged one ($N = 1$), two ($N = 5$), or three ($N = 1$) young. More variation in demand for prey, particularly for older nestlings, might be apparent in larger broods (e.g., 5, 6, or 7 young).

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LITERATURE CITED

BILDSTEIN, K.L. AND F. HAMERSTROM. 1980. Age and sex differences in the size of Northern Harriers. *J. Field Ornithol.* 51:356–360.

CLARK, W.S. AND B.K. WHEELER. 1987. A field guide to hawks of North America. Houghton Mifflin Co., Boston, MA U.S.A.

CRAIGHEAD, J.J. AND F.C. CRAIGHEAD. 1956. Hawks, owls, and wildlife. Stackpole Books, Harrisburg, PA U.S.A.

DEL HOYO, J., J. SARGATAL, AND J. CABOT. [EDS.]. 1995. Handbook of the birds of the world: New World vultures to guineafowl. Lynx Edicions, Barcelona, Spain.

FILLIATER, T.S., R. BREITWISCH, AND P.M. NEALEN. 1994. Predation on Northern Cardinal nests: does choice of nest site matter? *Condor* 96:761–768.

HAMERSTROM, F. 1969. A harrier population study. Pages 367–383 *in* J.J. Hickey [ED.], Peregrine Falcon populations: their biology and decline. Univ. of Wisconsin Press, Madison, WI U.S.A.

———, F.N. HAMERSTROM, AND C.J. BURKE. 1985. Effect of voles on mating systems in a central Wisconsin population of harriers. *Wilson Bull.* 97:332–346.

HAMMOND, M.C. AND C.J. HENRY. 1949. Success of Marsh Hawk nests in North Dakota. *Auk* 66:271–274.

HERKERT, J.R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. *Ecol. Appl.* 4:461–471.

JAMES, F.C. AND H.H. SHUGART. 1970. A quantitative method of habitat description. *Aud. Field Notes* 24:727–736.

JONES, Z.F. AND C.E. BOCK. 2002. Conservation of grassland birds in an urbanizing landscape: a historical perspective. *Condor* 104:643–651.

MACWHIRTER, R.B. AND K.L. BILDSTEIN. 1996. Northern Harrier (*Circus cyaneus*). *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 210. The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists' Union, Washington DC U.S.A.

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NEWTON, I. 1986. The Sparrowhawk. T. & A.D. Poyser, Calton, U.K.

NOON, B.R. 1981. Techniques for sampling avian habitats. Pages 42–52 *in* D.E. Capen [ED.], The use of multivariate statistics in studies of wildlife habitat. Rocky Mtn. For. Range Exp. Station, USDA Forest Service, Fort Collins, CO U.S.A.

PALMER-BALL, B.L., JR. 1996. The Kentucky breeding bird atlas. Univ. Press of Kentucky, Lexington, KY U.S.A.

——— AND A. BARRON. 1990. Notes on breeding birds of the reclaimed surface mines in western Kentucky. *Kentucky Warbler* 66:73–80.

PETERJOHN, B.G. AND D.L. RICE. 1991. The Ohio breeding bird atlas. Ohio Dept. of Natural Resources, Columbus, OH U.S.A.

RICKETTS, M.S. AND G. RITCHISON. 2000. Nesting success of Yellow-breasted Chats: effects of nest site and territory vegetation structure. *Wilson Bull.* 112:510–516.

ROHRBAUGH, R.W., JR. AND R.H. YAHNER. 1996. Reclaimed surface mines: an important nesting habitat for Northern Harriers in Pennsylvania. Pages 307–314 *in* D.M. Bird, D.E. Varland, and J.J. Negro [EDS.], Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press, San Diego, CA U.S.A.

SAS INSTITUTE. 1999. SAS OnlineDoc, version 8. SAS Institute, Cary, NC U.S.A.

SERRENTINO, P. 1987. The breeding ecology and behavior of Northern Harriers in Coos County, New Hampshire. M.S. thesis, Univ. of Rhode Island, Kingston, RI U.S.A.

———. 1992. Northern Harrier, *Circus cyaneus*. Pages 89–117 *in* K.J. Schneider and D.M. Spence [EDS.], Migratory nongame birds of management concern in the northeast. USDI, U.S. Fish and Wildl. Serv., Newton Corner, MA U.S.A.

SIMMONS, R.E. 2000. Harriers of the world: their behaviour and ecology. Oxford Univ. Press Inc., New York, NY U.S.A.

——— AND P.C. SMITH. 1985. Do Northern Harriers (*Circus cyaneus*) choose nest sites adaptively? *Can. J. Zool.* 63:494–498.

———, ———, AND R.B. MACWHIRTER. 1986. Hierarchies among Northern Harrier harems and the costs of polygyny. *J. Anim. Ecol.* 55:755–771.

———, P. BARNARD, AND P.C. SMITH. 1987. Reproductive behavior of *Circus cyaneus* in North America and Europe: a comparison. *Ornis Scand.* 18:33–41.

SMALLWOOD, J.A. AND D.M. BIRD. 2002. American Kestrel (*Falco sparverius*). *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 602. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington DC U.S.A.

SUTHERLAND, J.E. 1987. The predation ecology of the Northern Harrier on Mallard Island, North Dakota. M.S. thesis, Univ. of North Dakota, Grand Forks, ND U.S.A.

U.S. FISH AND WILDLIFE SERVICE. 1987. Migratory nongame birds of management concern in the United States: the 1987 list. U.S. Fish Wildl. Serv., Washington, DC U.S.A.

WATSON, D. 1977. The Hen Harrier. T. & A.D. Poyser, Hertfordshire, U.K.

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