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BANDING REVEALS POTENTIAL NORTHWARD MIGRATION OF COOPER'S HAWKS FROM SOUTHERN CALIFORNIA

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ABSTRACT.—Cooper's Hawks (*Accipiter cooperii*) from approximately the northern third of the species' breeding range are considered migratory, hawks in the central portion are either migratory or resident, and hawks farther south are believed to be nonmigratory. We compared long-distance movements (>100 km between natal nest and encounter location) of Cooper's Hawks banded as nestlings at two different ranges of latitudes (>35° and <35°N). Our goal was to determine whether long-distance movements indicate that Cooper's Hawks from southern latitudes (south of 35°N) are migratory and whether any migrate north, as do Bald Eagles (*Haliaeetus leucocephalus*) from several locations in the southern U.S.A. and Red-tailed Hawks (*Buteo jamaicensis*) from southern California. Long-distance movements by hawks banded as nestlings north of 35°N were strongly oriented to the south, with only 17% in a northerly direction. The only hawks encountered >100 km from nests south of 35°N were from southern Arizona and southern California. As opposed to the strong southward orientation of long-distance movements of hawks from north of 35°N, mean direction south of 35° was bipolar. Northward long-distance movements from nests in southern Arizona were relatively short (<200 km), while southward movements were substantially longer (1637 km in one case). Three Cooper's Hawks from southern Arizona were encountered in central Mexico, well south of the known breeding range, which suggests some individuals from southern Arizona are migratory. The pattern of long-distance movements from southern California was the reverse of that from southern Arizona. Most long-distance movements toward the south from southern California nests were comparatively short, whereas the three longest movements from that area (616–993 km) were to the north. Although tentative, we believe these longer movements are indicative of northward migration rather than natal or breeding dispersal.

KEY WORDS: *Cooper's Hawk*; Accipiter cooperii; *banding*; *migration*; *movement*; *nestling*.

EL ANILLAMIENTO DE *ACCIPITER COOPERII* REVELA UNA MIGRACIÓN POTENCIAL HACIA EL NORTE DESDE EL SUR DE CALIFORNIA

RESUMEN.—Los individuos de *Accipiter cooperii* de aproximadamente el tercio norte del área reproductiva de la especie son considerados migratorios, los individuos de la porción central son migratorios o residentes y aquellos de la parte sur son residentes. Comparamos los movimientos de larga distancia (>100 km entre los nidos y las localidades de encuentro) de individuos de *A. cooperii* anillados a la edad de polluelos en dos latitudes diferentes (>35° y <35°N). Nuestro objetivo fue determinar si los movimientos de larga distancia indican que los individuos de *A. cooperii* de latitudes australes (al sur de 35°N) son migratorios y si alguno migra hacia el norte, como lo hacen los individuos de *Haliaeetus leucocephalus* provenientes de distinto sitios del sur de Estados Unidos y los individuos de *Buteo jamaicensis* provenientes del sur de California. Los movimientos de larga distancia realizados por los individuos anillados a la edad de polluelos al norte de los 35°N estuvieron fuertemente orientados hacia el sur, con solo el 17% en dirección norte. Los únicos *A. cooperii* encontrados a >100 km de los nidos al sur de 35°N fueron los del sur de Arizona y sur de California. De manera opuesta a la fuerte orientación hacia el sur de los movimientos de larga distancia de los individuos provenientes del norte de los 35°N, la dirección principal al sur de los 35°N fue bipolar. Los movimientos de larga distancia hacia el norte desde los nidos en el sur de Arizona fueron relativamente cortos (<200 km), mientras que los movimientos hacia el sur fueron substancialmente más largos (1637 km en un caso). Se encontraron tres individuos de *A. cooperii* provenientes del sur de Arizona en el centro de México, bastante al sur de su área de cría, lo que sugiere que algunos de los individuos del sur de Arizona son migratorios. El patrón de movimientos de larga distancia desde el sur de California fue inverso al patrón del sur de Arizona. La mayoría de los movimientos de larga distancia hacia el sur desde los nidos del sur de California fueron comparativamente cortos, mientras que los tres movimientos más largos desde esa área

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(616–993 km) fueron hacia el norte. Aunque estos resultados son preliminares, creemos que estos movimientos más largos son indicativos de una migración hacia el norte más que de una dispersión natal o de cría.

