Journal of Raptor Research

Advancing the science, conservation, and understanding of birds of prey

Journal of Raptor Research 59(3):jrr2465
doi: 10.3356/jrr2465

Factors Associated with Homing Behavior in Cooper's Hawks Following Mitigation Translocations from Airports

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ABSTRACT.—Raptor-aircraft collisions pose a serious safety risk to civilian aircraft throughout North America and elsewhere in the world; however, the hazard posed by Cooper's Hawks (*Accipiter cooperii*) to safe aircraft operations is unknown. Based on our query of the Federal Aviation Administration's National Wildlife Strike Database (from 1 January 1990 to 31 December 2023) we found reported Cooper's Hawk-aircraft collisions increased by 3200% during that period. One nonlethal management method to reduce strike hazards posed by this species is mitigation translocation. We conducted a study to determine which biological (e.g., age and sex of the bird) and logistical factors (e.g., month and translocation distance) might influence the return of Cooper's Hawks translocated from airports within the Los Angeles Basin (7565 km^2 in area) during 2017–2022. Overall, 10.2% of translocated Cooper's Hawks exhibited homing behavior. The age of the bird, sex, and distance translocated away from an airfield influenced Cooper's Hawk return rates. Specifically, second year hawks had the highest return rate, females returned at a higher proportion compared to males, and the farther away hawks were translocated from an airport the lower the return rate. Hazard management programs that only translocate hatching year and after second year Cooper's Hawks to release sites at least 48 km from airfields would increase program efficacy (i.e., minimize hawk returns) and decrease implementation costs.

KEY WORDS: *airports*; *bird strikes*; *management*; *raptors.*

FACTORES ASOCIADOS AL COMPORTAMIENTO DE REGRESO AL HOGAR EN ACCIPITER COOPERII TRAS REUBICACIONES DE MITIGACIÓN DESDE AEROPUERTOS

RESUMEN.—Las colisiones entre aves rapaces y aeronaves representan un serio riesgo para la seguridad de vuelos civiles en América del Norte y en otras partes del mundo; sin embargo, el peligro específico que representa *Accipiter cooperii* para la seguridad de las operaciones aéreas es desconocido. Según nuestra consulta a la Base Nacional de Datos de Colisiones con Fauna Silvestre de la Administración Federal de Aviación (del 1 de enero de 1990 al 31 de diciembre de 2023), encontramos que los reportes de colisiones entre *A. cooperii* y aeronaves aumentaron en un 3200% durante ese período. Un método de manejo no letal para mitigar el riesgo de colisiones causadas por esta especie es la reubicación. Realizamos un estudio para determinar qué factores biológicos (e.g., edad y sexo del ave) y logísticos (e.g., mes y distancia de reubicación) podrían influir en el regreso de individuos reubicados de *A. cooperii* desde los aeropuertos dentro de la cuenca de Los Ángeles (un área de 7565 km^2) durante 2017–2022. En general, el 10.2% de los individuos reubicados de *A. cooperii* mostraron comportamiento de regreso al hogar. La edad del ave, el sexo y la distancia de reubicación desde el aeropuerto influyeron en las tasas de regreso de *A. cooperii.* Específicamente, los individuos en su segundo año de vida tuvieron la tasa de regreso más alta, las hembras regresaron en mayor proporción que los machos, y cuanto más lejos eran reubicados del

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aeropuerto, menor era la tasa de regreso. Los programas de manejo de riesgos que únicamente reubiquen a individuos de *A. cooperii* del primer año de vida o mayores al segundo año en sitios de liberación a al menos 48 km de los aeropuertos, aumentarían la eficacia del programa (i.e., minimizarían los regresos de *A. cooperii*) y reducirían los costos de implementación.

[Traducción del equipo editorial]

INTRODUCTION

Worldwide, wildlife collisions with aircraft (wildlife strikes) pose a serious safety risk to civil and military aviation, especially for commercial aviation (DeVault et al. 2013, Metz et al. 2020). Allan et al. (2016) estimated the total cost of wildlife strikes to commercial aviation worldwide to be more than USD 1.5 billion per yr. Birds are the primary taxa involved in these events, accounting for approximately 97% of wildlife strikes to civil aviation in the USA reported to the Federal Aviation Administration (FAA; Dolbeer et al. 2023). Within North America (and elsewhere in the world), raptors are one of the most frequently struck bird guilds, posing high economic risks and serious safety concerns to civilian and military aircraft (Zakrajsek and Bissonette 2005, DeVault et al. 2011, DeVault et al. 2018, Pfieffer et al. 2018).

Raptors (and other species hazardous to aviation) use airport environments to meet one or more of their life history requirements (DeVault et al. 2013). Airports and military airfields often host habitat for prey preferred by raptors such as small mammals, birds, and grasshoppers (Washburn et al. 2011, Witmer 2011, Pitlik and Washburn 2016). In addition, structures within airport environments can provide perching locations (for roosting and hunting) and nesting sites for many raptors (Cleary and Dolbeer 2005). Movements of raptors on airfields, especially during migratory periods when the abundance of some species increases substantially, can result in raptor-aircraft collisions and increase human health and safety risks (DeVault et al. 2013, Washburn 2018).

