J. Raptor Res. 36(1):51–57

RAPTOR ABUNDANCE AND HABITAT USE IN A HIGHLY-DISTURBED-FOREST LANDSCAPE IN WESTERN UGANDA

NATHANIEL E. SEAVY[1] AND CHRISTINE K. APODACA
Department of Zoology, 223 Bartram Hall, P.O. Box 118525, University of Florida, Gainesville, FL 32611-8525 U.S.A.

ABSTRACT.—We conducted roadside raptor surveys in an area of western Uganda that included undisturbed forest, agricultural mosaics, and tea plantations. Between September 1997–April 1998, we surveyed three transects (51 km of roadway) twice each month, once during the morning and again in the afternoon. During these surveys, we detected 14 falconiform species and 77 individuals. We detected significantly more raptors during morning than afternoon surveys. Wahlberg's Eagles (*Aquila wahlbergi*) and Long-crested Eagles (*Lophaetus occipitalis*) were observed most frequently and were sighted consistently throughout the study. Most raptors observed were resident species, whereas Palearctic migrants comprised less than 25% of all raptors, noteworthy considering their abundance in other African regions. We did not detect an equal number of raptors in all habitat types. Agriculture mosaics accounted for 61% of the habitat we surveyed and 75% of all raptor detections were in these habitats. In contrast, tea plantations were 14% of the area surveyed, but only 3% of all raptors were detected there. Based on these results, we suggest that tea plantations may be suboptimal habitat for larger, open-habitat raptors. We did not detect large, forest-dwelling eagles outside of large areas of undisturbed forest, which are probably critical to their persistence in these landscapes.

KEY WORDS: *Uganda; roadside survey; conservation; habitat use; deforestation; tea plantation;* Aquila wahlbergi; *Wahlberg's Eagle;* Lophaetus occipitalis; *Long-crested Eagle.*

Abundancia de repaces y uso de habitat en un paisaje de bosque altamente disturbado en el oeste de Uganda

RESUMEN.—Hicimos estudios de rapaces alrededor de las carreteras en un área del oeste de Uganda que incluía bosque sin intervención, mosaicos agrícolas, plantaciones de te. Entre septiembre de 1997–abril de 1998, estudiamos tres transeptos (51 km de carreteras) dos veces cada mes, una vez en la mañana y otra en la tarde. Durante estos estudios detectamos 14 especies falconiformes y 77 individuos. Detectamos significativamente más especies durante los estudios de la mañana que en los de la tarde. Las águilas de Wahlberg (*Aquila wahlbergi*) y las águilas de cresta alargada (*Lophaetus occipitalis*) fueron observadas más frecuentemente y fueron avistadas consistentemente a lo largo del estudio. La mayoría de rapaces observadas fueron especies residentes, mientras que las migratorias palearticas comprendieron menos del 25% de todas las rapaces, esto es digno de mencionarlo considerando su abundancia en otras regiones africanas. No detectamos un número igual de rapaces en todos los tipos de hábitats. Los mosaicos agrícolas dieron cuenta de 61% del hábitat que estudiamos y 75% de todas las detecciones de rapaces estuvieron en esos hábitats. En contraste, las plantaciones de te fueron 14% del área estudiada, pero únicamente 3% de todas las rapaces fueron detectadas allí. Basados en estos resultados, sugerimos que las plantaciones de te pueden ser hábitats sub óptimos para las rapaces más grandes y de hábitats abiertos. No detectamos grandes águilas residentes de bosque fuera de grandes áreas de bosque no perturbado, los cuales probablemente son críticos para su supervivencia en estos paisajes.

[Traducción de César Márquez]

When compared to Nearctic and Palearctic species, Afrotropical raptors are relatively unstudied. This deficiency was recently illustrated by Virani and Watson (1998); describing the state of knowledge of 79 raptors breeding in East Africa, they considered only 6.3% of these species "well-known," while rating 60.8% "unknown." For many of these unknown species, little or no information exists on distribution, abundance, breeding biology, or feeding ecology—basic information for iden-

[1] E-mail address: nseavy@zoo.ufl.edu

tifying populations that are threatened by habitat alteration. Determination of populations that are threatened is an important aspect of conservation, especially in areas where forests are being cleared to support growing human populations.

