Reducing Management and Research Disturbance

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INTRODUCTION

Researchers may disturb raptors in several ways during breeding or other seasons, and in so doing skew the results of their fieldwork. For example, disturbance may be a problem in achieving unbiased estimates of reproductive success and other behavior. It is thus desirable to understand and minimize the effects of disturbance on research work and on the birds themselves. Because raptor conservation has received considerable attention, we have much information on the actual or potentially deleterious effects that researchers and managers have had or may inflict on raptors. In this chapter we discuss some of the problems associated with research and management disturbance to raptors and offer possible solutions.

Destructive effects of human activity on raptors are varied and rather well documented in both non-technical and technical publications. The sub-lethal and lethal effects of various toxic chemicals have produced a rich literature (Parker 1976, White et al. 1989, Goldstein et al. 1996, Mineau et al. 1999, Klute et al. 2003, Ratcliffe 2003). Other threats to raptor populations stem from the loss and degradation of habitat due to logging, agriculture, industrial pollution, climate change, recreational activities, weapons-testing noise, and even still, direct persecution through shooting, trapping, and poisoning (Bildstein et al. 1993, White 1994, Fuller 1996, Kirk and Hyslop 1998, Brown et al. 1999, Fletcher et al. 1999, Wood 1999, Noon and Franklin 2002, Klute et al. 2003, Newbrey et al. 2005). Impacts of researcher disturbance on breeding raptors also have been documented, including nesting failures after climbs to nests (Boeker and Ray 1971, Luttich et al. 1971), lowered nesting success (Wiley 1975, Buehler 2000), and displacement of birds from home ranges (Andersen et al. 1986, 1990).

That said, many species of raptors worldwide recently have found ways to co-exist and breed successfully in human-altered and occupied environments, often nesting on man-made structures such as power-line poles, buildings, smoke-stacks and bridges (e.g., Bird et al. 1996). Although raptors as a group often are described as being sensitive to human disturbance, especially when nesting (Newton 1979, Snyder and Snyder 1991, Roberson et al. 2002), recent studies report numerous populations of "forest" raptors nesting successfully in human-dominated landscapes. For example, 70 breeding territories of Northern Goshawks (*Accipiter gentilis*) were found within Berlin, Germany in 1999 (Krone et al. 2005). Cities, in fact, now harbor some of the highest nesting densities yet recorded for some woodland and forest species, including Mississippi Kite (*Ictinia mississippiensis*) (Parker 1996), Red-tailed Hawk (*Buteo jamaicensis*) (Stout et al. 2006) and Cooper's Hawk (*A. cooperii*) (Rosenfield et al. 1995, Boal and Mannan 1999).

Raptor scientists have documented behavioral and demographic differences between raptors nesting in rural areas where disturbance is reduced and those nesting in relatively high-disturbance settings including urban areas where birds are more habituated to human presence and are less wary and, sometimes, more aggressive as well (Götmark 1992, Steidl and Anthony 1996, Bielefeldt et al. 1998, Aradis and Carpaneto 2001, W.E. Stout and A.C. Stewart, pers. comm.; see also Andersen et al. 1989). Northern Goshawks in Britain, central Europe, and Japan nest in close proximity to humans in rural landscapes where some populations are not especially prone to disturbance (Squires and Kennedy 2005). The docile behavior and interactions with humans, for instance, indicate low levels of direct human impact on the Spotted Owl (*Strix occidentalis*) (Gutierrez et al. 1995).

There are several reviews of negative human impacts on raptors (e.g., Stalmaster and Newman 1978, Newton 1979, Keran 1981; see also various species accounts on raptors in the Birds of North America series [Poole 2004]). Much literature suggests that human disturbance is a problem during the nesting period, especially during incubation (e.g., Fyfe and Olendorf 1976, Boal and Mannan 1994, Roberson et al. 2002). Management attempts to lessen such impacts, including buffer zones around nests and timed restrictions on activities, are described by Stalmaster and Newman (1978), Suter and Jones (1981), Grier et al. (1983), Squires and Reynolds (1997), Erdman et al. (1998), Jacobs and Jacobs (2002), and Watson (2004). Attempts to minimize investigator disturbance are varied and include actions such as building tunnels to observation blinds (Nelson 1970, Shugart et al. 1981), limiting the duration of nest visits (Rosenfield and Bielefeldt 1993a, Squires and Kennedy 2006), and using small, silent cameras installed near nests to reduce or eliminate the need for repeated visits to nests by observers (Booms and Fuller 2003, Rogers et al. 2005, Smithers et al. 2005).