The Cooper's Hawk (*Accipiter cooperii*) is a medium-sized raptor with a broad distribution in North America that extends from southern Canada, across the USA, and into northern Mexico. This species is expanding its range in both northern and southern directions (Rosenfield et al. 2024). In addition, Cooper's Hawks have been extending their breeding range out from the traditional deciduous and mixed-deciduous forested habitats into suburban and urban areas (Mannan et al. 2008, Rosenfield et al. 2009, 2024). Expansion of Cooper's Hawk populations into urbanized areas is likely one of the major factors that has increased the frequency and severity of Cooper's Hawk-aircraft collisions at airports within urbanized landscapes.

Cooper's Hawks are nonmigratory in the southern half of their range, such as southern California, and spend much of their year within established breeding and wintering territories (Boggie and Mannan 2014, Briggs et al. 2020, Rosenfield et al. 2024). However, hawks from the northern extent of their range do migrate south during the fall and north during the spring; thus, these birds exhibit transient behavior during migratory periods (DeLong and Hoffman 1999, Hull et al. 2012). Consequently, the movement characteristics of Cooper's Hawks in southern California is likely more diverse at certain times of the year (e.g., fall migration period) and less so during the breeding and wintering periods. Importantly, we suspect that the time of year (e.g., month, life history period) influences the behavioral responses of translocated Cooper's Hawks.

Based on the findings of related studies (Pullins et al. 2018, Washburn 2024) and our understanding of Cooper's Hawk movement ecology and habitat use, we hypothesized that biological factors (such as age and sex of individual hawks) and logistical factors related to mitigation translocation events (such as distance of the release site away from an airfield and the month when the translocation occurred) would influence the frequency of homing behavior in Cooper's Hawks. Specifically, we predicted that older birds would have higher return rates than younger birds as the older birds are more likely to have an existing breeding territory. We also predicted that translocating individual hawks farther from the airports would reduce return rates due to the high energetic costs of flying back to the live-capture location. Lastly, we predicted that Cooper's Hawk homing behavior would be highest during the breeding season (i.e., summer months) and wintering period (i.e., winter months) when the majority of the birds present would be nonmigratory. The objectives of our study were to: (1) quantify and characterize Cooper's Hawk-aircraft collisions reported to have occurred with civilian aircraft in the USA, (2) determine return rates of Cooper's Hawks following a mitigation translocation from an airport, and

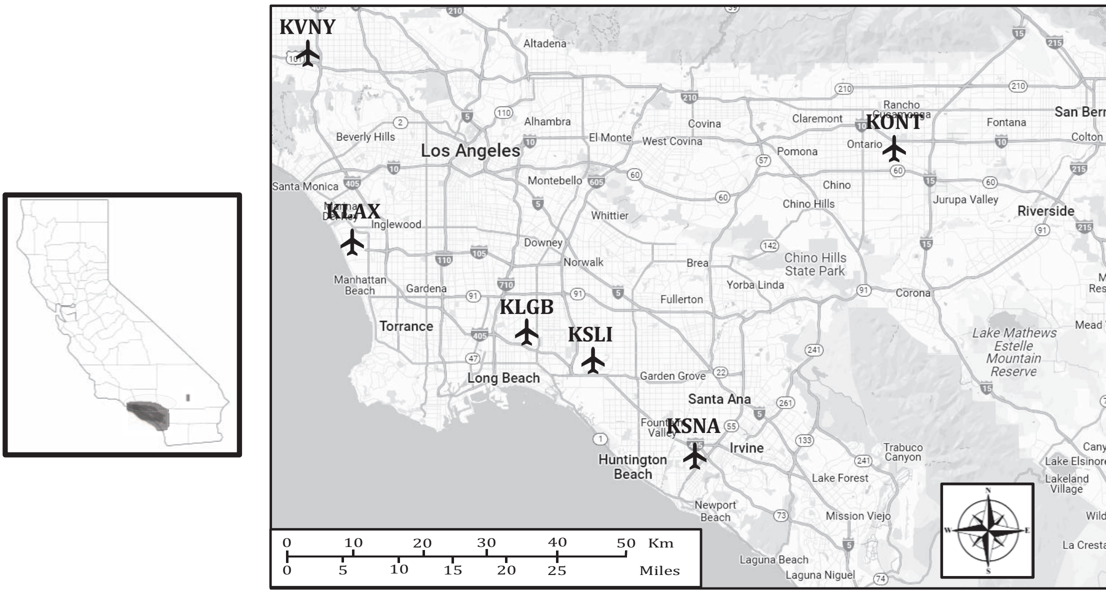

Figure 1. Map of the southern California study area that shows the location of the six airports and military airfields [Los Angeles International Airport (KLAX), Long Beach Airport (KLGB), John Wayne/Orange County Airport (KSNA), Ontario International Airport (KONT), Van Nuys Airport (KVNY), and Joint Forces Training Base Los Alamitos (KSLI)] where Cooper's Hawks were live-captured, banded, and translocated away from.