[Traducción del equipo editorial]

Fledglings and young adults of some raptor species migrate northward from their natal region in summer, returning later in the year. For example, Bald Eagles (*Haliaeetus leucocephalus*) from southern portions of the United States (Florida [Broley 1947, Wood 1992, Millsap et al. 2004, Mojica et al. 2008], California [Hunt et al. 1992, Jenkins et al. 1999, Linthicum et al. 2007], Texas [Mabie et al. 1994], and Arizona [Hunt et al. 2009]) migrate northward from their natal region in summer, returning later in the year. Bloom et al. (2015) recently reported that fledgling and young adult Red-tailed Hawks (*Buteo jamaicensis*) from nests south of 35°N in California also migrate north from their natal region, returning later in the year; one individual repeated the same pattern over 4 yr. Reduced prey availability during the hotter summer months has been suggested as one reason for northward migration of both Bald Eagles (Hunt et al. 1992, Wood 1992) and Red-tailed Hawks (Bloom et al. 2015), and Bloom et al. (2015) hypothesized that other raptor species from southern latitudes (<35°N) might also migrate northward from their natal regions for the same reason.

One species that shares some important similarities to the distribution and migratory pattern of Red-tailed Hawks is the Cooper's Hawk. Like Red-tailed Hawks, Cooper's Hawks (*Accipiter cooperii*) have a breeding range that encompasses a large portion of North America, from approximately 53°N in central Canada to approximately 22.5° in west-central Mexico, while the winter range extends farther south into Central America (Curtis et al. 2006). Cooper's Hawks, like Red-tailed Hawks, are partial migrants. Cooper's Hawks from approximately the northern third of the species' breeding range are believed to be predominantly migratory, whereas individuals farther south are either migratory or resident (Palmer 1988). Cooper's Hawks in the southern portion of the species' breeding range are widely believed to be nonmigratory (Garrett and Dunn 1981, Cartron et al. 2010, Chiang et al. 2012, Goodrich et al. 2012). Red-tailed Hawks in the southern portion of the species' breeding range were also considered residents (Garrett and Dunn 1981, Brinker and Erdman 1985), until Bloom et al. (2015) found that at least some individuals from south of 35°N in southern California were migratory, although the direction of migration was northward from their natal nests. Red-tailed Hawks banded as nestlings at higher latitudes displayed the opposite pattern, with migration strongly oriented toward the south.

Although Cooper's Hawks have been studied for many decades, most of what is known about their migration derives from autumn observations of hawks flying over fixed-location "watchsites" (e.g., Hawk Mountain, Pennsylvania). In addition to monitoring flight behavior and abundance, researchers have also banded thousands of Cooper's Hawks at these locations; however, interpreting migratory patterns from banding at watchsites is limited to a degree because the location of natal nests or breeding territories of captured individuals is seldom known. In this report, we investigated movements of Cooper's Hawks that were banded as nestlings and therefore of known origin. We compared directions and distances of long-distance movements (>100 km between natal nest and encounter location) of hawks banded as nestlings both north and south of 35°N latitude. Our goal was to determine whether Cooper's Hawks in the southern portion of the species' breeding range, south of 35°N, are migratory and whether any individuals migrate northward in a manner similar to Bald Eagles and Red-tailed Hawks.

METHODS

In June 2016, we received from the U.S.G.S. Bird Banding Laboratory (BBL) all banding records of Cooper's Hawks banded as nestlings. From 1974 through June 2015, we banded 1424 nestling Cooper's Hawks, the majority of which were from nests in southern California ($n=1388$) south of 35°N latitude. Including those banded by us, 15,067 nestling Cooper's Hawks were banded in the U.S.A. and Canada from 13 June 1946 through 1 August 2015 (most recent record on file as of June 2016 when we received the BBL data): 10,786 north of 35° and 4282 south of 35°N. We also obtained all encounter (banded bird found dead or alive or recaptured) records ($n=882$) of nestlings through 9 June 2016 (latest encounter when we received the

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data). Upon examining the BBL encounter records, however, we found six with no encounter location, one banded in November outside the nesting season for the species (Curtis et al. 2006), two that died while still in the nest, and six duplicate records, all (n = 15) of which we excluded from our analysis.