With ca. 104 people per km^2, Uganda has one of the densest populations in sub-Saharan Africa and it continues to grow at a yearly rate of 2.6% (FAO 1999). This population has driven widespread deforestation. A hundred years ago, ca. 13% of Uganda was covered by moist, broadleaf forest, but only 3% of this forest remains (Sayer et al. 1992). The remaining forested areas, many in reserves and national parks, are under increasing pressure from growing rural populations. Thus, information on raptor abundance and habitat use both inside and outside of these protected areas is important for management and conservation decisions.

Roadside raptor surveys have been widely used to study relative abundance, community composition, and habitat use of raptors (e.g., Woffinden and Murphy 1977, Ellis et al. 1990). Although limitations of roadside surveys are well-recognized (Millsap and LeFranc 1988, Bunn et al. 1995), the method offers an efficient means of describing raptor communities. Roadside raptor surveys have been conducted in East Africa (Brown 1971, Thiollay 1978, Sorley and Andersen 1994), but these efforts have occurred mostly in savanna habitats that are characterized by high densities of large mammals, vultures, and eagles. Here we present results from eight months of roadside raptor surveys in the Kabarole District of western Uganda. We describe the abundance and diversity of raptors in mature forest, agriculture/forest mosaic, agriculture/grassland mosaic, tea plantation, secondary vegetation, villages, papyrus swamp, and lakeshore habitats.

STUDY AREA AND METHODS

The study area (0°13′–0°41′N, 30°19′–30°32′E) lies just north of the equator at the foot of the Ruwenzori Mountains in western Uganda (Fig. 1). This area is volcanic in origin and characterized by rolling hills. Elevation ranges from 1100 m in the south to 1590 masl in the north. Although historically forested, much of the land has been cleared for subsistence farming and banana (*Musa* spp.) and tea (*Thea sivensis*) plantations to support the growing human population. Within this agricultural landscape, forest fragments remain, especially on steep slopes around crater lakes (Onderdonk and Chapman 2000), but the only extensive forested area is within the 766 km^2 Kibale National Park (KNP). Yearly rainfall, measured at the Makerere University Biological Field Station in KNP, averaged 1778 mm between 1990–98 (L. Chapman and C. Chapman unpubl. data) and peak periods of rainfall occur in April and October (Struhsaker 1997).

We conducted roadside raptor surveys along three transects (19, 15, and 17 km in length; Fig. 1) between September 1997–April 1998. We surveyed transects twice each month, once in the morning (between 0800–1000 H) and again in the afternoon (between 1500–1700 H), usually on the same day. Driving at speeds of 20–40 km/hr with five observers in the vehicle, we stopped briefly to identify raptors on both sides of the transect and recorded the time, distance from the transect, habitat type, and activity (perched or flying) for each bird. During heavy rain we did not conduct surveys.

To quantify habitat availability, we visually estimated habitat composition (10% increments) within 100 m of either side of the road of each km traveled. For this analysis, we recognized eight habitat types: mature forest, agriculture/forest mosaic, agriculture/grassland mosaic, tea plantation, secondary vegetation, villages, papyrus swamp, and lakeshore. *Mature forest* was primarily encountered when transects passed through portions of Kibale National Park. This forest is considered moist, evergreen forest, transitional between lowland rainforest and montane forest (Struhsaker 1997). Canopy height ranges from 25–30 m, with a few trees as tall as 55 m, and common tree species include *Diospyros abyssinica, Markhamia platycalyx, Celtis durandii, Uvariopsis congensis,* and *Bosqueia phoberos* (Chapman et al. 1997). *Agriculture/forest mosaic* was characterized by a patchwork of remnant forest fragments surrounded by subsistence agriculture (primarily bananas, millet, cassava, and corn), fallow fields dominated by elephant grass (*Pennisetum purpureum,* 3–5 m tall), cattle pasture, pine and eucalyptus plantations, and scattered houses. Similar to this habitat, *agriculture/grassland mosaic* was also a patchwork of farmland, cattle pasture, and forest plantations, but uncultivated land was covered by large areas of elephant grass, and there were no remaining natural forest fragments. *Agriculture/grassland mosaic* occurred in the southern portion of the study area. *Tea plantations* are large fields of tea shrubs grown in rows and trimmed regularly to maintain a uniform height of about 1 m. This crop is one of the few intensive, large-scale agricultural industries in western Uganda. Four other habitat types—*secondary vegetation, villages, papyrus swamp, and shores of crater lakes*—together comprised <10% of the area surveyed.