(3) evaluate factors that might influence the homing behavior of translocated hawks.

METHODS

As with all raptor species in the USA, Cooper's Hawks are protected by the Migratory Bird Treaty Act (16 USC §§703-712). We conducted all raptor management activities under federal and state permits issued by the US Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife. Similarly, all banding and marking activities were conducted under permits issued by the USGS Bird Banding Laboratory. This work was conducted under National Wildlife Research Center (NWRC) Quality Assurance Protocol (QA-2968) and was reviewed and approved by the NWRC Institutional Animal Care and Use Committee.

Study Area. We conducted this study within the Los Angeles Basin of southern California. Nonlethal management efforts regarding Cooper's Hawks were conducted at the Los Angeles International Airport (33.9424964°N, 118.4080486°W), Long Beach Airport (33.8179297°N, 118.1518906°W), John Wayne/Orange County Airport (33.6756619°N, 117.8682331°W), Ontario International Airport (34.0560142°N, 117.6011875°W), Van Nuys Airport (34.2098056°N, 118.4899722°W), and Joint Forces Training Base Los Alamitos (33.7900300°N, 118.0514200°W).

The study area is approximately 7565 km^2 and encompasses Los Angeles and Orange Counties as well as parts of Riverside, San Bernardino, and Ventura Counties in southern California (Fig. 1). The climate in the study area is Mediterranean, characterized by an average daily temperature during summer of 27°C and 20°C during winter. Mean annual precipitation is 305 mm per year, most of which occurs during the winter months (primarily February; Wachtell 1978).

With a human population of over 13 million people within the study area, most of the low-elevation areas are highly urbanized. Small green spaces occur as parks, golf courses, greenbelts, tree-lined streets, and other small patches of mostly nonnative vegetation. Canyons on the edges of this highly developed landscape contain remnant natural areas.

Cooper's Hawk Collisions with Civilian Aircraft. We queried the FAA's National Wildlife Strike Database (NWSD; Dolbeer et al. 2018) for a 34-yr period (1990–2023) for civilian and joint-use airports and extracted only those records for which the species struck was identified as a Cooper's Hawk. Using these records, we identified temporal and spatial trends in Cooper's Hawk strikes with civil aircraft. We used linear regression analysis and two-sample *t*-tests to examine potential trends in Cooper's Hawk strikes to aircraft among years (Zarr 1999). Descriptive statistics were used to quantify the frequency of Cooper's Hawk strikes to aircraft that occurred among geographic areas, as well as financial costs of Cooper's Hawks strikes (in USD; Dolbeer et al. 2018).

Live-capture and Handling. During 11 September 2017–16 June 2022, we (United States Department of Agriculture—Wildlife Services [USDA WS] personnel) employed a variety of standard methods, including Swedish goshawk traps and modified E-Z Catch net traps, to live-capture Cooper's Hawks that were presenting a hazard to aircraft at the study airfields (Bub 1991, Bloom et al. 2007). We assigned all live-captured Cooper's Hawks to age classes based on plumage and feather molt (Pyle 2008, Liguori et al. 2020) and sex classes based on morphological measurements (Pitzer et al. 2008, Pyle 2008). We used the age classification system employed by the USGS Bird Banding Laboratory (www.usgs.gov/labs/bird-banding-laboratory). Hatching year (HY) birds were between 6 wk and 9 mo old at the time of capture, second year (SY) birds were between 9 and 21 mo of age, and after second year (ASY) birds were ≥22 mo of age. Each live-captured Cooper's Hawk was banded with a standard USGS aluminum leg band and a colored plastic leg band specific to USDA WS operational activities (i.e., orange band with white alphanumeric code).

Mitigation Translocations. Using a stratified random selection process to ensure relatively equal sample sizes, we assigned each Cooper's Hawk to one of four preselected release location distances. Translocated individuals were released at locations that were 24 km, 48 km, 72 km, and 96 km from the airport where the bird was live-captured. We chose these specific distances based on the findings of a similar study involving American Kestrels (*Falco sparverius*; Washburn 2024). All Cooper's Hawks were held for <48 hr (from time of capture to release) per federal regulatory policy (USFWS 2022). All hawks were kept in individual cages, under climate-controlled conditions, and with minimal human disturbance while in captivity. We selected release sites that provided available hunting cover and abundant avian prey, such as small urban parks, golf courses, and other greenspaces within the highly urbanized landscape (Mannan and Boal 2000, Mannan et al. 2004, Rosenfield et al. 2024). We attempted to use release sites located away from major interstate highways and airports.

