FINAL REPORT TO ILLINOIS DEPARTMENT OF NATURAL RESOURCES

STUDY OF FACTORS AFFECTING REPRODUCTIVE SUCCESS OF COOPER'S HAWKS IN SOUTHERN ILLINOIS

Daniel R.Kirk and George H. Waring
Department of Zoology
Southern Illinois University at Carbondale

Project 6-23902 CEB

December 1997

INTRODUCTION

The Cooper's hawk (*Accipiter cooperii*) was once one of the most common hawks in the United States (Bent 1937) and, among accipiters, has the most cosmopolitan distribution in North America (AOU 1957). Human persecution is but one reason for declining Cooper's hawk populations. The Cooper's hawks' habit of taking chickens has earned it the name "chicken hawk" and is the major reason for antipathy toward hawks (Bent 1937). Habitat destruction (Olendorff and Kochert 1977) and organochloride compounds such as DDE and DDT (Henny and Wight 1972, Snyder et al. 1973) have been implicated as the principal cause of declining populations of many raptors. The Cooper's hawk was listed as an endangered species in Illinois (Herkert 1992) but delisted in August of 1996 by the Illinois Endangered Species Protection Board.

There is considerable variation in nesting habits of Cooper's hawks. Preference for deciduous forest (Meng 1951, Rosenfield and Anderson 1983, Asay 1987), coniferous forest (Bent 1937, Reynolds and Wight 1978, Kritz 1989), or an equal mixture for nest sites (Vogl 1988, Bosakowski et al. 1992, Wiggers and Kritz 1994) varies with geographic location. In coniferous forests, white pine (*Pinus strobus*), Douglas fir (*Pseudotsuga menziesii*), and ponderosa pine (*Pinus ponderosa*) were the dominant trees used as nest sites (Reynolds et al. 1982, Rosenfield and Anderson 1983, Moore and Henny 1983) while in deciduous forests, oak (*Quercus spp.*) and beech (*Fagus grandifolia*) were the tree species most utilized (Asay 1987, Meng 1951). Nests are usually located in the upper portion of the tree, immediately below the crown (Reynolds et al. 1982), with nest height ranging from 4-31 m (Reynolds et al. 1982, Asay 1987, Kennedy 1988). Nests are usually

built in main or secondary crotches (Bosakowski et al. 1992), or rarely out on limbs (Asay 1987).

It is evident from studies that a dense canopy is a requisite for Cooper's hawks. Cooper's hawks prefer to nest in mature tree stands (Bosakowski et al. 1992) with dense canopy closure (Moore and Henny 1983, Rosenfield and Anderson 1983) and dense understory (Titus and Mosher 1981) that protects the nest from adverse weather and predators (Reynolds et al. 1982). Moore and Henny (1984) noted differences in nest site selected by immature and adult hawks in Oregon. Young birds nested in early successional stands with sparse understory, while adults tended to nest in more mature stands with denser understory. This is perhaps due to inexperience in breeding of immatures.

Nest density varies with geographic location. In central Wisconsin, Rosenfield and Anderson (1983) reported 1 nest/734 ha. In Michigan, densities were 1 nest/1,166 ha in 1942 and 1 nest/1,554 ha in 1947-1948 (Craighead and Craighead 1956). In western Oregon, nest density was as low as 1 nest/2,321 ha (Reynolds and Wight 1978). Internest distances also vary, from 0.6-5.5 km (Reynolds and Wight 1978, Asay 1987).

Nest building begins in mid-March (Rosenfield and Bielefeldt 1992) to mid-April (Reynolds and Wight 1978). In west-central Arizona the earliest egg laid was 28 March, with 50% of clutches completed by 25 April. The following data indicate a range of laying dates. In New England and New York, Bent (1937) cited 119 records of laying between 25 April and 26 June; from Ohio to Minnesota and Canada, 52 records between 26 April and 21 June; and from lower California to Florida, 21 records from 22 February to 16 June. The mean number of eggs/clutch is 4-5 (Newton 1979, Rosenfield and Anderson 1983) with

a range of 3-6 (Bent 1937). Eggs are laid every other day and incubation begins after the third egg is laid. Hatching is asynchronous (Meng and Rosenfield 1988), following the same order they were laid (Meng 1951). Brown and Amadon (1968) reported an incubation period of 36 days for the Cooper's hawk based on review of literature. In Oregon, incubation lasted 30-32 days (Reynolds and Wight 1978). Meng (1951) reported 36 days in New York. After hatching, the nestlings remain at the nest 30-34 days (Meng 1951, Reynolds and Wight 1978).