Because the number of raptors detected per transect was low, we pooled survey results from the three transects and considered them a single transect, though surveyed on different days. We considered monthly surveys independent samples and used a Wilcoxon signed-ranks test to compare distributions of raptor count data from morning and afternoon surveys. We investigated the relationship between monthly rainfall and raptor detections (morning and afternoon surveys pooled) using Spearman rank correlation. We used Chi-square goodness-of-fit tests to compare observed and expected numbers of raptors among months and habitat types (all months pooled). We recognize that pooling survey results violates conditions of statistical independence, but

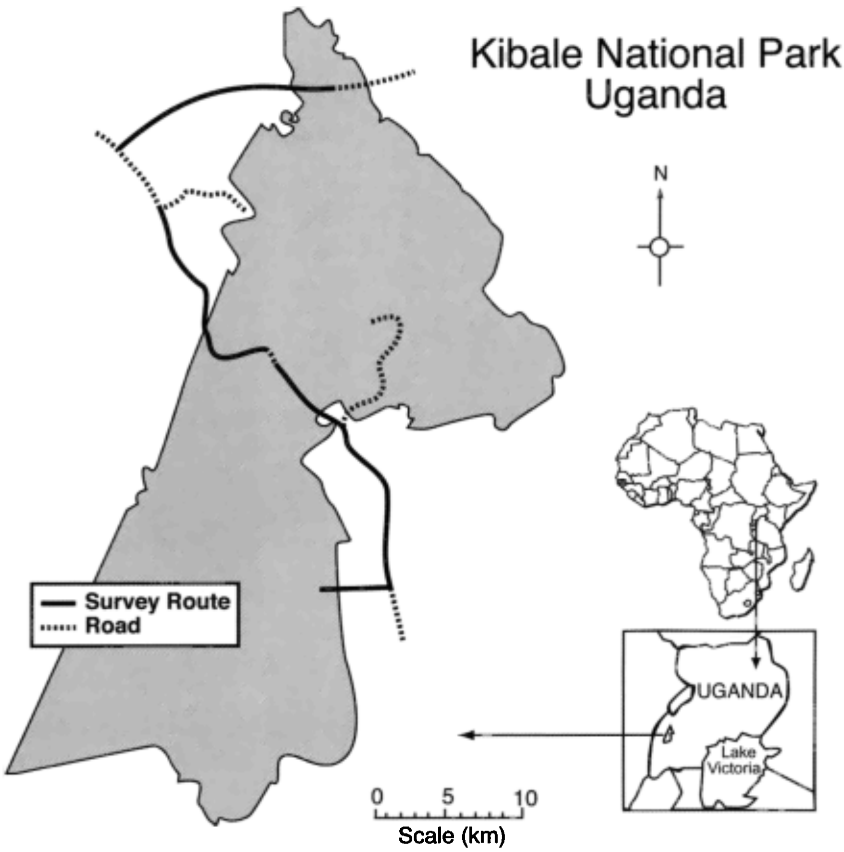

Figure 1. Map of study area and roadside survey transects in Kabarole district, Uganda.

our limited sample size prevented us from using other techniques to compare data.

To meet the assumptions of the Chi-square goodness-of-fit test for the habitat analysis, we combined habitat types that made up less than 5% of the transect length (secondary vegetation, villages, papyrus swamp, and lakeshore) into one category, so all categories had >5 expected detections. Differences between observed use and availability may occur if raptor detectability varies systematically among habitat types. To evaluate whether detectability varied among habitats, we compared detection distances (Kruskal-Wallis test) for mature forest, agriculture/forest mosaic, and agriculture/grassland mosaic. Significance level for all tests was $P = 0.05$.