Monitoring for Returns of Cooper's Hawks. We defined a Cooper's Hawk return as any situation where an individual hawk was resighted (i.e., visually observed or photographed; considered an "encounter" by the Bird Banding Lab), recaptured alive (also considered an "encounter" by the Bird Banding Lab), or recovered (i.e., found dead) at any airport or military airfield following a mitigation translocation event. Live-trapping activities for Cooper's Hawks, standard avian point-count surveys for wildlife recognized as hazardous to aviation safety (Cleary and Dolbeer 2005, DeVault et al. 2013, FAA 2018), and continual monitoring efforts during daily wildlife detection and hazard management activities were conducted on the airports and airbases from September 2016 (the start of this study) to June 2023 (1 yr after the marking phases of the project ended). Biologists examined all Cooper's Hawks that were recaptured, involved in aircraft strikes, or observed on an airfield for the presence of the colored leg band and a metal leg band (if possible). We recorded the identity of all known individuals in addition to other pertinent information (e.g., date, time, location).

Using the date they were live-captured, we placed all Cooper's Hawks that were translocated from an airport into one of three life history periods: (1) breeding season, (2) migratory periods, and (3) wintering period. The breeding season consisted of April, May, June, and July, the migratory periods consisted of March, August, September, October, and November, and the wintering period consisted of December, January, and February (Asay 1987, Hull et al. 2012, Rosenfield et al. 2024).

Cooper's Hawks that returned to a civilian airport or military airfield following a mitigation translocation were managed according to wildlife damage management actions outlined within the facility's airport wildlife hazard management plan. Upon their return, these individuals were either lethally removed or recaptured. Cooper's Hawks that were recaptured were translocated away from the facility for a second time (or more) to a randomly selected distance.

Statistical Analyses. A Cooper's Hawk return (i.e., following the first translocation event) was a binary response variable, with 0 representing individuals that were not resighted or recaptured on an airport or airbase following the first translocation event and 1 representing those that returned to an airport or airbase at some point in time. We developed a set of candidate generalized linear mixed models with logit link and binomial error distributions (involving all possible subsets of four factors [age, sex, month, and distance translocated] as well as interactions). We used the location (i.e., airport) where a hawk was live-captured as a random factor in all mixed models.

We determined the days to return as the number of days from the translocation date to the first resighting, recapture, or recovery of the bird for each individual Cooper's Hawk that returned to an airport or airbase. We developed a set of candidate Poisson-distributed generalized linear mixed models (involving two fixed-effect factors, age [of the bird] and sex [of the bird], as well as additive and interactive models) to explain days to return. The location where a hawk was live-captured (i.e., airfield) was included as a random factor in all mixed models. We removed the data associated with the two ASY birds from these analyses as they were having a strong influence (acting as outliers).

We evaluated the Cooper's Hawk return models using Akaike's Information Criterion (AIC; Burnham and Anderson 2002); for the number of days to return models we used the small sample size-adjusted Akaike's Information Criterion (AIC_c; Burnham and Anderson 2002). We examined whether explanatory coefficients in the selected model(s) were informative via 95% CIs and overlap with 0 (Arnold 2010). We considered any models within 2 ΔAIC units of the top ranked model to be competitive (Symonds and Moussalli 2011). We used Program R Version 4.3.3 (R Core Team 2024) and the R package *lme4* (Bates et al. 2015) to run and evaluate the generalized linear mixed models (return rates) and the generalized linear mixed models (days to return).

We used a goodness of fit chi-squared analysis to multi-way tables (Zarr 1999) to determine if there was an association in Cooper's Hawk return rates between the different age classes and the life history periods when they were live-captured. We used a *G*-test for independence test (Zar 1999) to compare the percentage of Cooper's Hawks that returned following the first mitigation translocation to the percentage of Cooper's Hawks that returned following a second (or more) mitigation translocation.

RESULTS

Cooper's Hawk Strikes with Civilian Aircraft. During 1990–2023, 217 Cooper's Hawk strikes with aircraft in the USA and Canada (an average of 6.4 ± 1.2 [SE] annually) were reported to the FAA NWSD. During this 34-yr period, Cooper's Hawk collisions with aircraft increased by 3200% ($y = 0.622x - 2241.1$; $R^2 = 0.79$; $F_{1,33} = 117.23$; $P < 0.0001$). The average number of reported Cooper's Hawk strikes per year was higher ($t_{18} = -11.65$, $P < 0.001$) during 2014–2023 (15.6 ± 1.3 events per year) than in earlier years (1990–1999; 0.1 ± 0.1 events per year). Notably, Cooper's Hawk strikes occurred throughout the year, but 50% of these events occurred from July through October.

Among the 210 Cooper's Hawk strikes for which the specific geographic location could be determined, the states with the highest number of reported events were Texas (13%), Florida (11%), and California (10%). Cooper's Hawk strikes were reported in 36 states and the District of Columbia, USA. Although only 11 of the strike events resulted in damage to aircraft, the estimated total cost was more than USD 258,500. Almost all events resulted in mortality of the birds involved.

Mitigation Translocations. We live-captured 606 individual Cooper's Hawks and conducted 669 mitigation translocation events (some hawks were translocated >1 time) during 2017–2022. The initial mitigation translocations involved 465 HY, 101 SY, and 40 AHY Cooper's Hawks. Of these actions, 287 translocations involved males and 319 events involved females. We conducted 119, 234, 116, and 137 Cooper's Hawk initial mitigation translocations to the 24 km, 48 km, 72 km, and 96 km distances, respectively. Mitigation translocations of Cooper's Hawks occurred during all months of the year, but 69% of all events occurred during July through October.