Migration can most simply be defined as a seasonal movement from a breeding area to a nonbreeding area and back again. Because banded raptors are seldom encountered more than once, however, we analyzed long-distance movements (>100 km between nest and encounter location) of Cooper's Hawks. Although to a degree arbitrary, movements >100 km have been considered as indicating migration for Eurasian Kestrels (*Falco tinnunculus*; Adriaensen et al. 1997), Prairie Falcons (*Falco mexicanus*; Steenhof et al. 2005) and Red-tailed Hawks (Bloom et al. 2015). The BBL dataset contained records of 168 Cooper's Hawks banded as nestlings and later encountered >100 km from their natal nest.

In most cases, banding and encounter locations in BBL data are limited to the centers of the 10-min blocks. (A 10-min block in southern California where most of our banding took place measures approximately 18.4 × 15.6 km.). Therefore, directions and distances are approximations based on the straight line between the centers of the natal and encounter 10-min block for each hawk. We used NCSS statistical software (Hintze 2007) to analyze distances and the program ORIANA (Kovach 2009) to analyze directions. Mean distances are reported ±SE, and mean directions are reported ±SD; we used $\alpha = 0.05$ as the level of significance for statistical tests.

RESULTS

Cooper's Hawks that were encountered >100 km from their natal nest (n = 168) were banded as nestlings across a latitudinal range of 22.4° that included six Canadian provinces and 17 states, from central Alberta, Canada (53.8°N) to just north of the Mexican border in Arizona (31.4°N). The greatest number of these hawks was banded in Wisconsin (n = 53, 32%), followed by British Columbia (n = 19, 11%) and North Dakota (n = 16, 10%). Most (n = 144, 86%) originated from nests north of 35°N, whereas 24 (14%) were from nests south of 35°N.

Nests North of 35°N Latitude. Mean direction of long-distance movements of hawks banded in nests north of 35°N was strongly oriented to the south (174 ± 55.8°, r = 0.62, Fig. 1), with directions deviating significantly from a uniform circular distribution (Rayleigh's test, Z = 55.7, P < 0.01). When compass directions were divided between those hawks heading north (270–90°, n = 24) and those heading south (90–270°, n = 120), the proportion of hawks encountered in each of the two directions differed significantly from expected (binomial test, Z=7.92, P< 0.01); significantly more hawks (83%) headed south from their natal nests, while far fewer hawks flew north (17%).

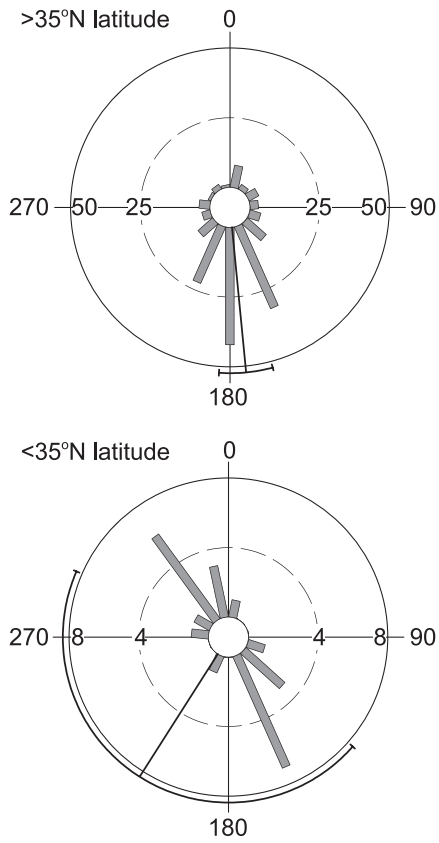


Figure 1. Directions of long-distance movements (>100 km between natal nest and encounter location) of Cooper's Hawks banded at nests north (n=144) and south (n=24) of 35°N latitude in North America. Each bar in the circular histogram represents 24° of the total circular range, and bar length (radius from center) represents number of observations. Mean direction is shown as the line running from center to outer edge, and arcs extending to either side represent 95% confidence limits.