Movements are the means by which local densities vary in response to changing food supply (Newton 1979). Raptors, like many northern hemisphere birds are migratory in the northern portion of their breeding range and resident in the southern portion. In some areas, individuals exhibit partial migration where some migrate and others are resident year-round (Newton 1979). Cooper's hawks breeding in the northern part of their range are generally migratory (Rosenfield 1988) but some individuals remain throughout the winter (Craighead and Craighead 1956). Birds in the south are locally migratory or are residents (Rosenfield 1988). Most of the information on migratory habits comes from Bird Banding Laboratory (BBL) data during autumn migration in eastern states. Autumn migration begins in late August, ends in early November, and peaks in late September to mid-October (Cape May Bird Observatory and Hawk Mtn. Sanctuary unpubl. data). Some Cooper's hawks winter in Illinois and can be distinguished from spring migrants by habitat and behavior (Bohlen 1989). Spring migrants may appear as early as mid-February in Urbana; the earliest fall migrants appear in August (Bohlen 1989). In southern Illinois, Cooper's

hawks seem to be residents year-round, although it is difficult to distinguish northern migrants.

Many species of birds exhibit philopatry to their natal and breeding sites. Only some individuals are faithful to an area and one sex, usually the males in birds (Greenwood 1980), is generally more faithful than the other (Newton 1979). Raptors are assumed to breed in the vicinity of their natal area and repeatedly return each nesting season (Newton 1979). Moore and Henny (1984) reported a 59% reoccupancy rate where only successful adult females returned to the same nest area, whereas SY (second year) females did not return whether they were successful or not. Cooper's hawks rarely reuse the same nest (Meng 1951), but Asay (1987) found that previous year's nests were used 32% of the time in California which is probably an uncharacteristically high rate for the species.

Most studies of Cooper's hawks have been conducted in western and eastern states with few being conducted in the midwest and even fewer in Illinois. There has been only one study, (Ehrlich 1990), conducted in Illinois. Ehrlich (1990) found Cooper's hawks did not nest in tree species in proportion to their availability. Similar findings are given by Mutter et al. (1984). Dense pine have high canopy cover that protects nests from predators and direct sunlight (Reynolds et al. 1982). Pine stands may be preferred to deciduous stands for the greater protection they offer before deciduous trees have leafed-out early in the nesting season (Rosenfield and Anderson 1983).

Habitat conditions impose selection pressures that produce life history traits such as age specific fecundity, mortality, and philopatry (Lessells 1991). Previous nest success has been suggested to reinforce nest site selection (Moore and Henny 1984). European

sparrowhawks (*Accipiter nisus*) that nested in good habitats returned the following year more frequently than those that nested in poor habitats (Newton 1979), presumably because they were less successful. Timber harvesting may have detrimental impacts on nest site suitability, foraging habitats, and prey populations but the degree of impact is questionable (Reynolds 1989). Englert (1985) found that Cooper's hawks did not nest in stands that were surrounded by open fields.

Pine stands are not native to southern Illinois but they makeup approximately 19% of the forest; The U.S. Forest Service has proposed that the majority of pine stands be removed from the Shawnee National Forest (USDA Forest Service 1991), thus returning it to its historical composition. Many species now rely on pine for nesting and wintering habitat. The Cooper's hawk is just one example. The importance and preference of pine is not well understood especially when there is abundant deciduous nesting habitat available. The removal of these preferred nesting stands may have detrimental impacts on the nesting population in southern Illinois.

Cooper's hawks were once common in all wooded portions of the state (Ridgway 1889) but are now found only in 21 counties (Herkert 1992). Little information on nest density, reproductive success, nesting habits, and population stability has been conducted in Illinois. The overall health of birds of prey populations is largely dependent on reproductive success (Brown 1974). Estimates of reproductive success and productivity are often used alone to make inferences about populations, but these estimates are of greater use when compared with estimates from other areas and years (Steenhof 1987). The decline of some raptor species indicates sensitivity to environmental degradation and the need for baseline

data (Janik and Mosher 1981). Reproductive differences between years may indicate changes in land use, contaminant levels, or human activity as well as environmental phenomena (Steenhof 1987). Reproductive parameters (clutch size, hatching success, and fledging success), population trends from impacts of habitat change, chemical contaminants, and human activity need to be assessed in order to obtain an understanding of the Cooper's hawk biology and population status in southern Illinois. The present study focuses on reproductive parameters and human disturbance.

The objectives of this study are:

1) To determine nesting chronology, clutch sizes, incubation period, and hatching and fledging success.
2) To compare reproductive success in coniferous and deciduous woodlands.
3) To assess reproductive success in relation to human disturbance (i.e., distance of nests to human habitation and roads that received traffic year-round).
4) To determine the affects of weather and predation on reproductive success.
5) To determine macro-habitat variables (distance to nearest paved road, human habitation, and open fields) and micro-habitat variables (stand selection and diameter at breast height (DBH).

METHODS

STUDY AREA

My study was conducted primarily within the Shawnee National Forest (SNF) of southern Illinois. The SNF encompasses 107,297 hectares and is comprised primarily of

oak-hickory (*Quercus-Carya)* species. There are six major forest types in the Shawnee, with oak-hickory and pine (*Pinus*) as the dominant types. The SNF includes oak-hickory 62.9%, pine 19.0%, cove hardwood 8.4%, bottomland hardwood 7.1%, black locust (*Robinia pseudoacacia*) 1.0%, and eastern red cedar (*Juniperus virginiana*) 0.4% (USDA Forest Service 1991).