Return Rates. The top-ranked model had most of the Akaike weight (w_i) = 0.81 and included age, sex, and distance as fixed effects (Tables 1 and 2). Thus, we found evidence that the age of the bird, sex of the bird, and distance translocated all influenced return rates of Cooper's Hawks following a mitigation translocation (Fig. 2).

We did not find evidence that the month a Cooper's Hawk was live-captured and translocated influenced the probability of that bird exhibiting homing behavior. However, we did find an association ($\chi^2 = 26.84$, df = 4, $P < 0.001$) between the age classes and life history periods of Cooper's Hawks that exhibited homing behavior. Interestingly, HY Cooper's Hawks exhibited the highest return rate during the wintering period and ASY Cooper's Hawks only exhibited homing behavior during the breeding and wintering periods (Fig. 3). In contrast, SY Cooper's Hawk homing behavior was relatively high during all life history periods (Fig. 3).

The proportion of Cooper's Hawks that exhibited homing behavior following the first mitigation

Table 1. Top generalized linear mixed models (binomial distribution), ranked by Akaike's Information Criterion (AIC), predicting Cooper's Hawk returns following a translocation event ($n = 606$) from a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

Model	K[a]	LL[b]	AIC	ΔAIC[c]	w_i[d]	Cumulative w_i
Age + Sex + Distance	8	−179.64	375.28	0.00	0.81	0.81
Age + Distance	7	−182.12	378.24	2.96	0.18	0.99
Age + Sex	5	−187.88	385.77	10.49	0.01	1.00
Null	2	−198.17	400.24	25.06	0.00	1.00

[a] Number of parameters in model.
[b] Log likelihood.
[c] Difference in AIC_c compared with lowest AIC_c model.
[d] Model weight.

translocation (10.2%; $n = 62$) was similar ($G = 1.46$, $P = 0.23$) to the proportion of hawks returning after a second (or more) mitigation translocation (15.9%; $n = 10$). Interestingly, two Cooper's Hawks returned to the same airport after undergoing three consecutive mitigation translocations but did not return after a fourth translocation.

Days to Return. Of the 62 hawks that returned, approximately 58% were resighted, recaptured, or recovered at an airfield within 60 d (Fig. 4). The top ranked model, with most of the Akaike weight (w_i) = 0.76, included the age of the birds and sex of the birds as fixed factors (Table 3, 4). No other models were competitive. In addition, the 95% CIs for the age (β = 0.22, SE = 0.03, lower 95% CI = 0.16, upper 95% CI = 0.28) and sex (β = 0.26, SE = 0.02, lower 95% CI = 0.22, upper 95% CI = 0.30) factors did not encompass 0.

Known Fates of Translocated Hawks. Approximately 85% of translocated Cooper's Hawks ($n = 606$) were not resighted, recaptured, or recovered post-release, and we consider these individuals to be of unknown fate. Sixty-two of the 89 Cooper's Hawks with a known fate returned to an airport or airbase and were resighted, recaptured, or recovered following the first mitigation translocation (Fig. 5). The other 27 hawks did not return to an airport and were observed or collected by the public at other locations.

Upon their return from the mitigation translocations, three Cooper's Hawks were found dead, two Cooper's Hawks were lethally removed, and 57 Cooper's Hawks were taken on a second mitigation translocation away from the airport. Almost all Cooper's Hawks (96.8%) returned to the same airport or airbase from which they were translocated, whereas only two hawks were recaptured at a different aviation facility.

Almost one-third (30.3%) of the Cooper's Hawks with known fates were resighted, recaptured, or recovered by the general public and reported to the USGS Bird Banding Laboratory. Seven hawks were resighted (alive), six hawks were recaptured due to an injury, and 15 translocated hawks were found dead. Many of the public reports suggest that Cooper's Hawks were involved in collisions with anthropogenic objects (e.g., building, vehicles, and windows).

Table 2. Parameter estimates with unconditional standard errors (SE) and 95% confidence intervals (lower [LCL] and upper [UCL]) for Cooper's Hawk returns following a translocation event ($n = 606$) from a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

Parameter	Estimate	SE	LCL	UCL
Intercept	−2.22	0.93	−4.04	−0.40
Age	1.61	0.79	0.06	3.16
Sex	−0.69	0.31	−1.30	−0.08
Distance	−1.74	0.49	−2.70	−0.96

DISCUSSION

Information regarding the hazard that Cooper's Hawks pose to safe aircraft operations, as well as management programs to reduce these potential hazards at civil airports and military airfields, is relatively scarce. Our findings suggest that collision between Cooper's Hawks and civilian aircraft is a contemporary and growing aviation safety concern. Part of this increase is likely related to higher levels of wildlife strike reporting to the FAA NWSD resulting from increased awareness following the ditching of US Airways Flight 1549 in the Hudson River in 2009 (Washburn et al. 2013, Linnell and Washburn 2018). On a national scale, Cooper's Hawk strikes with aircraft are far less frequent and are