The effectiveness of minimizing disturbance associated with research and management activities with nesting raptors is rarely known or reported (Gotmark 1992). This is because disturbance is difficult to measure and, generally, is not directly quantified by raptor researchers (but see Grier 1969, Busch et al. 1978, White and Thurow 1985, Crocker-Bedford 1990). Also, because raptors tend to nest at relatively low densities, the effects of disturbance may be harder to detect because of difficulties in collecting large enough samples of nests (Gotmark 1992; but see Riffel et al. 1996). Researcher disturbance *per se* is not mentioned in some reviews of management efforts for various raptor species of high conservation profile (Cade et al. 1988, Reynolds et al. 1992, Klute et al. 2003, Andersen et al. 2005). However, one report (United States Fish and Wildlife Service 1998) stated that observations of nests for short periods after the young hatch, or trapping of adults for banding or attaching radio transmitters during nesting, did not cause nest desertion. The report concluded that disturbance usually is not a significant factor affecting the long-term survival of any North American goshawk population.

Grier (1969) found no disturbance effects from a large-scaled, three-year, controlled experimental study of possible effects from climbing to Bald Eagle (*Haliaeetus leucocephalus*) nests in northwestern Ontario, Canada. Similarly, Steenhof (1998) indicated that properly designed field studies have no measurable effect on Prairie Falcon (*Falco mexicanus*) populations; and that during 24 years of research on this species in the Snake River Birds of Prey Natural Conservation Area in Idaho, investigators caused egg or nestling losses at only 11 (0.7%) of 1,555 nesting attempts (Steenhof 1998).

Likewise, during hundreds of thousands of hours of research on and monitoring of Spotted Owls, including more than 2,065 captures with no deaths, there was no clear evidence of significant impact by research activity except for a negative effect on reproduction from backpack radio transmitters (Gutierrez et al. 1995, see below). In a review that compared the effects of investigator disturbance at nests, non-raptors seemed to be more vulnerable to disturbance effects than were raptors (Gotmark 1992). Although sample sizes were small, one possible reason for the disparity may have been that raptor biologists made comparatively fewer visits to nests or employed relatively benign forms of disturbance compared with methods used to study other birds (Gotmark 1992).

Because the problems of general human disturbance are so diverse (Riffel et al. 1996) and are discussed in Chapter 20, we focus on the responsibilities and possible consequences of the actions of researchers and managers. Most literature on disturbance deals with research on breeding raptors. Fyfe and Olendorff (1976) reviewed and provided excellent suggestions for remedying a variety of research and management disturbance problems among nesting raptors. Below we summarize their suggestions and offer modifications of some of their suggestions in light of Gotmark (1992), as well as attempt to coordinate some of our recommendations with those presented elsewhere in this book.

PRELIMINARY CONSIDERATIONS

It is imperative that researchers and managers consult the technical literature, as well as knowledgeable persons during the design of their projects to learn of potential disturbance problems that could arise from field activities, along with ways to minimize such disturbance. They should not rely solely on literature as disturbance effects may not always be mentioned in papers (Gotmark 1992).

Some disturbance problems may be species- or site-specific, or both. For example, White and Thurow (1985) found that Ferruginous Hawks (*B. regalis*) in Utah were quite susceptible to disturbance at their nest. In some areas but not others, Swainson's Hawks (*B. swainsoni*) may desert their nests if they are visited by humans during incubation (Houston 1974, England et al. 1997). Cooper's Hawks in Wisconsin do not desert nests in trees climbed to count eggs (Rosenfield and Bielefeldt 1993a). However, Erdman et al. (1998) cautioned against flushing incubating, congeneric Northern Goshawks there; they do not climb to their nests to count eggs because they believe that such activity will cause the birds to desert their nest, although they did not document this effect.

Within a population, most individuals exhibit variation in behavioral responses to human presence (Grier 1969, Andersen et al. 1989, McGarigal et al. 1991, Gotmark 1992), and some variation relates to the bird's activity at the time of approach. Snail Kites (*Rostrhamus sociabilis*), for example, are approachable on their foraging grounds but tend to be very sensitive to human intrusion around nests (Snyder and Snyder 1991). In response to human presence, breeding Bald Eagles were less likely to flush, and flushed at shorter distances to people than did nonbreeding adults (Steidl and Anthony 1996). Successfully reducing disturbance to raptors may call for close attention to their behavior and a willingness to break off operations if signs of stress become evident, such as prolonged alarm calling, extended absence of adults from a nest (during which time predators may gain access to nests [Craighead and Craighead 1956]), or a shift of activity within home ranges (Andersen et al. 1990).

Raptor scientists should contact the proper agencies for procuring research permits and, when appropriate, seek approval of field procedures from an animal-care entity. Within the U.S. and Canada, wild birds are given legal protection through The Migratory Bird Treaty Act and the Migratory Bird Conservation Act, respectively. Any research that involves disturbing, handling, collecting, or in any way manipulating wild birds requires written approval from the appropriate Federal, State, or Provincial regulatory authorities in North America. Details regarding permit applications and wildlife protection in North America are in Little (1993), and can be obtained directly from the U.S. Fish and Wildlife Service regional offices or the Canadian Wildlife Service, or Provincial wildlife authorities as appropriate. In addition, researchers and managers working with raptors also may need approval for projects including field work from their institution's Animal Care and Use Committee.