PROCEDURES

I began nest searches in mid-March 1996 and continued throughout the nesting season, until early August. Nest searches were conducted again in the 1997 nesting season. Cooper's hawk nests are difficult to locate because of the birds' secretive behavior (Rosenfield et al. 1985), but playing taped calls facilitates locating nests (Fuller and Mosher 1981, Rosenfield et al. 1988). I located nests using taped Cooper's hawk alarm calls and then followed the birds back to the nest (after Rosenfield et al. 1985, 1988). Local falconers and biologists were also contacted for the presence of birds and/or nests. Nest searches were not conducted using taped calls during incubation due to their general unresponsiveness (Rosenfield at al. 1988). Areas searched for nests were determined by historical data and habitats that met structural characteristics for nesting areas.

All nests were plotted on USGS topographical maps (7.5 min. X 7.5 min.) and linear distances were measure from each active nest to the disturbance type. Differences in reproductive success were compared to disturbance type using logistic regression. Chi square analysis with Yates correction for continuity (Zar 1975) was used to compare reproductive success in coniferous and deciduous forests.

Precipitation data were obtained from the Southern Illinois University weather station at the Jackson County airport. Although rainfall was not consistent from nest site to nest site, precipitation data reflect a general trend over the study area.

To determine the effects of predation I visually monitored nests from the farthest distance were I could still see the nest. The presence of avian predators (i.e., crows, owls, and other hawks) in the same nest stand were noted. Predator or competitor nests were plotted on maps and linear distances were measured to the nearest Cooper's hawk nest. I checked the nest site, nest tree, and nest for signs of mammalian predation (loose hairs, fecal material in the nest, and tracks).

I monitored nests from adjacent trees or by climbing the nest tree to determine reproductive success. I attempted to record when the first egg was laid in each nest, onset of incubation, duration of incubation, number of eggs in the clutch, number of eggs that hatched, and the number of eyases that fledged during 1996 and 1997.

Site fidelity is only accurate if adults are banded and then positively identified the following breeding season; so I determined reoccupancy by the presence of breeding pairs (indicated by an active nest) in the nesting area. A nesting area was defined as the area (ca 400 m radius) in which the breeding individuals nest and conduct their breeding activities (Rosenfield 1990). Birds were placed in two age classes (Moore and Henny 1983): SY (second year) -- birds one year old and retain juvenile plumage and ASY (after second year) -- birds two years or older with adult plumage.

I banded nestlings by climbing the nest tree and placing bands on eyases in the nest. Banding was generally done when the nestlings reached one-half to two-thirds of fledging

age (Frye and Olendorff 1976) at ≥ 14 days of age (Rosenfield and Bielefeldt 1991a). Banding was not be attempted after 25 days of age to prevent premature fledging. I determine sex by tarsus diameter and body weight. At ≥12 days of age, the female has a markedly larger tarsus than the male (Rosenfield, pers. commun.). At hatching, the average weight of both sexes is about 28 grams. During the first week, the females growth rate is slightly faster than the males, with females averaging about 7 grams heavier. After the first week the female becomes much heavier (Meng and Rosenfield 1988).

Caution was taken not to disrupt fledging success. Frye and Olendorff (1976) discussed some potential problems encountered by researchers when visiting raptor nests, including:

1) Desertion of eggs or young;

2) Egg breakage, trampling, cooling, overheating, loss of humidity, and predation of eggs;

3) Newly hatched chicks may become chilled or overheated;

4) Premature fledging by older chicks;

5) Scent trails may be followed by mammalian predators to the nest;

6) Other people may be attracted to the nest; and

7) Mishandling of eyases may damage feathers, bones, and claws.

Frye and Olendorff's (1976) recommendations include:

1) Reduced disturbance prior to egg laying because this is the time that nest desertion is most likely to occur. After egg laying has begun desertion is less likely to occur the longer incubation is allowed to progress;

2) The element of surprise should be eliminated to prevent frightened adults from trampling eggs or hatchlings;

3) Climatic conditions differ depending on the research area. Visits should be kept as short as possible and weather, sun position, and the time of day are variables that should be kept in mind when visiting nests;

4) Like eggs, nestlings are more susceptible to overheating than cooling. If the ambient temperature is above 7°C, warming of newly hatched (but dried) eyases is not necessary if visits are kept between 10-15 minutes. Full exposure to sunlight should be avoided. To prevent premature fledging, movements should be slow and deliberate with the hand moving in an arc rather than straight at the bird. Maneuver the bird against the back of the tree to prevent escape;

5) Sprinkling the trail with naphthalene crystals after exiting the nest tree destroys human scent and decreases the chance of mammalian predation;

6) Handle nestlings only when necessary and use two hands when possible.

The recommendation against pre-incubation trapping given by Frye and Olendorff (1976) came from data collected on falcons, eagles, and some buteos in western states. They noted that species and individuals within a species varied in their susceptibility to pre-incubation trapping. This type of trapping did not have any discernible effects during the study by Rosenfield et al. (1991) on Cooper's hawks. They captured hawks at 41 nests during pre-incubation and 98% of the 41 pairs completed clutches. During the same time period, 1987-91, 127 other pairs were discovered during pre-incubation but were not trapped, among these 93% laid eggs.