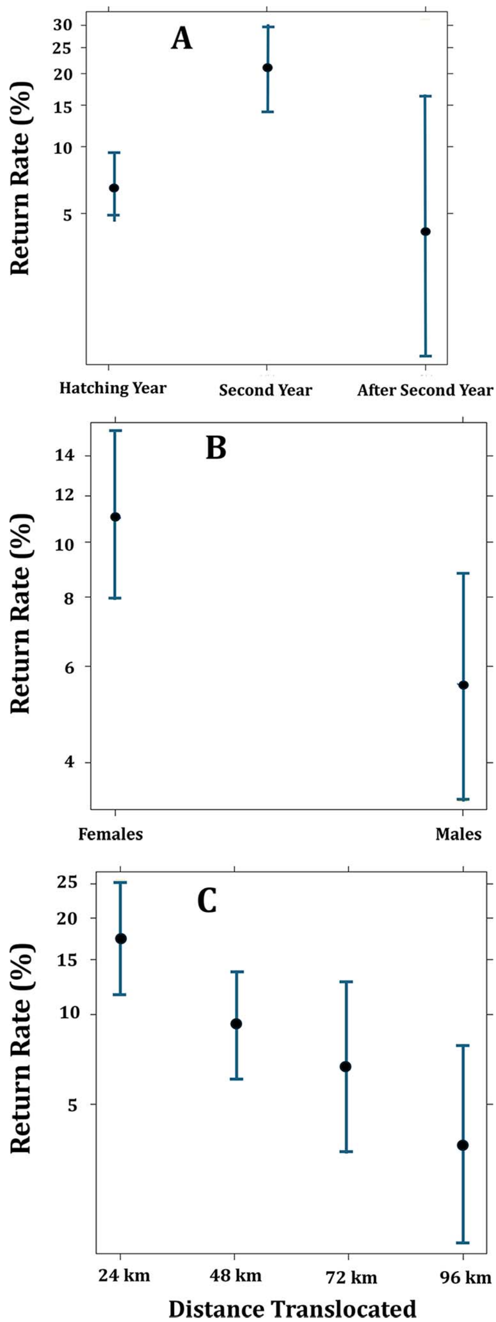

Figure 2. Cooper's Hawk return rates (with 95% confidence intervals) as influenced by (A) age of the bird, (B) sex of the bird, and (C) the distance translocated for a mitigation translocation event ($n = 606$) from a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

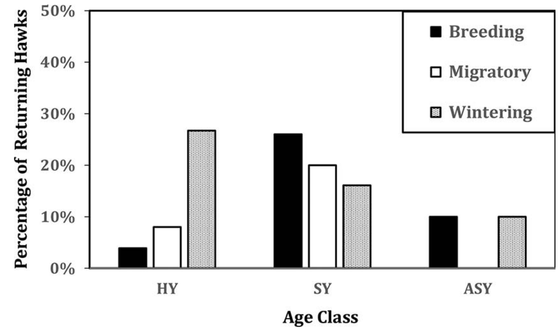

Figure 3. Percentage of Cooper's Hawks that returned to an airport following a mitigation translocation as influenced by age class and life history period when the birds were live-captured at a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

considerably less of a risk to both civilian (DeVault et al. 2018) and military aircraft (Pfieffer et al. 2018) than collisions with other North American raptors [notably Red-tailed Hawks (*Buteo jamaicensis*)]. However, Cooper's Hawks can represent an important hazard to safe aircraft operations within specific regions or at individual airports. These events occur throughout the USA, but are most frequent in California, Texas, and Florida. Cooper's Hawk collisions with aircraft appear to be a more important problem at airfields contained within large, urbanized landscapes. This finding is consistent with the relatively recent expansion of Cooper's Hawk breeding ranges into urban habitats (Rosenfield et al. 2018, 2024).

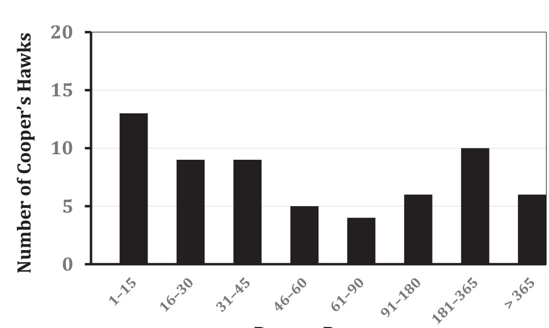

Figure 4. Distribution of the number of days it took for Cooper's Hawks that were involved in a mitigation translocation to return to a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

Table 3. Poisson-distributed generalized linear mixed models, ranked by small sample size-adjusted Akaike's Information Criterion (AIC_c), predicting the number of days it took Cooper's Hawks to return following a translocation event ($n = 62$) from a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

Model	K[a]	LL[b]	AIC_c	ΔAIC_c[c]	w_i[d]	Cumulative w_i
Age + Sex	4	−6193.75	12396.23	0.00	0.76	0.76
Age*Sex	5	−6193.70	12398.52	2.29	0.24	1.00
Sex	3	−6228.11	12462.66	66.43	0.00	1.00
Age	3	−6247.81	12502.04	105.82	0.00	1.00
Null	2	−6322.81	12649.82	253.59	0.00	1.00

[a] Number of parameters in model.
[b] Log likelihood.
[c] Difference in AIC_c compared with lowest AIC_c model.
[d] Model weight.