Finally, based on eight months of pooled data, we present three measures of relative abundance to facilitate comparison to other roadside raptor literature: (1) individuals detected per km traveled, (2) km traveled per individual detected, and (3) Woffinden and Murphy's (1977) Index of Relative Abundance (IRA), calculated as:

$$\text{IRA} = \frac{\text{No. ind. of each species observed}}{\text{No. km traveled}} \times 1000$$

RESULTS AND DISCUSSION

We observed 14 falconiform species and 77 individuals during our study (Table 1). During morning surveys we detected more raptors (median = 5.5, $\bar{x} = 6.5$ raptors/survey) than during afternoon surveys (median = 2.5, $\bar{x} = 3.1$, Wilcoxon signed-ranks test, $z = -2.54$, $N = 8$, $P < 0.05$). This difference is consistent with temperate zone studies demonstrating that roadside raptor surveys are affected by raptor activity patterns (Bunn et al. 1995). The mean number of detections per month was 8.0 raptors, ranging from 5 (December) to 20 (October). The number of detections in October was inflated when we observed 13 Common Buzzards (*Buteo buteo vulpinus*) migrating southward. When these sightings were omitted there was no significant difference between the number of raptors detected each month ($\chi^2_7 = 4.25$, $P > 0.05$). There was no relationship between monthly rain-

Table 1. Numbers of raptors detected, detection frequencies, and relative abundance indices of raptors during roadside surveys in Kabarole district, Uganda.

SPECIES	NO. OBSERVED	INDIV. PER km	Km TRAV. PER INDIV.	INDEX OF REL. ABUND.[a]
Black-shouldered Kite (*Elanus caeruleus*)	3	0.004	272.0	3.7
Black Kite (*Milvus migrans*)	5	0.006	163.2	6.1
African Fish-Eagle (*Haliaeetus vocifer*)	1	0.001	816.0	1.2
Palm-nut Vulture (*Gypohierax angolensis*)	3	0.004	272.0	3.7
African Harrier-Hawk (*Polyboroides typus*)	4	0.005	204.0	4.9
Unidentified harrier (*Circus* spp.)	1	0.001	816.0	1.2
African Goshawk (*Accipiter tachiro*)	2	0.002	408.0	2.5
Lizard Buzzard (*Kaupifalco monogrammicus*)	2	0.002	408.0	2.5
Common (Steppe) Buzzard (*Buteo buteo vulpinus*)	14	0.017	58.3	17.2
Wahlberg's Eagle (*Aquila wahlbergi*)	18	0.022	45.3	22.1
Long-crested Eagle (*Lophaetus occipitalis*)	16	0.020	51.0	19.6
Crowned Hawk-eagle (*Stephanoaetus coronatus*)	2	0.002	408.0	2.5
Gray Kestrel (*Falco ardosiaceus*)	2	0.002	408.0	2.5
Northern Hobby (*Falco subbuteo*)	1	0.001	816.0	1.2
Unidentified hobby (*F. subbuteo* or *cuvieri*)	3	0.004	272.0	3.7

[a] Analysis of relative abundance after Woffinden and Murphy (1977).

fall and the number of raptors detected ($r_s = 0.13$, $N = 8$, $P = 0.76$). Omitting the October flight of Common Buzzards did not change the significance of this relationship ($r_s = -0.12$, $N = 8$, $P = 0.77$).

Raptors were not equally abundant in all habitats ($\chi^2_4 = 19.0$, $P < 0.05$). However, the detection distances for mature forest (median = 0, $\bar{x} = 0.9$ m, $N = 9$), agriculture/forest mosaic (median = 40, $\bar{x} = 44.7$ m, $N = 31$) and agriculture/grassland mosaics (median = 40, $\bar{x} = 64.2$ m, $N = 27$) were significantly different (Kruskal-Wallis, $H_2 = 20.26$, $P < 0.05$). As a result, raptor detectability was undoubtedly reduced in forest habitats, but when forest habitat was excluded from the analysis, raptor detections were still not equally abundant in all habitats ($\chi^2_3 = 15.57$, $P < 0.05$). Therefore, we do not believe that this result simply reflects differential detectability.