RESULTS

Twenty-five active Cooper's hawk nests were found during two breeding seasons, 12 in 1996 and 13 in 1997. Thirteen nests were found in Jackson County, 5 in Union County, 5 in Williamson County, and 2 in Johnson County. Nine nests were located on federally-owned land within the Shawnee National Forest, 5 on Crab Orchard National Wildlife Refuge, 6 on state-owned land, and 5 on privately-owned land.

NEST TREE SPECIES

Nests were constructed in 6 tree species (Table 1a). The majority of nests, 21 of 25 (84%), were located in pine stands (Table 1b). Twenty nests were located in short-leaf pine and 1 in eastern white pine (*Pinus strobus*). Of the nests in deciduous stands, 1 was located in sugar maple (*Acer saccharum*), 1 in hickory (*Carya spp*), 1 in tulip (*Liriodendron tulipifera*), and 1 in honey locust (*Gleditisia triacanthos*). The mean diameter at breast height was 28.6 ± 4.3 cm (range = 17.8 - 36.6 cm, N = 25), mean nest height was 15.1 ± 3.1 m (range = 7.6 - 22.2 m, N = 25), and mean height of the nest tree was 15.1 ± 3.1 m (range = 10.3-22.2 m, N = 21). These values are within the range of other studies with the exception of (DBH) (Table 2).

NEST SPACING

Mean distance between nesting pairs of Cooper's hawks was 5.3 ± 3.1 km (range = 1.6 - 12.4 km). Nest densities of Cooper's hawks were not calculated.

NEST SITE TENACITY

Eight of 12 (66.7%) nest sites were reused in the next breeding season. A local falconer reported 1 of my nest sites had been reused 7 consecutive years, although confirmation of the same breeding pair could not be established. Most nest sites contained 2 or more nests. When a pair reused the same nest site, a new nest was usually constructed within 100 m of the old nest. One 1997 nest was constructed 200 m from the previous years' nest. Of the 8 nest sites reused, 2 of 8 (25%) nests were reused. I observed one additional pair tending the same nest but later abandoned it and the nest site.

AGE OF BREEDING ADULTS

Of the 25 nesting pairs, all 25 females were in ASY plumage, 1 male was in SY plumage, although not all males were observed.

NESTING CHRONOLOGY

The nesting cycle for Cooper's hawks in southern Illinois is highly variable (Figure 1). One pair of Cooper's hawks was first detected in the nest site on 6 March with a nest already constructed, although I presume it was the previous years' nest. Most pairs were observed around nest sites by the first week of April. The earliest date for clutch initiation was 15 April with the majority of egg laying taking place between 27 April and 10 May (N = 14). The earliest hatching and fledging dates were 17 May and 13 June, respectively. The majority of hatching took place between 27 May and 10 June (N = 14), and fledging between 27 June and 10 July (N = 12). Incubation lasted 32-34 days while the nestling period lasted 30-34 days.

REPRODUCTIVE SUCCESS AND PRODUCTIVITY

The mean clutch size per nest was 4.1 ± 0.6 (range = 3-5, N = 20), mean number hatched was 3.5 ± 1.3 (range = 0-5, N = 20), and mean number of young fledged per nest attempt was 2.8 ± 1.4 (range = 0-5, N = 25) (Table 3). There were no significant differences in clutch size (U = 80.0, P = 0.64), number of young hatched (U = 85.0, P = 0.70), and number of young fledged (U = 95.0, P = 0.36) between years. There was no significant difference found between deciduous versus pine habitat types ($X^2 = 2.93$, $P > 0.05$). Logistic regression failed to reveal any relationship between reproductive success and disturbance type (distance to human habitation, roads, or forest edge).

Of the 25 active Cooper's hawk nests found, 22 of 25 (88%) were successful. All 12 nests were successful in1996 and 10 of 13 (76.9%) in 1997 (Table 4). Success was determined by at least 1 ayes fledging (Postupalsky 1974). Every nest in the study area was not found, some nests may have been lost before discovery, and those that were located were found during different stages of the nesting cycle. An additional 7 pairs of Cooper's hawks were found in the study area that exhibited breeding or territorial behavior but did not lay eggs or nests were not found. Counting these as a form of nest failure, the number of young/pair was 2.2 (Table 5). Mayfield (1961, 1975) estimates were also used to calculate nest success for comparison and correct for observation bias; new estimates yielded a 76.5% nesting success.

EGG AND NESTLING LOSS

Twelve eggs of 82 (14.6%) did not hatch. Three (25%) remained unhatched due to infertility, 2 (16.7%) were attributed to egg breakage sometime during incubation, and the

failure to hatch of the remaining 7 (58.3%) eggs could not be determined. Of the 9 eggs that were lost to something other than infertility one egg was lost during the first week of incubation while the remaining 8 were lost during the last 2 weeks of incubation.