When possible, we urge researchers and managers to seek training on the use of techniques by participating in workshops that provide, for example, field instruction by experienced biologists in the natural history of raptors and their usual responsiveness to people, training on how to find and monitor nests, and knowledge of ways to collect reproductive data by observing or climbing to raptor nests (e.g., Jacobs and Jacobs 2002). In Wisconsin, Erdman et al. (1998) indicated that their workshops and field training on the nesting biology of Northern Goshawks generated so much interest and cooperation among U.S. Forest Service personnel that these employees helped double the number of known goshawk territories in a national forest. Workshops often are announced in newsletters published by the Ornithological Societies of North America and by the Raptor Research Foundation. Appropriate government agency offices also are good sources of this information.

An inadvertent and indirect cause of disturbance at nest sites involves public knowledge of the locations and resulting attention. Problems can result if individuals seek to deliberately harm or collect the birds, and when well-intentioned individuals interfere by their presence at the site. Such disturbance from unauthorized falconers, photographers, birders, zoologists, and even wildlife managers is well known. As a result, several concerned wildlife groups have adopted resolutions recommending that such site information be kept confidential, but made available to the appropriate land managers. Problems result not only for the birds, but also for persons working with them, including future access and spending money to guard and protect the sites. The obvious solution to this is maintaining the confidentiality of site-specific information, even in reports, graduate theses, and scientific publications. In case of conflicts with freedom of information laws or regulations, site information may be placed under provisions of special protection or kept in the files of researchers or other agencies not subject to public disclosure. Maps and site-specific information also can be kept at widely dispersed locations, at various offices and in different files, with only statistical results stored in central, public locations. Dispersed information would likely slow access by unauthorized persons, increase inability to find all of the information, and facilitate detection of unauthorized use. Ellis (1982) refers to the treatment of information to ensure protection and privacy as “information management.” Information management is extremely important and should be heeded by all persons working with birds of prey. Proper attention to information management not only will reduce disturbance, but also will greatly reduce or eliminate the need for eyrie wardens and other forms of site protection.

BASIC RECOMMENDATIONS FOR REDUCING DISTURBANCE AT NESTS

Nest Desertion

Nest desertion, which is serious, can be unpredictable. In general, the likelihood of desertion varies by nesting stage, among different species, among different individuals within species, and probably gender. Nest desertion due to researcher disturbance is poorly documented in many studies. Nest desertion may be underestimated because of the likelihood that abandoned nests may be preyed upon or scavenged before they are detected (Gotmark 1992). It is generally believed, and some studies show, that nest desertion due to disturbance is more likely to occur early, as opposed to late, in a season. For example, in an intensive 14-year study of Cooper’s Hawks in Wisconsin, involving multiple and repeated sources of potential disturbance (e.g., attempts [often successful] to trap adults at *all* stages of nesting, climbs to nests to count eggs and band young), including an estimated cumulative total of more than 3,000 visits over 3–4 months to 330 nests, only four (1.2%) nests were known to have failed due to researcher disturbance. All four were deserted following extended visits of about 1 hour by field workers during the incubation stage (Rosenfield and Bielefeldt 1993a, R. Rosenfield, unpubl. data). In all four instances, only females deserted; males tried unsuccessfully at all four sites to incubate clutches for about 7–10 days following their mates’ desertion (R. Rosenfield, unpubl. data).

Human activities near nests with young rarely cause nest abandonment, and then only because of severe disturbance. For example, logging activities including cutting, loading, and skidding within 50–100 m of a goshawk nest can cause abandonment even when 20-day-old nestlings are present (J. Squires, unpubl. data). Intra-seasonal nest desertion due to researcher presence is highly unlikely after young hatch, but Golden Eagle (*Aquila chrysaetos*) pairs whose young were banded in three Rocky Mountain states were more likely to move to alternate nests or not breed the following year than pairs whose young were not banded (Harmata 2002). Nesting Bald Eagles responded similarly in coastal British Columbia, Canada (D. Hancock, unpubl. data), but no such effects have been found for Bald Eagles in Ontario, where a study involving several thousand climbs into nests revealed no difference in nesting success between nests that were climbed into and those that were not (Grier 1969). It also seems likely that little disturbance occurs to other adult raptors, including Eastern Screech Owls (*Megascops asio*) and Barn Owls (*Tyto alba*), that are caught in nestboxes while incubating (Taylor 1991; K. Steenhof, per comm.).