Agricultural/forest mosaic was the most common habitat along the route and accordingly had the greatest species richness ($N = 8$) and total detections ($N = 31$; Table 2). Agriculture/grassland mosaic had the second highest species richness ($N = 6$) and total number of detections ($N = 27$; Table 2). However, detections per km were higher in agriculture/grassland mosaic (0.17 raptors/km) than in agriculture/forest mosaic (0.09 raptors/km).

Tea plantations accounted for 14% of the area surveyed, but only 3% of all raptor detections. In this habitat, we detected 0.02 raptors/km and only a single species, the small, insectivorous Gray Kestrel (*Falco ardosiaceus*; Table 2). Larger, vertebrate-eating raptors were conspicuously absent from tea plantation habitats, despite the fact that these fields were often bordered by forest fragments or crossed by rows of utility poles, providing suitable perches.

In mature forest we detected only Crowned Hawk-Eagles (*Stephanoaetus coronatus*) and Common Buzzards. All observations ($N = 7$) of Common Buzzards in this habitat occurred during a single survey in October while this species was passing through on migration. Common Buzzards normally winter in open savanna habitats throughout Africa, and their occurrence in this forested area was probably an unusual event associated with migration. In contrast, Crowned Hawk-Eagles are breeding residents in KNP, where they prey primarily upon arboreal monkeys (Skorupa 1989, Mitani et al. 2001). The absence of Crowned Hawk-Eagles outside of mature forest suggests that they may be sensitive to deforestation in this region of Africa, perhaps because many primates are absent from forest fragments outside of the park (Onderdonk and Chapman 2000).

The least common habitat, lakeshore, occurred only where one transect passed a small crater lake

Table 2. Number of raptors observed in eight habitat types during roadside surveys in Kabarole district, Uganda.

Species	Habitat Type[a]							
	AFM	AGM	TP	MF	VI	SV	PS	LS
Black-shouldered Kite		3						
Black Kite	3				2			
African Fish-Eagle								1
Palm-nut Vulture								3
African Harrier-Hawk	3	1						
Unidentified harrier		1						
African Goshawk	2							
Lizard Buzzard	2							
Common Buzzard	2	3		7	1	1		
Wahlberg's Eagle	2	16						
Long-crested Eagle	13	3						
Crowned Hawk-Eagle				2				
Gray Kestrel			2					
Northern Hobby	1							
Unidentified hobby	3							
Total species	8	6	1	2	2	1		2
Total individuals	31	27	2	9	3	1		4
Raptors per km	0.09	0.17	0.02	0.06	0.10	0.05	0.0	1.25
Km habitat surveyed	337.6	160.0	110.4	148.8	28.8	22.4	4.8	3.2
Percent of total survey length	41.4	19.6	13.5	18.2	3.5	2.8	0.6	0.4

[a] Habitat types: AFM = Agriculture/forest mosaic, AGM = Agriculture/grassland mosaic, TP = Tea plantation, MF = Mature forest, VI = Village, SV = Secondary vegetation, PS = Papyrus swamp, and LS = Lakeshore.

and accounted for <1% of the habitat surveyed. However, this habitat was the only area where we observed an African Fish-Eagle (*Haliaeetus vocifer*) and Palm-nut Vultures (*Gypohierax angolensis*; Table 2).

Long-crested Eagles (*Lophaetus occipitalis*) and Wahlberg's Eagles (*Aquila wahlbergi*) were the most abundant raptors, accounting for 34 of 77 (44%) raptors detected (Table 2). We observed no true vultures during our surveys, despite the fact that Brown (1971) recorded four vulture species during roadside surveys in Queen Elizabeth National Park, less than 50 km south of our study area. Most (75%) of the raptors we observed were either residents or intra-African migrants. The other 25% of detections were Palearctic migrants, but this percentage is inflated by migrating Common Buzzards that did not have a sustained presence in the area. Thus, the proportion of migrant species wintering in the area was much less than 25%, even though our surveys took place during the Palearctic winter when northern migrants would be present. Determining the exact proportion of wintering migrants is difficult, because some or all of the unidentified raptors (e.g., *Circus* spp. and *Falco* spp.) may have been migratory and some species, such as Black Kites (*Milvus migrans*), may have been represented by both migrant (*M. m. migrans*) and resident (*M. m. parasitus*) subspecies. However, even if we assume that all unidentified species were wintering Palearctic migrants, these individuals account for only 8% of all raptor detections when Common Buzzards are omitted.