Eleven of 70 nestlings (15.7%) failed to fledge. Five were attributed to harsh weather conditions (heavy rainfall or strong winds) and the remaining 6 deaths could not be determined. Two nests were destroyed by storms. Mean weekly precipitation did not vary significantly between 1996 and 1997, although, mean precipitation was greater in 1996. The 1996 and 1997 breeding seasons were relatively dry, but periodic intense storms were present. Four nestlings were lost within the first 2 weeks after hatching, the remaining 7 nestlings were lost during the final 2 weeks of the nestling stage.

No avian or mammalian predators were observed preying upon eggs or nestlings, although some or all of the unexplained egg and nestling losses could have been the result of predation. I encountered avian predators/competitors at 20 of 25 (80%) and mammalian predators at 6 of 25 (24%) active nest sites. Raccoons (*Procyon lotor*) were the only mammalian predator encountered. Five active avian predator/competitor nests were found nesting in the same stand, 4 crows (*Corvus brachyrynchos*) and 1 broad-winged hawk (*Buteo platypterus*). Three additional raptors (1 great-horned owl, 1 red-shouldered hawk (*Buteo lineatus*), and 1 red-tailed hawk (*Buteo jamaicensis*) nested within 1 km but nests were separated by fields. Mean distance between Cooper's hawk nests and other raptor nests was 222.0 m (range = 50 m - 500 m, N = 5).

DISCUSSION

The number of fledglings produced per active and successful nest plus hatching and nest success of Cooper's hawks nesting in southern Illinois appears to be as high as any in the country (Table 6). I found little evidence to suggest there is a limiting factor affecting the reproductive success of Cooper's hawks nesting in southern Illinois. Stand selection may have some influence on their reproductive success. Although I found no significant difference in reproductive success between pine and deciduous forests, it is interesting to note that 2 of the 4 (50%) nests in deciduous forests failed to produce fledglings. There was also little evidence to suggest human intrusion had a significant impact on nest success. Predators (e.g., great-horned owls, and crows) have been reported to be the one of the most important factors reducing fledging success (Reynolds and Wight 1978). I found no indication of predation on eggs or nestlings, though predators were often seen in the vicinity of the nest. When flushed one female was incessantly harassed by a pair of crows that nested in the same stand. Although precipitation did not vary greatly between years, except during April, the timing of the rain event may have a detrimental impact on newly hatched nestlings. Three nestlings were lost during intense rain storms and two others were lost when the nest was blown down by strong winds. Reynolds and Wight (1978) stated egg loss was an important factor reducing productivity of Cooper's hawks, but they noted losses during the nestling period were greater. Egg and nestling losses were equal during this study.

Cooper's hawks in southern Illinois did not nest in tree species in proportion to their availability and showed a preference for coniferous forests. The frequent use of pine stands indicates this is important nesting habitat for Cooper's hawks in Illinois and throughout the midwest. Other studies (Wiggers and Kritz 1991, Kritz 1989, Reynolds and Wight 1978) also indicate a preference for coniferous forests. Cooper's hawks will use the same nest site in consecutive years (Meng 1951, Asay 1987, Rosenfield and Bielefeldt 1996). My study also indicated breeding pairs are using the same stands. The U.S. Forest Service has planned the removal of the majority of pine stands in the SNF. If the Forest Service decides to manage pine stands with respect to Cooper's hawks, I suggest recommendations given by Kritz (1989).

1. No thinning in stands accipiters use.
2. A minimum of 6 ha around the most recent nest should be left undisturbed if cutting must takes place.
3. No cutting should take place during the nesting season (April - September).

Although the preference for pine stands is substantial in southern Illinois, I believe there are more nesting attempts in deciduous stands than the data reflects. Most of the pine stands in the study area were relatively small (< 30 ha) and could be easily searched for nesting activity, whereas most deciduous stands searched were frequently in excess of 200 ha, thereby leaving nest discovery more open to chance. Three of the 4 nests in deciduous forests were found on repeat visits. Initially pairs were either out of the immediate vicinity or were nonvocal.

There are also numerous private inholdings within the Shawnee National Forest Purchase Unit making these areas difficult to search. These privately-owned areas within the national forest create a mosaic of small woodlots, many of them suitable for nesting. Three of the 4 nests found in deciduous stands were found in small woodlots (< 20 ha). Ehrlich (1990) found an average stand area of 8-10 ha, although she did not search privately-owned land. Because of the secretive nature of Cooper's hawks, nests are often overlooked even when nests are located close to human dwellings. It is important not to overlook privately-owned land when searching for Cooper's hawk nests.

Meng (1951) reported the two closest nests of Cooper's hawks in New York to be 2.4 km apart. Reynolds and Wight (1978) gave mean distances between nests of 5.0 and 5.5 km in western Oregon and 3.5 in eastern Oregon. Asay's (1987) mean distances between nests of 1.6 and 2.1 km in the Sacramento and southern California study areas, respectively, suggest the highest density of nesting Cooper's hawks in the country. My mean value of 5.3 km was between active nests and did not account for pairs that had established territories and constructed nests but did not lay eggs.