Cooper's Hawk homing behavior following a mitigation translocation event was influenced by two biological factors (i.e., age and sex of the bird) and one logistical factor (i.e., distance the birds were translocated). Return rates (a measure of homing behavior) of Cooper's Hawks were lower than those reported for Red-tailed Hawks (Pullins et al. 2018, Washburn et al. 2021), Snowy Owls (*Bubo scandiacus*; McCabe et al. 2022), vultures (Galvão Novaes et al. 2020), and Burrowing Owls (*Athene cunicularia*; Santos et al. 2023); and higher than American Kestrel return rates (Washburn 2024). Overall, the return rate of Cooper's Hawks in our study (10.2%) was (arguably) slightly higher than that reported for Cooper's Hawks also at airports in southern California (5.4%; Biteman et al. 2018) as well as at many airports across the USA (2.1%; Schafer and Washburn 2016).

We believe our estimates of return rates (and homing behavior) are conservative, as detection and identification of marked Cooper's Hawks (and other raptors) using colored leg bands can be challenging; thus, it is likely that not all hawks that returned following a mitigation translocation were observed or recaptured. The foraging behavior of Cooper's Hawks (i.e., relying on concealment and then bursting from hidden perches to stealthily approach and attack prey) makes detecting and quantifying their presence using visual surveys challenging as they are secretive (Rosenfield et al. 2018, 2024). Previous related research with Red-tailed Hawks demonstrates that detection rates of returning hawks following a mitigation translocation are highest with telemetry, notably lower with patagial tags, and lowest with colored leg bands and/or federal bird bands (Schafer and Washburn 2016, Biteman et al. 2018, Pullins et al. 2018, B. Washburn unpubl. data).

More than two-thirds of the mitigation translocation events conducted during our study occurred during late summer and early fall, suggesting much of the airfield use by Cooper's Hawks might be associated with initial dispersal from the natal area by juveniles, adult post-breeding dispersal, and migratory behaviors. Although Cooper's Hawks are nonmigratory in the southern part of their range (including

Table 4. Days to return for Cooper's Hawks following a translocation event ($n = 62$) from a civil airport or military airfield in the Los Angeles Basin of southern California, USA, 2017–2022.

Parameter: Sex	Parameter: Age	n	$\bar{x}$	SE	Minimum	Maximum
Females	Hatching year[a]	29	107.9	54.0	2	1532
	Second year[b]	9	224.3	99.8	5	949
	After second year[c]	1	48.0	—	48	48
Males	Hatching year	9	149.2	45.1	13	421
	Second year	13	158.9	45.2	5	531
	After second year	1	372.0	—	372	372

[a] Hatching year birds were between 6 wk and 9 mo of age.
[b] Second year birds were between 9 and 21 mo of age.
[c] After second year birds were ≥22 mo of age.

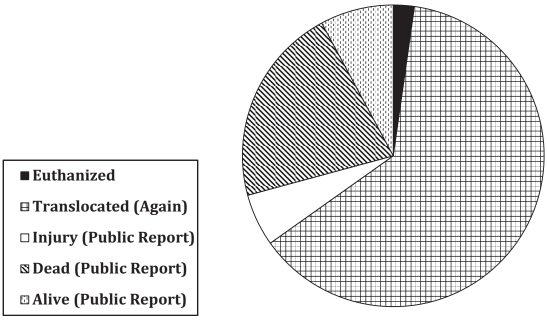

Figure 5. Distribution of known fate outcomes for Cooper's Hawks ($n = 89$) following a mitigation translocation from a civil airport or military airbase in the Los Angeles Basin of southern California, USA, 2017–2022.

our study area), Bloom et al. (2017) and Briggs et al. (2020) found evidence that at least some individuals in this region do migrate northward after the breeding season.

Less frequent homing behavior exhibited by HY and ASY Cooper's Hawks is not unexpected as migratory (i.e., transient) hawks likely make up a substantial proportion of the birds live-captured during the migration periods and upon release these hawks would continue their migratory movements (either north or south, as appropriate). Higher return rates of HY Cooper's Hawks in the wintering period and ASY Cooper's hawks in both the breeding and wintering periods would be expected as these individuals were likely transiting back to an established territory or nonbreeding range (Pullins et al. 2018). We suspect that SY Cooper's Hawks exhibited higher rates of homing behavior compared to HY and ASY hawks due to the fact that they might have established breeding or wintering ranges near the airports, either for active nesting activities or as nonbreeding "floaters" attempting to acquire a mate and breeding territory when one became available. Millsap (2018) found that a high percentage of SY female Cooper's Hawks established a nesting territory and laid eggs in an urbanized study area. Future research to determine if the use of airfields by this species is seasonal would be valuable for the development and implementation of Cooper's Hawk management protocols on airfields.