Based on raptor surveys in Mexico, Guiana, and Ivory Coast, Thiollay (1985) demonstrated that when tropical forests are fragmented and converted to open agricultural habitats, resident species tolerant of open habitats and northern migrants replace resident forest species. Similarly, in a review of roadside raptor surveys in South Africa, Cade (1969) recognized that Palearctic migrants were abundant in the disturbed agricultural habitats of Transvaal and Orange Free State, where they accounted for 33–95% of all raptor detections, but were relatively rare in Kruger National Park and Kalahari Gemsbok Park, where they accounted for only 2–4% of all detections. In savanna habitats of Uganda, Palearctic migrants comprised only 11% of the raptors detected by Brown (1971) and 31–43% of raptors detected by Thiollay (1978). Most of our study area was deforested and highly-disturbed, and although the commonly-detected residents were associated with open, agricultural mosaic habitats, we did not observe a large proportion of wintering migrants.

Roadside raptor surveys generally work well in open habitats; however, they are less effective in forested habitats (Millsap and LeFranc 1988). This may be especially problematic in tropical forests where raptor communities are notoriously difficult to sample and complete surveys often involve special techniques (Thiollay 1989, Whitacre et al. 1992). Thus, the low number of raptors we detected in mature forest is probably not indicative of overall raptor abundance and species richness in this habitat. For instance, we did not detect Cassin's Hawk-Eagles (*Spizaetus africanus*) nor Ayres' Hawk-Eagles (*Hieraaetus ayresii*). Both are large, uncommon, forest-dwelling eagles that breed in Kibale National Park (Skorupa et al. 1985, Seavy 2000). Similarly, smaller raptors that use easily overlooked perch sites are often difficult to detect (Millsap and LeFranc 1988) and these biases should be considered when interpreting our survey results. Species that were observed in the study area, but not detected on our transects, were Osprey (*Pandion haliaetus*), Banded Snake-Eagle (*Circaetus cinerascens*), Black-chested Snake-Eagle (*Circaetus pectoralis*), African Marsh-Harrier (*Circus ranivorus*), Black Goshawk (*Accipiter melanoleucus*), Little Sparrowhawk (*Accipiter minullus*), Martial Eagle (*Polemaetus bellicosus*), and African Hobby (*Falco cuvieri*).

The results of our surveys provide two conclusions with implications for raptor conservation in East African forest landscapes. First, in the dominant agricultural habitat we detected species associated with agricultural habitats, but very few forest-associated species. Thus, although some raptors may be numerous in these cleared habitats, forest-associated species appear to be uncommon, restricted to large tracts of forest, and sensitive to deforestation. If the large, forest-dwelling raptors are entirely absent from open habitats surrounding KNP, then these species may be confined to the forest inside the park. Second, our results suggest that tea plantations may provide unique foraging opportunities for small insectivorous raptors, but unsuitable habitat for many larger, open-habitat raptors. In short, not all open habitats are of equal value to all open-habitat raptors. These results should be considered by managers and researchers concerned with raptor conservation and protected area design in forested landscapes of East Africa.

ACKNOWLEDGMENTS

Invaluable assistance in the field was provided by E. Aliganyiri, S. Balcomb, A. Ermosi, T. Lawrence, and J. Mugenyi. We thank L.J. Chapman and C.A. Chapman for support of this project. We express our gratitude to the Makerere University Biological Field Station for providing logistical support in Kibale National Park. J. Piascik prepared the figure of the study area. C.A. Chapman, R.S. Duncan, P. Mundy, J. Paul, D.F. Whitacre, and two anonymous reviewers provided comments on drafts of the manuscript.

LITERATURE CITED

BROWN, L. 1971. African birds of prey. Houghton Mifflin Co., Boston, MA U.S.A.

BUNN, A.G., W. KLEIN, AND K.L. BILDSTEIN. 1995. Time-of-day effects on the numbers and behavior of non-breeding raptors seen on roadside surveys in eastern Pennsylvania. *J. Field Ornithol.* 66:544–552.