Nest sites were defined as the area (with 400 m radius) in which breeding individuals nest and conduct breeding activities (Rosenfield 1990). Most nest sites contained more than one nest, indicating reuse. Three pairs reoccupied the same nest, although one nest was abandoned before egg laying. Cooper's hawks tend to use the same nest site in successive years (Meng 1951) but may abandon the nest site if

disturbed. The timing and frequency of disturbance seem to be the major factors causing nest abandonment, although individuals vary greatly in their response to human disturbance. One nest that was abandoned was located on a trail regularly used by school groups. I observed the female sitting in the nest 3 times in 5 days but she deserted the nest after my last observation. This female was particularly sensitive and flushed at the first sight of a human. One additional nest site was abandoned and a new site established about a mile south of the previous one. Both nest sites were abandoned before egg laying had began. Fifteen nest sites were found before egg laying began; frequent visits were made throughout the nesting cycle without nest abandonment occurring.

The female and male, if he was present, varied in their response to human intrusion from flying away silently to stooping at the observer. In the latter case, this happened only once. Defensive behavior was the most prevalent during the first few days after hatching. Females and males, if he was present, would fly around the nest while giving alarm calls for as long as the observer was present. During incubation, females generally would sit quietly on the nest and not respond to humans or taped recordings of great-horned owls. One female sat quietly on the nest while a raccoon slept in a tree 40 m away in full view of the nest.

Productivity of populations should be based on all territorial pairs, including non-breeders, because some individuals may defer breeding in some years, depending on a variety of conditions. Non-breeding should be treated as a type of nest failure

(Postupalsky 1974). Many researchers fail to account for non-breeding pairs in a population, though they may account for 10-30% of the population (Brown 1974). In breeding studies researchers at least need to know:

4. The total number of pairs in the area.
5. The total number that breed and lay eggs.
6. The total number of young reared.

Items 1 and 3 give an idea of the replacement rate per pair; item 2 estimates the proportion of the population breeding. Even if the species appears to be numerous and producing-average sized broods, they may be in trouble (Brown 1974).

The Cooper's hawk was taken off the Illinois endangered species list by the Illinois Endangered Species Protection Board in August 1996. Status was determined from spring bird counts from 1975-1994. Since 1986, there has been a 20-30% increase per year in sightings. This increase may be, in part, due to more people in the field or an increase in effort. Reproductive studies conducted concurrently with spring and breeding bird counts give a more reliable estimate of population status.

Table 1a. The number and species of nest tree used by Cooper's hawks in southern Illinois. (b) Number and location of Cooper's hawk nests by stand type.

(a)

Tree Species	N	% Occurrence
Short-leaf pine	20	80.0
Eastern white pine	1	4.0
Tulip	1	4.0
Hickory	1	4.0
Sugar maple	1	4.0
Honey locust	1	4.0

(b)

	Nests N = 25	
	Pine	Deciduous
1996	12	0
1997	9 (69.2%)	4 (30.8%)
Total	21 (84%)	4 (16%)

Table 2. Nest tree characteristics of Cooper's hawks in southern Illinois and other North American studies.

Study area	Nest height (m)	Tree height (m)	DBH (cm)
This study	15.1 ± 3.1	18.5 ± 3.8	28.6 ± 4.26
S. Illinois[1]	12.1	15.8	36.6
Wisconsin[2]	12.8	20.4	33.2
New Jersey-New York[3]	16.7	25.0	44.0
NW Oregon[4]	15.2	22.3	33.2
E Oregon[5]	14.0	22.6	39.6
New Mexico[6]	16.1	24.1	52.1

[1] - Ehrlich (1990), [2] - Rosenfield and Anderson (1983),
[3] - Bosakowski et al. (1992), [4], [5] - Reynolds et al. (1982),
[6] - Kennedy (1988).

Table 3. Mean number of eggs laid, hatched, and young fledged per nest of Cooper's hawks in southern Illinois.

Year	Eggs	Eggs hatched	Young fledged/nest attempt
1996	4.2 (9)[1]	3.9 (9)	3.2 (12)
1997	4.0 (11)	3.2 (11)	2.5 (13)
Total	4.1 (20)	3.5 (20)	2.8 (25)

[1] - Number of nests.

Table 4. Hatching success, fledging success, and nesting success of Cooper's hawk in southern Illinois.

Year	Eggs	Hatch	Fledge	No. Nests	successful
1996	38	35 (92.1)[1]	31 (88.6)[1]	9	12 (100.0)[2]
1997	44	35 (79.5)	28 (80.0)	11	10 (76.9)
Total	82	70 (85.3)	59 (84.3)	20	22 (88.0)

[1] - Percent of eggs that hatched and young that fledged.
[2] - Percent of nests that fledged at least 1 young.

Table 5. Productivity of nesting Cooper's hawks in southern Illinois.

Year	No. of pairs in study area	No. of pairs that bred	No. of pairs that succeeded	No. of young fledged	No of young/pair/ year	No. of young/ breeding pair	No. young/successful nest
1996	16	12	12	38	2.4	3.2	3.2
1997	16	13	10	32	2.0	2.5	3.2
Total	32	25	22	70	2.2	2.0	3.2

Table 6. Comparison of mean nesting parameters of Cooper's hawk in southern Illinois to other North American studies. Sample size indicated in parentheses.