Mean distance of the long-distance movements of hawks from nests north of 35°N was 961 ± 80 km (n = 144, range 102–4473 km). Most long-distance

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Table 1. Long-distance (>100 km) movements of Cooper's Hawks banded as nestlings from <35°N latitude in southern Arizona and southwestern California.

NATAL NEST	ENCOUNTER MONTH	AGE (MO) AT ENCOUNTER	DIRECTION (DEGREES)	DISTANCE (KM)	CONDITION AT ENCOUNTER
AZ	Jun	2	320	169	Injured
AZ	Oct	5	340	138	Dead (fresh)
AZ	May	24	313	191	Dead (unk)
AZ	Mar	58	316	156	Dead (unk)
AZ	Oct	29	320	169	Dead (unk)
AZ	Dec	6	155	810	Dead (unk)
AZ	Nov	6	156	779	Shot (fresh)
AZ	Nov	6	151	1578	Shot (fresh)
AZ	Dec	7	201	287	Shot (fresh)
AZ	Mar	10	139	1637	Dead (unk)
AZ	Sep	17	139	122	Dead (unk)
AZ	Feb	21	151	1578	Shot (fresh)
CA	Aug	3	321	145	Dead (fresh)
CA	Ukn	≤5	16	993	Dead (unk)
CA	Dec	8	321	169	Dead (unk)
CA	Nov	6	353	616	Injured
CA	Jan	8	287	128	Dead (unk)
CA	Apr	14	341	629	Dead (unk)
CA	Dec	79	302	127	Dead (fresh)
CA	Dec	7	105	208	Dead (unk)
CA	Jan	8	149	151	Dead (unk)
CA	Jan	9	145	136	Dead (unk)
CA	Apr	12	140	334	Dead (unk)
CA	Apr	47	146	112	Dead (unk)

movements toward the north were relatively short (mean = 295 ± 69 km, $n = 24$, range 110–1779 km); only two (8%) of those heading north were >500 km. Long-distance movements toward the south (mean = 1090 ± 90 km, $n = 120$, range 102–4473 km) were significantly greater (Mann-Whitney *U*-test, $Z = -4.08$, $P < 0.01$), with 71 (59%) of the distances between banding and encounter >500 km.

Nests South of 35°N Latitude. Nestlings banded south of 35°N ($n = 4282$) were almost entirely from southern California ($n = 1758$, 41%) and southern Arizona ($n = 2432$, 57%), and the only long-distance movements of hawks from nests south of 35°N were from those two areas (southern California, $n = 12$, Table 1; southern Arizona, $n = 12$, Table 1). Overall mean direction of long-distance movements of hawks banded in nests south of 35°N was toward the southwest (212 ± 161.8°, $n = 24$, $r = 0.02$, Fig. 1), but the distribution of directions did not deviate significantly from a uniform circular distribution (Rayleigh's test, $Z < 0.01$, $P = 0.99$), and the overall distribution was bipolar (Fig. 1), with 12 hawks heading in a northerly direction (270–90°) and 12 in a southerly direction (90–270°). Similar numbers of hawks from southern California and southern Arizona made long-distance movements to the north ($n = 7$ and $n = 5$, respectively, Table 1, Fisher's exact test, $P = 0.68$).

Mean distance of the long-distance movements of hawks banded in nests south of 35°N was 473 ± 103 km ($n = 24$, range 112–1637 km). Mean distance to the south (644 ± 179 km, $n = 12$, range = 112–1637 km) did not differ significantly from mean distance to the north (mean = 303 ± 82 km, $n = 12$, range 127–993 km; Mann-Whitney *U*-test, $Z = -1.1$, $P = 0.27$).