CADE, T.J. 1969. The status of the peregrine and other Falconiformes in Africa. Pages 289–321 *in* J.J. Hickey [ED.], Peregrine Falcon populations, their biology and decline. Univ. of Wisconsin Press, Madison, WI U.S.A.

CHAPMAN, C.A., L.J. CHAPMAN, R.W. WRANGHAM, G. ISABIRYE-BASUTA, AND K. BEN-DAVID. 1997. Spatial and temporal variability in the structure of a tropical forest. *Afr. J. Ecol.* 35:287–302.

ELLIS, D.H., R.L. GLINSKI, AND D.G. SMITH. 1990. Raptor road surveys in South America. *J. Raptor Res.* 24:98–106.

FAO. 1999. State of the world's forests. 1999. United Nations, Rome, Italy.

MILLSAP, B.A. AND M.N. LEFRANC, JR. 1988. Road transect counts for raptors: how reliable are they? *J. Raptor Res.* 22:8–16.

MITANI, J.C., W.J. SANDERS, J.S. LWANGA, AND T.L. WINDFELDER. 2001. Predatory behavior of Crowned Hawk-Eagles (*Stephanoaetus coronatus*) in Kibale National Park, Uganda. *Behav. Ecol. Sociobiol.* 49:187–195.

ONDERDONK, D.A. AND C.A. CHAPMAN. 2000. Coping with forest fragmentation: the primates of Kibale National Park, Uganda. *Int. J. Primatol.* 21:587–611.

SAYER, J.A., C.S. HARCOURT, AND N.M. COLLINS. 1992. The conservation atlas of tropical forests: Africa. Macmillan, U.K.

SEAVY, N.E. 2000. Observations at an Ayres' Hawk-Eagle nest in Kibale National Park, Uganda. *J. Raptor Res.* 34:59–60.

SKORUPA, J.P. 1989. Crowned Eagles *Stephanoaetus corona-*

tus in rainforest: observations on breeding chronology and diet at a nest in Uganda. *Ibis* 131:294–298.

———, J. KALINA, T.M. BUTYNSKI, G. TABOR, AND E. KELLOG. 1985. Notes on the breeding biology of Cassin's Hawk-Eagle *Hieraaetus africanus*. *Ibis* 127:120–122.

SORLEY, C.S. AND D.E. ANDERSEN. 1994. Raptor abundance in south-central Kenya in relation to land-use patterns. *Afr. J. Ecol.* 32:30–38.

STRUHSAKER, T.T. 1997. Ecology of an African rainforest: logging in Kibale and the conflict between conservation and exploitation. Univ. Presses of Florida, Gainesville, FL U.S.A.

THIOLLAY, J.-M. 1978. Population structure and seasonal fluctuations of the Falconiformes in Uganda National Parks. *E. Afr. Wildl. J.* 16:145–151.

———. 1985. Composition of Falconiform communities along successional gradients from primary rainforest to secondary habitats. Pages 181–190 *in* I. Newton and R.D. Chancellor [EDS.], World conference on birds of prey: conservation studies on raptors. ICBP Tech. Publ. No. 5, Cambridge, U.K.

———. 1989. Censusing of diurnal raptors in a primary rainforest: Comparative methods and species detectability. *J. Raptor Res.* 23:72–84.

VIRANI, M. AND R.T. WATSON. 1998. Raptors in the east African tropics and western Indian Ocean islands: state of ecological knowledge and conservation status. *J. Raptor Res.* 32:28–39.

WHITACRE, D.F., L.E. JONES, AND J. SUTTER. 1992. Censusing raptors and other birds in tropical forest: further refinements of methodology. Pages 39–52 *in* D.F. Whitacre and R.K. Thorstrom [EDS.], Maya Project Report No. 5. The Peregrine Fund, Boise, ID U.S.A.

WOFFINDEN, N.D. AND J.R. MURPHY. 1977. A roadside raptor census in the eastern Great Basin—1973–74. *Raptor Res.* 11:62–66.

Received 25 January 2001; accepted 21 November 2001