Unexpectedly, we found that Cooper's Hawks translocated for a second or third time were equally likely to return compared to after the initial translocation event. This finding is in contrast to homing behavior patterns observed in other North American raptors following a mitigation translocation. Pullins et al. (2018) found that the odds of a Red-tailed Hawk returning to an airport increased by a factor of 12 for each subsequent translocation event. Similarly, American Kestrels are over 10 times more likely to return following a second mitigation translocation compared to homing behavior following an initial translocation (Washburn 2024).

Most Cooper's Hawks that exhibited homing behavior returned to an airfield within 2 mo of being translocated. Consequently, most of these hawks returned to the airfields within the same life history period when they were translocated. Only six of the returning individual hawks did so after (apparently) being elsewhere for a year and two hawks after being elsewhere for three or more years; of course it is possible they returned earlier and were undetected for some time. Interestingly, the number of days to return for Cooper's Hawks were very similar to that of Red-tailed Hawks returning after a mitigation translocation (Pullins et al. 2018), but three times longer than for American Kestrels following a mitigation translocation (Washburn 2024).

Although we had a limited number of public resightings and recoveries of translocated Cooper's Hawks in our study, anthropogenic-related sources of possible mortality (e.g., collisions with vehicles, structures, and windows) were prominent in our study area. Such mortality sources were noted in other research examining Cooper's Hawk mortality in urban areas (Boal 1997, Roth et al. 2005, Millsap 2018, Millsap et al. 2024). However, other studies have shown that Cooper's Hawks (and other raptors) killed by human-related causes are more likely to be discovered than those that die of natural causes (e.g., disease, starvation, predation; Franson and Little 1996, Hernandez et al. 2018).

Within the airport environment, the abundance of hazardous wildlife, as well as the specific behaviors exhibited by those species, is an important factor related to the likelihood of wildlife-aircraft collisions (DeVault et al. 2013, Blackwell et al. 2019). A study of American Kestrels at the Los Angeles International Airport found that the relative abundance of kestrels was correlated with the number of kestrel-aircraft strikes at the airport (Pitlik and Washburn 2016). Efforts to reduce the presence of Cooper's Hawks on or near airfields should increase aviation safety and reduce hawk mortalities, but more research is needed to better understand how the abundance and behavior of Cooper's Hawks (and other wildlife hazardous to aviation) within airport environments influences the potential for wildlife-aircraft collisions.

Cooper's Hawk diets consist primarily of small- to medium-sized avian prey, although mammals can be important in some locations (Estes and Mannan 2003, Roth and Lima 2003, Cava et al. 2012). Introduced bird species, such as European Starlings (*Sturnus vulgarus*), House Sparrows (*Passer domesticus*), and Rock Pigeons (*Columba livia*), as well as native doves (*Zenaida* spp.) and songbirds are preferred prey for Cooper's Hawks in urban areas (Rosenfield et al. 2024). Interestingly, the recent range expansion of invasive Eurasian Collared Doves (*Streptopelia decaocto*) throughout southern California (Garrett 1998, Veech et al. 2011) might be providing a new prey resource for urban Cooper's Hawks. Reducing populations of introduced birds and native doves within airport environments might have benefits in regard to reducing the attractiveness of airports to foraging Cooper's Hawks, as well as reducing the hazards these species themselves pose to safe aircraft operations (Washburn et al. 2011, DeVault et al. 2013).

The recent development of highly accurate GPS-capable transmitters small enough to be used on Cooper's Hawks presents opportunities to gain unprecedented information regarding the ecology and management of this species (e.g., Millsap et al. 2024). Using such technology to determine the survival, post-translocation movement patterns, and habitat use of Cooper's Hawks following a mitigation translocation (or other management action) represents an essential area of future research and would provide highly valuable information for management decisions.

In summary, Cooper's Hawk strikes with civilian aircraft are a contemporary and growing aviation safety concern at the local or regional scale. Our findings suggest that to reduce the potential for Cooper's Hawk strikes and concurrently maximize the benefits of program resources, a civil airport or military airfield wildlife mitigation program should consider mitigation translocation of HY and ASY Cooper's Hawks to a distance of at least 48 km from airfields as part of an integrated raptor hazard management plan.

ACKNOWLEDGMENTS

The FAA, five civilian airports, and a military airfield provided funding and logistical support for this project. This research was supported in part by the intramural research program of the USDA, Animal Plant Health Inspection Service, Wildlife Services. We thank W. Carter, D. Collins, E. Herrmann, J. Marrow, and E. Peralta for providing assistance in the field. Comments provided by B. Blackwell, Associate Editor Vince Slabe, B. Millsap (reviewer), and one anonymous reviewer improved the manuscript. Opinions expressed in this study do not necessarily reflect current FAA or USDA policy decisions governing the control of wildlife on or near airports.

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Received 23 August 2024; accepted 2 April 2025
Associate Editor: Vince Slabe