Six of the seven hawks that made long-distance movements to the south of their natal nests in southern Arizona were encountered in Mexico (Fig. 2), with three encountered at latitudes (19.4–20.5°N) south of the known breeding range of the species (Fig. 2). Although most of these southern Arizona hawks for which age at time of encounter could be determined were encountered in their first year (Table 1), one hawk from southern Arizona was shot when 21 mo of age and 1578 km south of its

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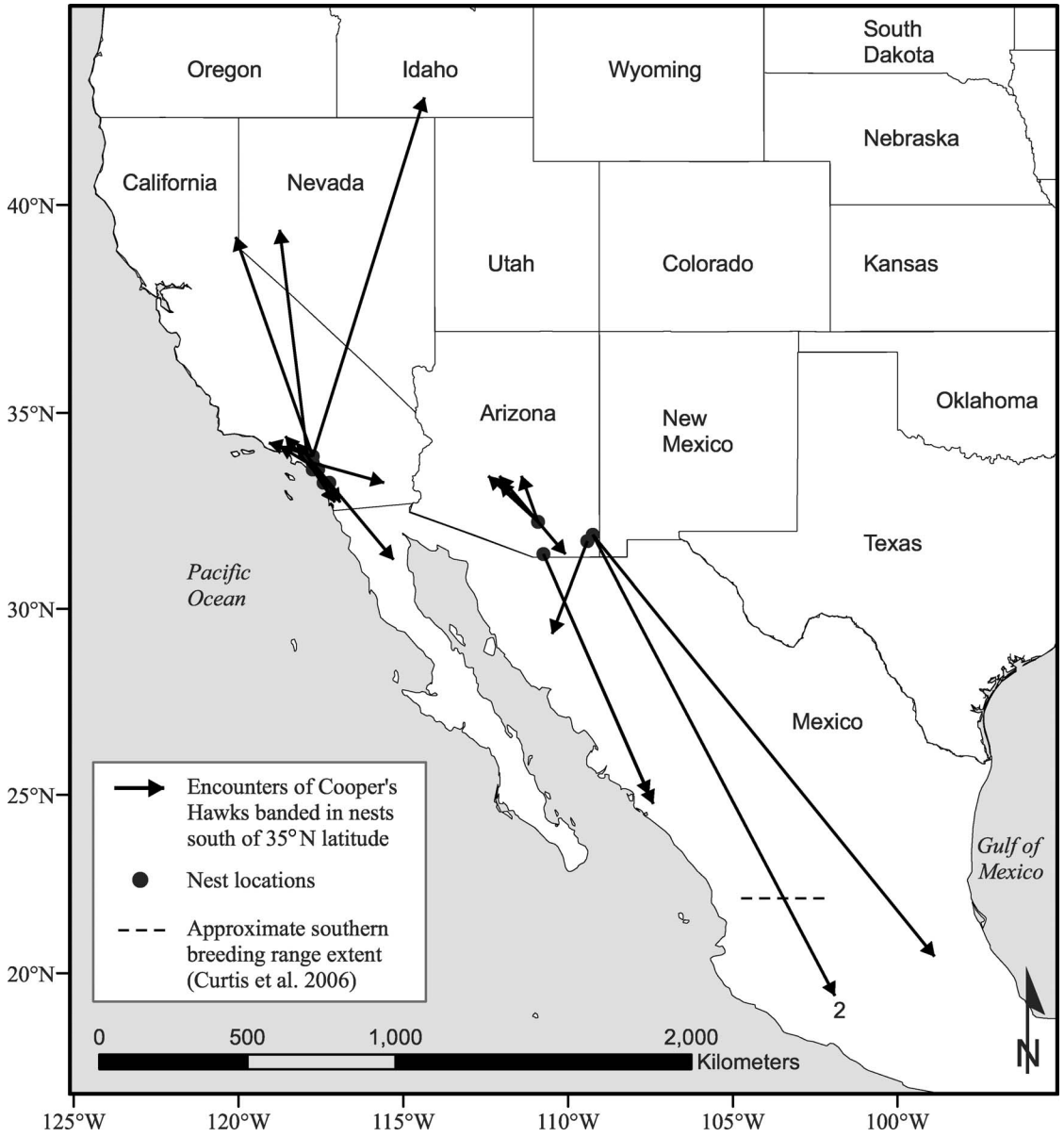


Figure 2. Long-distance movements (>100 km between natal nest and encounter location) of Cooper's Hawks banded at nests south of 35°N latitude.

nest, indicating the possibility of multiple trips. Long-distance movements of the five hawks from southern Arizona that traveled north were comparatively short, with none >200 km (Table 1).