Study area	Hatching success %	No. fledglings/ active nest	No. fledglings/ successful nest	Nest success %
This study	85 (82)	2.8 (25)	3.2 (22)	88 (25)
Wisconsin[3]	96 (111)	2.4 (83)[2]	3.5 (57)	69 (83)[2]
Michigan[4]	74 (54)	2.8 (13)	na	na
California[5]	77 (221)	2.3 (55)	2.7 (47)	85 (55)
Oregon[6]	74 (50)	2.1 (24)	2.9 (na)	69 (29)
w. Virginia[7]	na[1]	2.0 (11)	2.9 (9)	82 (11)
Iowa[8]	na	2.1 (29)	3.0 (20)	69 (29)

[1] na = not available.
[2] Number of bandable young aged ≥ 14 days.
[3] Rosenfield and Anderson (1983), [4] Craighead and Craighead (1956),
[5] Asay (1987), [6] Reynolds and Wight (1978),
[7] Janik and Mosher (1982), [8] Conrads (1990).

March	April	May	June	July	August
29-30	15-16	16-17	5-13	7-8	8-9

N----------N

E----------E

H----------H

F----------F

N - Nest building (29 March - 20 May)[1]
E - Egg laying (15 April - 5 June)
H - Hatching (17 May - 7 July)
F - Fledging (13 June - 8 August)

Figure 1. Nesting chronology of Cooper's hawks in southern Illinois for 1996 and 1997.
[1] Indicates early and late dates.

LITERATURE CITED

American Ornithologists' Union. 1957. Checklist of North American Birds, 5th edition. Lord Baltimore Press, Baltimore, MD.

Asay, C. E. 1987. Habitat and productivity of Cooper's hawks nesting in California. Calif. Fish and Game 73:80-87.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. U. S. National Museum Bulletin 167.

Bohlen, H. D. 1989. The birds of Illinois. Indiana Univ. Press. Indianapolis, IN.

Bosakowski, T., D. G. Smith, and R. Speiser. 1992. Nest sites and habitat selected by Cooper's hawks, *Accipiter cooperii*, in northern New Jersey and southeastern New York. Can. Field Nat. 102:474-479.

Brown, L. 1974. Data required for effective study of raptor populations. Pp.9-20 in Management of Raptors. Proc. Conf. Raptor Conserv. Tech. Raptor Research Report No. 2.Brown, L. and D. Amadon. 1968. Eagles, hawks and falcons of the world. Part 1 and 2. McGraw-Hill, New York, NY.

Brown, L. and D. Amadon. 1968. Eagles, hawks, and falcons of the world. Part 2. McGraw-Hill, New York.

Conrads, D. J. 1990. Status of the Cooper's hawk in Iowa. Unpubl. Rept., Iowa Dept. Nat. Resour., Des Moines, IO.

Craighead, J. J. and F. C. Craighead. 1956. Hawks, owls and wildlife. Dover Publications, New York, NY.

Ehrlich, R. M. 1990. Nest site habitat of Cooper's hawks (*Accipiter cooperii*) in southern Illinois. Masters Thesis, Southern Illinois University. Carbondale, IL.

Englert, T. 1985. Observations on Accipiters and their nesting habitat. J. North American Falconers Assoc. 24:6-20.

Frye, R. W. and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occas. Pap. 23. Ottawa, Ontario, Canada.

Fuller, M. R. and J. A. Mosher. 1981. Methods of detecting and counting raptors: a review. Studies in Avian Biol. 6:235-246.

Greenwood, P. J. 1980. Mating systems, philopatry and dispersal in birds and mammals. Anim. Behav. 28:1140-1162.

Henny, C. J. and H. M. Wight. 1972. Population ecology and environmental pollution: red-tailed and Cooper's hawks. Pp. 229-250 *in* Population ecology of migratory birds: a symposium. U.S. Dept. of Inter. Fish and Wildlife Service Report 2. Washington, DC.

Herkert, J. R. editor. 1992. Endangered and threatened species of Illinois: Status and distribution, Vol. 2- Animals. Illinois Endangered Species Protection Board, Springfield, IL.

Janik, C. A. and J. A. Mosher. 1982. Breeding biology of raptors in the central Appalachians. J. Raptor Res. 16:18-24.

Kennedy, P. L. 1988. Habitat characteristics of Cooper's hawks and northern goshawks nesting in New Mexico. Pp 218-227 *in* proceedings of the Southwest Raptor Management Symposium and Workshop, Nat. Wildl. Fed., Washington, DC.

Kritz, K. J. 1989. Nesting ecology and nest site habitat of sharp-shinned and Cooper's hawks in Missouri. Masters Thesis, Univ. of Missouri, Columbia, MO.

Lessells, C. M. 1991. The evolution of life histories. Pp 32-68 in J. R. Krebs and N. B. Davies, eds. Behavioral Ecology an Evolutionary Approach. 3rd ed. Blackwell Scientific pub., Oxford, England.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

----. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Meng, H. K. 1951. The Cooper's hawk, *Accipiter cooperii* (Bonaparte). Ph.D. Dissertation. Cornell University, Ithaca, NY.