Some species may be quite tolerant of various forms of researcher disturbance during the earlier pre-incubation and incubation periods. For example, using bait birds in traps set out before dawn, Rosenfield et al. (1993b) captured 38 different adult Cooper’s Hawks (25 males, 13 females) at 41 nests that were under construction during the pre-incubation period in Wisconsin. Trapping at this time was expeditious because traps were placed precisely where the hawks were expected to appear at dawn. The hawks detected the human-controlled movement of bait birds quickly and were usually caught (or missed) within 0.5 hours. None of the nests were deserted and 98% of the 41 pairs laid eggs; whereas among 127 pairs they discovered at the pre-incubation stage and where trapping was not attempted, 93% laid eggs (Rosenfield and Bielefeldt 1993b).

No nest desertions occurred during 35 years of capturing more than 400 adult Ospreys (*Pandion haliaetus*) in Michigan using a dome-shaped, noose “carpet” trap set over eggs or young (S. Postupalsky, pers. comm.).

Adult Ospreys were attentive and were caught within minutes during incubation, whereas trapping took 1 to 2 hours during the nestling stage. Trapping of Ospreys always was done during rainless periods. Houston and Scott (1992) reported no "adverse effects" with the use of noose carpets to trap adult Ospreys in Saskatchewan. Slip-noose traps also have been used on nests during the incubation period to trap adult Eurasian Sparrowhawks (*A. nisus*) in Scotland and Peregrine Falcons (*F. peregrinus*) in West Greenland, with no known desertions by adults attributed to this disturbance (Newton 1986, W.G. Mattox, unpubl. data). Catching adult American Kestrels (*F. sparverius*) in boxes is a common technique that rarely results in disturbance unless it occurs during egg-laying (K. Steenhof, pers. comm.). It also seems that little disturbance occurs to other adult raptors (e.g., Western Screech Owls [*M. kennicottii*] and Barn Owls) caught in nest boxes when incubating (K. Steenhof, pers. comm.).

Cooper's Hawks in Wisconsin also have been caught during the incubation period using a mist net placed near plucking posts with an owl as a lure (Rosenfield and Bielefeldt 1993a). The limbs and other perches where males pluck and transfer prey to females are usually about 50–100 m from the nest and typically out of view of the nest. Males call immediately to their mates upon arrival at plucking posts, which also alerts the researcher hidden nearby to play a recording of a Cooper's Hawk alarm call to draw attention to the owl. Males, the target of this technique, usually are caught within 15 minutes after they detect the owl. If not, the researchers immediately leave the nest area to minimize disturbance to the incubating female. This type of disturbance has been used at 40 nests and resulted in captures of 35 males and, inadvertently, seven females (the other 33 females remained on their nests), with no nest desertions attributed to this technique (R. Rosenfield and J. Bielefeldt, unpubl. data). Adult male Broad-winged Hawks (*B. platypterus*) and Sharp-shinned Hawks (*A. striatus*) also have been caught at prey-transfer sites in Wisconsin without causing nest desertion (E. Jacobs, pers. comm.).

Raptor biologists often use blinds near the nest to study nesting behavior (e.g., Harris and Clement 1973, Kennedy and Johnson 1986, Bielefeldt et al. 1992, and see Chapter 5 of this book). Blinds are erected either during late incubation or, more often, during the early nestling stage during favorable weather, and often are placed 5–20 m horizontally from and a little above the nest to facilitate observation. Some researchers also have placed blinds within 2 m of Eurasian Sparrowhawk nests to allow for more accurate identification of prey (Newton 1978, Geer and Perrins 1981). Such close placement allowed the researchers to extend tongs through a hole in the blind to retrieve some of the songbird prey that were leg-banded; prey were replaced with the tongs after the bands were removed (Geer and Perrins 1981). Initially, the parent birds flew off when tongs were extended, but soon they became so accustomed to the procedure that tugs-of-war developed over prey items that the researchers tried to remove. Adult Prairie Falcons also tolerate observation blinds within 2 m of their nests (Sitter 1983).

Nesting adult raptors appear to habituate to blinds, as well as to people entering and leaving them (e.g., Geer and Perrins 1981, Steenhof 1998, but see Snyder and Snyder 1991 for Snail Kites). Nest abandonment, apparently, is rare, although researchers have generally not detailed their procedures on blind placement and the behavior of adults in response to human activity. Adult females returned to nests within 20 minutes of completion of blind set-up, and no desertions of nests occurred after blinds were installed in about 2 hours and within 5 m of nests when young were about 1 week old at each of three Broad-winged Hawk and five Cooper's Hawk nests in Wisconsin, and at four Peregrine Falcon nests in West Greenland (Rosenfield 1983, Bielefeldt et al. 1992, Rosenfield et al. 1995, R. Rosenfield, pers. obs). On the other hand, at a Gyrfalcon (*F. rusticolus*) nest on Ellesmere Island in 1973, the male, but not the female, abandoned a brood of four young when a wooden blind was relocated from hundreds of meters from the nest to a spot approximately 12 m away (D. Muir and D. M. Bird, pers. comm.). Blinds can be constructed during short work periods (< 2 hours) over a series of days to reduce disturbance of parent raptors (Geer and Perrins 1981, Boal and Mannan 1994).