The pattern of long-distance movements of southern California hawks was somewhat the reverse of that of long-distance movements of southern Arizona hawks. Long-distance movements of southern California hawks that were toward the south were relatively short (Table 1, Fig. 2), while the three longest movements of hawks from the same area (>600 km) were all to the north (Table 1, Fig. 2). The longest movement from southern California was of an individual encountered when ≤5 mo of age in

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Idaho, 993 km north of its natal nest (Fig. 2). Also, only one of the hawks from nests in southern California was encountered in Mexico, specifically in northern Baja California, 334 km south of its natal nest.

DISCUSSION

The direction of migration of Cooper's Hawks in autumn as observed over many years at raptor watchsites, almost all of which are located north of 35°N latitude, is predominantly to the south. Although not conclusive, the fact that most long-distance movements of Cooper's Hawks from nests north of 35°N in this study were also toward the south lends some support to our considering movements >100 km as indicative of possible migration. Far fewer long-distance movements of hawks from nests north of 35°N were toward the north, and northward long-distance movements were relatively short compared to southward ones, with all but two hawks encountered <500 km north of their nest. Such shorter movements may be more suggestive of postfledging dispersal behavior or possibly overshooting during spring migration. We documented a few instances of overshooting by satellite-transmittered Red-tailed Hawks returning to their natal region (Bloom et al. 2015).

Although populations in the southern portion of the Cooper's Hawk's range are thought to be resident (Garrett and Dunn 1981, Cartron et al. 2010, Chiang et al. 2012, Goodrich et al. 2012), results of this study suggest that at least a few individuals from southern latitudes (south of 35°N) are migratory. This was most apparent in southern Arizona where southward long-distance movements were similar to those from farther north: five of 12 hawks from southern Arizona were encountered in Mexico well to the south of their natal nests and three of these were south of the known breeding range (Fig. 2). Indeed, one of these was 1578 km south of its natal nest at 21 mo old and was likely a migrant, given that the average natal dispersal in Arizona is only 7.4 km (males) or 9.7 km (females; Mannan et al. 2007). Although there were no long-distance movements from nests south of 35° in New Mexico, some individuals from that area may also be migratory, as suggested by Kennedy (1991), who noted that radio-tagged breeding adult female Cooper's Hawks disappeared from her study area just north of 35°N latitude in north-central New Mexico during the peak of autumn migration.

Although five hawks from southern Arizona nests were encountered north of their natal nests, northward long-distance movements of these individuals were all relatively short (<200 km), especially when compared to movements of southern Arizona hawks that were encountered in central Mexico. In contrast to hawks banded in southern Arizona, the longest movements by hawks from southern California were to the north, whereas movements to the south were comparatively short, with only one encountered in northern Mexico. Although speculative, we believe these longer movements are indicative of northward migration rather than natal dispersal. Although reports of natal dispersal distance for Cooper's Hawks are limited to only two areas, in both cases distances were relatively short (Wisconsin, mean = 12 km; Rosenfield and Bielefeldt 1992; southern Arizona, see above). Interestingly, the three Cooper's Hawks that traveled farthest north were all from the same 100-km section of the coast of southern California between Los Angeles and San Diego where fledgling and young Red-tailed Hawks were found to migrate north (Bloom et al. 2015).

Our original goal with this study was to compare long-distance movements and directions between banding and encounter locations for Cooper's Hawks banded at northern vs. southern latitudes, across the entire range of the species. However, upon examining the BBL encounter records, we did not find any long-distance movements of hawks from nests south of 35°N outside southern Arizona and southern California. To further our understanding of the movement patterns of Cooper's Hawks hatched at southern latitudes through banding alone would likely require banding thousands of nestlings or possibly also banding breeding adults throughout extensive portions of the southern breeding range of the species. Although expensive, satellite transmitters could be used on a comparatively much smaller number of nestling Cooper's Hawks from nests south of 35°N. Such data could help determine whether a population is at least partially migratory, identify migration pathways, stopover locations, and wintering areas. Hawks from nests in southern California would be of particular interest regarding the potential for northward migration, as suggested by this study. Mexico would also be of interest as Goodrich et al. (2012) suggested Cooper's Hawks banded south of <25°N latitude may move northward during winter, based on banding encounters. Determining the

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migratory status of Cooper's Hawk breeding populations throughout the species' southern range would be of both scientific interest and conservation value.

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