Meng, H. K. and R. N. Rosenfield. 1988. Reproduction. Pp 332-349 in R. S. Palmer ed. Handbook of North American birds, Vol. 4 Yale Univ. Press, New Haven, CT.

Moore, K. R. and C. J. Henny. 1983. Nest site characteristics of three coexisting Accipiter hawks in northeastern Oregon. J. Raptor Res. 17:65-76.

----. 1984. Age specific productivity and nest site characteristics of Cooper's hawks (*Accipiter cooperii*). Northwest Sci. 58:290-299.

Mutter, D., D. Nolan, and A. Shartle. 1984. Raptor populations on selected park reserves in Montgomery County, Ohio. Ohio Acad. Sci. 84:29-32.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.

Olendorff, R. R. and M. N. Kochert. 1977. Land management for the conservation of birds of prey. Proc. ICBP World Conf. on Birds of Prey, Vienna, 1975:294-307.

Postupalski, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Pp. 21-31 in Management of Raptors, Proc. Conf. Raptor Conserv. Tech. Raptor Research Report No. 2.

Reynolds, R. T. 1989. Status reports: Accipiters. Pp. 92-101 *in* Proc. western raptor management symposium and workshop. Natl. Wildl. Fed., Washington, DC.

Reynolds, R. T., E. C. Meslow, and H. M. Wight. 1982. Nesting habitat of coexisting Accipiter in Oregon. J. Wildl. Manage. 46:124-138.

Reynolds, R. T. and H. M. Wight. 1978. Distribution, density, and productivity of Accipiter hawks breeding in Oregon. Wilson Bull. 90:182-196.

Ridgway, R. 1889. The ornithology of Illinois. Vol. 1. Illinois state laboratory of natural history. Springfield, IL.

Rosenfield, R. N. 1988a. Migration. Pp 331-332 in R. S. Palmer ed. Handbook of North American birds, vol. 4. Yale Univ. Press, New Haven, CT.

Rosenfield, R. N. 1990. Pre-incubation behavior and paternity assurance in the Cooper's hawk (*Accipiter cooperii* [Bonaparte]). Ph.D. Dissertation, North Dakota State University, Fargo, ND.

Rosenfield, R. N. and R. K. Anderson. 1983. Status of the Cooper's hawk breeding in Wisconsin. Unpublished final report, Wis. Dept. Nat. Resour., Madison, WI

Rosenfield, R. N. and J. Bielefeldt. 1992. Trapping techniques for breeding Cooper's hawks: two modifications. J. Raptor Res. 27:170-171.

----. 1996. Lifetime nesting area fidelity in male Cooper's hawks in Wisconsin. Condor. 98:165-167.

Rosenfield, R. N., J. Bielefeldt, and R. K. Anderson. 1988b. Effectiveness of broadcast calls for detecting breeding Cooper's hawks. Wildl. Soc. Bull. 16:210-212.

Rosenfield, R. N., J. Bielefeldt, R. K. Anderson and W. A. Smith. 1985. Taped calls as an aid in locating Cooper's hawk nests. Wildl. Soc. Bull. 13:62-63.

Rosenfield, R. N., J. Bielefeldt, T. K. Anderson, and J. M. Papp. 1991. Accipiters. Pages 42-49 in B. G. Pendleton and D. L. Krahe eds. Midwest raptor management

symposium and workshop. Nat. Wildl. Fed. Sci. and Tech. Series No. 15. Washington, DC.

Snyder, N. F., H. A. Snyder, J. L. Lincer, and R. T. Reynolds. 1973. Organochlorines, heavy metals, and biology of North American Accipiters. Bioscience 23:300-305.

Steenhof, K. 1987. Assessing raptor reproductive success and productivity. Pp 157-169 *in* B. A. Giron Pendleton, B. A. Millsap, K.W. Cline and D. M. Bird, eds. Raptor management techniques manual, Natl. Wildl. Fed., Washington, D.C.

Titus, K. and J. A. Mosher. 1981. Nest-site habitat selected by woodland hawks in the central Appalachians. Auk 98:270-281.

U.S. Fish and Wildlife Service, Department of the Interior and Canadian Wildlife Service, Department of Fisheries and Environment. 1977. North American Bird Banding Manual. Vol.2 Bird banding techniques. Ottawa, Ontario, Canada.

USDA Forest Service. 1991. Draft environmental impact statement for the amended land and resource management plan: Shawnee National Forest. Eastern Region, Milwaukee, WI.

Vogl, J. S. 1988. Nesting Cooper's hawks in St. Joseph County, Indiana. Audubon Quarterly 66:30-31.

Wiggers, E. P. and K. J. Kritz. 1991. Comparison of nesting habitat of coexisting sharp-shinned and Cooper's hawks in Missouri. Wilson Bull. 103:568-577.

----. 1994. Productivity and nesting chronology of the Cooper's hawk and sharp-shinned hawk in Missouri. J. Raptor Res. 28:1-3.

Zar, H. 1975. Biostatistical analysis. Prentice-Hall, Englewood Cliffs, NJ.