It is generally assumed that nesting adult raptors will behave normally around blinds, but one adult female Broad-winged Hawk uttered alarm calls and attacked a cloth-covered blind, piercing it with her talons (Rosenfield 1978). In another instance an adult female Peregrine Falcon called and attacked a blind placed near her nest in West Greenland. The female responded to an "apparent" intruding conspecific, herself, because from the nest she could see her image reflected in the blind's one-way glass, which later was angled to prohibit mirroring (Rosenfield et al. 1995a, R. Rosenfield, pers. obs). Both of these females ceased calling within 3 days of blind installation and both fledged all their young. Adult males at these sites seemed disturbed by the blinds. One male Broad-winged Hawk and two male Peregrine Falcons uttered alarm calls when they flew by the blinds and appeared hesitant at times to land on their nests (R. Rosenfield, pers. obs). There was no indication, however, that their hunting activity and prey deliveries were adversely influenced by the presence of blinds (R. Rosenfield, pers. obs). One study has reported that nestling Cooper's Hawks exposed to frequent handling and study from blinds were more likely to die from human causes, especially shooting (Snyder and Snyder 1974).

Compared with observers hidden in blinds, the recent technology of using remote cameras to record nest activities can minimize researcher disturbance at raptor nests (Delaney et al. 1998, Booms and Fuller 2003, Rogers et al. 2005). Cameras are silent, small in size (ca. 12 × 4 × 4 cm, L × W × H), and can be installed on the nest tree or a nearby tree (Delaney et al. 1998), or on rock at a cliff site (e.g., Booms and Fuller 2003, Rogers et al. 2005). In time-lapse cameras, a long (75 m) video cable links the camera to a recording unit and power source, thus allowing researchers to change tapes at locations out of view of adult raptors on nests (Delaney et al. 1998, Booms and Fuller 2003). Responses of nesting birds to camera installation vary by species and individuals, timing of camera placement during the nesting season, and length of time needed for camera installation. Camera set-up time averaged 42 minutes at 20 nests of incubating Mexican Spotted Owls (Delaney et al. 1998), and took an average of about 2 hours at 10 nests with 4–7 day-old Northern Goshawks (Rogers et al. 2005). Camera installation during the mid-incubation to early nestling stage (young = 5 days old) took 2–4 hours at each of three Gyrfalcon cliff nests (Booms and Fuller 2003). Researchers reported no nest abandonment in response to remote cameras used with Mexican Spotted Owls (Delaney et al. 1998), Cooper's Hawks (Estes and Mannan 2003), Gyrfalcons (Booms and Fuller 2003), and Northern Goshawks (Lewis et al. 2004, Rogers et al. 2005). However, Cain (1985) reported abandonment of three Bald Eagle nests after installing cameras during the late incubation and early nestling periods. In some bird studies, miniature remote cameras have attracted predators. Thus, researchers may want to camouflage or hide cameras (Green 2004). Conversely, the use of cameras may repel predators and potentially bias an investigation aimed at documenting nest predation (Green 2004).

Raptor biologists frequently use broadcasts of conspecific vocalizations during population surveys to elicit behavioral responses of woodland raptors, determine their presence, or find nests (e.g., Forsman 1983, Rosenfield et al. 1988, Mosher et al. 1990, McLeod and Andersen 1998; also see Chapter 5). Prolonged playing of calls can lure some adult females repeatedly away from their nests, and broadcast calls also can attract potential avian predators such as American Crows (*Corvus brachyrhynchos*) (R. Rosenfield, unpubl. data). It is possible that broadcasts of raptor calls could result in nest abandonment or depredation of eggs or nestlings, or both. However, we are not aware of any such reports, or any published recommendations by raptor scientists about minimizing disturbance while using broadcast calls. On the other hand, while conducting experiments to evaluate the probability of detecting nesting Northern Goshawks, researchers did not use broadcast trials during incubation in part because they believed that broadcasts could disturb incubating females and cause egg loss (Roberson et al. 2005). These researchers also ended broadcast trials 2 hours before sunset to reduce the possibility of attracting nocturnal predators (i.e., Great Horned Owls [*Bubo virginianus*] and fishers [*Martes pennanti*]) to fledglings.

Lastly, many raptor researchers investigate movement and other behavior of breeding adults through the use of radio marking and associated technology (Fuller et al. 1995, and see Chapter 14 of this manual). Nesting adults sometimes are caught and radiotagged at the incubation stage. For example, across 9 years in West Greenland researchers trapped and radiotagged adult Peregrine Falcons (mostly females) at more than 600 eyries using noose gin traps placed among eggs. They recorded no abandonment at any nests, and did not detect any difference in productivity at nests where adults were radiotagged versus nests that were not disturbed by trapping and radiomarking of adults (W. Mattox, unpubl. data).

Adult raptors are more commonly radiotagged during the nestling stage so as not to compromise the viability of fragile eggs during the time it takes to capture, attach a transmitter, and allow birds to resume nesting activities. Investigators implicitly assume that radiomarked individuals behave and survive normally (Conway and Garcia 2005), especially if radio transmitters are small relative to the animal's mass (Reynolds et al. 2004). Several studies have investigated the effects of radio tagging on the behavior of breeding raptors, and none reported nest abandonment. However, decreased productivity in Golden Eagles, including nesting success, fledglings per occupied territory, and brood size, in one of three breeding seasons was associated with the presence of radio transmitters (Marzluff et al. 1997). Vekasy et al. (1996) reported no effect of radio tagging on Prairie Falcon nesting success and brood size, but indicated that biases may occur in certain years of varying weather and prey availability; they suspected that radio-tagged female Prairie Falcons may have had lower productivity and thus, they tended to quickly release gravid females without attaching radio tags. In related research, Spotted Owls carrying backpack transmitters had lower productivity than leg-banded owls (Foster et al. 1992). Although 25 of 29 radiomarked adult Northern Goshawks successfully fledged young, the annual survival of breeding male goshawks that carried a tailmount was lower than for males that carried backpack-style radio transmitters (Reynolds et al. 2004). Careful selection of an attachment method, practice on captive or wild non-nesting birds and, if required, innovation and testing can minimize potential effects of radio marking raptors and reduce the overall time spent attaching radios to nesting adults (Fuller et al. 1995).

We reiterate that some species may be less tolerant than others of research activity during the nesting season. For instance, breeding adult Gyrfalcons are relatively shy and do not seem to habituate as readily to radio tagging as do other nesting raptors. After being outfitted with a satellite-received, platform transmitter terminal (PTT), one female Gyrfalcon in West Greenland did not feed her young, which eventually died (M. Yates and T. Maechtle, pers. comm.). In another study in Greenland using PTTs, K. Burnham (pers. comm.) has never observed nest abandonment by Gyrfalcons, but he did not radio adults until nestlings were about 20–25 days old and can thus tolerate the several hours that breeding adults, especially females, may take to "accept" transmitters.

Damage to Eggs and Young by Frightened Adults

When incubating or brooding small young, adults often respond to human approach by hunkering down in the nest, presumably to avoid detection. Incubating or brooding adults sometimes also carefully walk to the rim of the nest before flying off. At other times, an adult is disturbed suddenly and bolts so quickly that the eggs or young, which are between or underneath its feet, are catapulted out of the nest cup or scrape onto the nest rim or out of the nest completely. Eggs on the nest rim likely will not be moved back into the nest by an adult, but sometimes young crawl back or are picked up by adults and returned to the cup (Olsen 1993). It also is possible for an adult to puncture an egg or to trample small young under circumstances of a sudden exit. Fortunately, these types of situations appear to be very rare. Problems are more likely during the days just prior to and after hatching, when adults of most species sit "tighter" (some birds will stay on the nest until a climber is halfway up a tree or down a cliff), making a sudden departure more likely, at a time when small, and weak young are dislodged easily. When researchers cannot see clearly into a tree nest, detect other sign of young (by looking for whitewash on the ground beneath a nest), or otherwise determine that a nest is active, they often tap the nest tree in an attempt to induce detectable movement by a tending adult to confirm occupancy. Tapping also may cause a fast exit by an adult, who accidentally may dislodge ad eject eggs or nestlings from the nest. To reduce this possibility, it is better to seek a distant vantage point and use binoculars or a spotting scope to determine occupancy. If this is not possible, one should slowly approach from a distance in an obvious and visible manner, perhaps even making sounds, so that the adults have an opportunity to detect one's presence and leave the nest in a less frantic manner. Walking tangentially rather than directly toward a nest will help slow the approach and is less threatening to the birds. We recommend tapping trees as a last resort and use only moderately strong repeated strikes, which tend to cause minimal movement in adults. When doing so, one should watch for ejected young. In two cases a nestling was knocked completely from a nest (among the thousands of visits made by the authors to nests of many species of raptors across North America). In one of these instances, R. Rosenfield (unpubl. data) caught a 5 day-old Cooper's Hawk in mid-air and returned the uninjured bird to the nest where it eventually fledged.

Cooling, Overheating, and Loss of Moisture from Eggs or Young

Eggs and small young (less than 7 days old), in particular, are vulnerable to chilling, overheating, and dehydration when the parents are kept away from the nest. The temporary cooling of eggs apparently does not pose a serious problem during normal field procedures, and some species can tolerate adult trapping procedures during incubation (see Nest Desertion above). Researchers that climb raptor nests during the incubation period to determine clutch size generally do not report weather or other conditions at the time they counted eggs

(Reynolds and Wight 1978, Janik and Mosher 1982, Andrusiak and Cheng 1997, Petty and Fawkes 1997). Climbs of < 10 minutes at more than 500 Cooper's Hawk nests in Wisconsin did not appear to result in nest abandonment or egg loss due to cooling (R. Rosenfield and J. Bielefeldt, unpubl. data); nests were never climbed when temperatures were < 18ºC, and the estimated maximum time that females were off their nests during such visits for clutch counts was 20 minutes.

Nestling raptors in hot environments, or in nests exposed to direct sunlight, may face extreme thermal- and water-balance problems. When stressed these individuals rely heavily on increased respiratory water loss via panting to combat hyperthermia. Heat-induced death of nestlings has been reported in several species of raptors, including Red-tailed Hawk (Fitch et al. 1946), Galapagos Hawk (*B. galapagoensis*) (deVries 1973), Golden Eagle (Beecham and Kochert 1975) and Peregrine Falcon (Nelson 1969). In most nestling birds of prey, the only source of water (except for metabolic water) is from food provided by the parents (Kirkley and Gessaman 1990), and thus missed feedings due to prolonged researcher presence may, besides diminishing nutrient intake, compromise water balance of chicks. Older nestlings avoid exposure to direct sunlight by moving to shaded parts of the nest, and when the nest is exposed to direct sunlight, attending adults shade their young with outstretched wings and tail. Heat-stressed nestlings tend to position themselves on the perimeter of the nest, presumably to enhance the effectiveness of convective cooling (Kirkley and Gessaman 1990). Some young may be heat-stressed and already near their limits of tolerance even without the added burden of disturbance. The situations vary with location (e.g., cooling is more likely in the Arctic whereas drying occurs in desert or grassland areas, and overheating in lower latitudes), although panting in response to direct sunlight can occur even at seemingly cool temperatures. For instance, a pair of 17 day-old Red-tailed Hawks began to pant in the early-morning sunlight at 08:30 when the air temperature was 13ºC (Kirkley and Gessaman 1990). Temperature and humidity are generally most favorable for nestlings in forested areas. Extremes are possible in all places however, and should always be considered. Wind, precipitation, and direct sunlight can exacerbate the situation. The times that nestlings can be exposed to adverse conditions are increased in timid species such as Gyrfalcons, Golden Eagles, and Snowy Owls (*B. scandiaca*), where parental birds stay away from the nest for extended times waiting for intruders to leave the area. To avoid such situations, keep visits as brief and unobtrusive as possible and consider weather, position of the sun, and time of day. If possible, do not visit nests at time of hatching, or during periods of extreme weather and avoid visiting unshaded nests during the hottest part of the day. If visits during inclement conditions are necessary and unavoidable, put the eggs or young in a fur-lined glove or protective container, or cover them with a piece of cloth or branches with leaves. Do not conduct adult trapping activities at nests until young can thermoregulate. See Steenhof et al. (1994) and Erdman et al. (1998) for details. And terminate trapping activity about 2 hours before sunset to allow adults ample time to return to their nest and resume normal behavior.

Premature Fledging and Banding Young

Fledging occurs when young first leave the nest. In most species, fledging is a gradual process that includes combinations of climbing, jumping, and flapping before flight feathers of the wings and tail are completely grown and sustained flight is possible (Newton 1986, Rosenfield and Bielefeldt 2006). Approximate fledging dates of selected North American and European raptors can be found online in the Birds of North America accounts (Poole 2004), Newton (1979b, Table 18), and Cramp and Simmons (1980). In most studies of raptor productivity researchers visit nests to count and, at the same time, band young. Fyfe and Olendorff (1976) suggested that the optimum time for banding is when the young are approximately one-half to two-thirds fledging age. This is because until about one-half of fledging age, a nestling's legs and feet are not fully grown, and a band may slip down a leg and encircle the foot. Prior to two-thirds fledging age, nestlings tend to move minimally when researchers are at the nest. Nestlings also tend to struggle less when handled at these ages, and banding at this stage is relatively straightforward and proceeds relatively quickly. Thus, overall time at the nest is reduced. When a researcher reaches a nest with older, unfledged youth, the young often spread their wings, move quickly to the opposite edge of the nest, and lean backward (often precariously) in a defensive posture. At this age, young are easily startled and may fledge or leave the nest prematurely by trying to fly off, or by stepping to the edge of the nest or onto branches or cliff ledges from which they may fall. The results of such falls depend on the bird's age and condition, and where it lands. Finally, there always is the risk of injury, loss, or increased vulnerability to predation due to premature fledging.

When reaching for older nestlings we recommend moving a hand slowly toward and at the level of the individual's feet, and allowing the bird to grab your hand if possible so as to establish reliable contact. If several birds are about to jump from a tree nest, try and capture them one at a time by reaching up and letting them grab a hand without putting your (obtrusive) head and shoulders above the nest. A makeshift poultry hook is useful in some situations (Grier 1969). We also recommend putting older young in a backpack to confine their movements. When the pack is closed, the darkness inside the bag seems to calm the nestlings. If young do jump, take care to mark where they went, retrieve them and, if there are no injuries, place in the nest one at a time. Again keep most of your body below the nest and replace the "jumper" nestlings in the reverse order in which they jumped. Thus, the young that jumped first and, presumably, would be more likely to jump again, will be minimally disturbed. One should then depart slowly and quietly from the nest. Premature fledging is best avoided by visiting nests early in the season. When older nestlings are encountered, they are best left alone or approached slowly and handled with extra caution. If handled carefully and slowly, young can be distracted from fledging and will adjust to the presence of the intruder. We also recommend that observations from blinds be discontinued about 3 to 4 days before the young are due to fledge to avoid causing them to leave the nest prematurely (Geer and Perrins 1981, Rosenfield et al. 1995).

Steenhof (1987) recommended visiting nests when young are about at 80% fledging age to assess nest success and productivity, a somewhat later nest visitation time than the one-half to two-thirds fledging age discussed above (Fyfe and Olendorff 1976). Steenhof and Newton (Chapter 11, this volume) now encourage determining an appropriate standard for timing of nest visits to assess productivity and band young of various raptor species. There are, however, temporal differences in behavioral development among species, and among populations of the same species (i.e., young may develop more slowly or more quickly in some populations [Rosenfield and Bielefeldt 1993a, 2006; Curtis and Rosenfield 2006; S. Postupalsky, pers. comm.). Temporal differences are sometimes accentuated in raptors because of reversed size dimorphism, in which smaller males develop faster and fledge earlier than females. For example, male Ferruginous Hawk nestlings leave nests about 10 days earlier than female nestlings (Bechard and Schmutz 1995). A universal application of an 80% fledging-age metric may make it difficult for researchers to capture mobile young, lead to unsafe handling of older young, and result in premature fledging, all of which can result in inaccurate productivity estimates. Consequently, we recommend that counts and banding of young should be done when young are at about 70% fledging age for Cooper's Hawks in British Columbia, North Dakota, and Wisconsin (Rosenfield and Bielefeldt 1999, 2006; Stout et al. 2007; A Stewart, unpubl. data); and at about 65% fledging age for Red-shouldered Hawks (*B. lineatus*) in Wisconsin (E. and J. Jacobs, unpubl. data); and 55% fledging age for Sharp-shinned Hawks in Wisconsin (E. Jacobs and R. Rosenfield, unpubl. data). Researchers should be cognizant of the possibility of population-specificity in nestling development when timing their nest visits, and should first learn how to handle nestling raptors in the field by spending time in the field with experienced researchers.

Avian and Mammalian Predation

Fyfe and Olendorff (1976) indicated that avian predators including jaegers, gulls, and corvids often visually cue onto unattended nests, and that after researchers had disturbed nests, predators might raid nests while the adults are away. Although in non-raptorial species avian predators have been shown to respond to or follow field workers and to prey on nests visited by investigators there is no direct evidence of this in the literature concerning raptor nests (Gotmark 1992). Even so, a crow (*Corvus* sp.) has been observed throwing one of two, unattended, small Great Horned Owl nestlings out of a nest about 30 minutes after a researcher climbed to it. Although the researcher returned this unhurt bird to its nest, several days later researchers found both owlets dead at the base of the nest tree and attributed their deaths to attacks by crows due to his presence at the nest (Craighead and Craighead 1956). Adult Cooper's Hawks are frequently mobbed and rarely struck by Northwestern Crows (*C. caurinus*) when researchers are near their nests in British Columbia, but the crows do not visit nests during the presence of researchers and there is no evidence of unattended eggs or nestlings being preyed upon by crows after visits (A. Stewart and R. Rosenfield, pers. obs.). Gotmark (1992) suggested that when avian predation has been documented, the predators responded opportunistically to unattended nests or young rather than to observer presence *per se*.

Some authors assume or emphasize that mammalian predators might find nests by following scent trails left by researchers during their nest visits (e.g., Hamerstrom 1970, Poole 1981, Gawlick et al. 1988), and that this problem is particularly serious for ground-nesting raptors (Fyfe and Olendorff 1976). Mammals also are sometimes thought to follow tracks in the vegetation made by observers. In his review, Gotmark (1992) found no evidence of increased predation by mammals due to researcher presence at nests. He also was unable to locate a study that documented mammalian predators following observers. He noted, however, that if precautions like avoiding the creation of trails in vegetation is effective (as recommended by Hamerstrom [1970]) and were being taken by researchers, such behavior may have influenced his inability to find investigator effects. Finally, to avoid drawing attention to a nesting area, one should withdraw from the site to complete field notes.

Mishandling Birds

Both raptors and handlers can be injured during improper handling. Young birds with growing bones, feathers, and talons are particularly vulnerable (see Chapter 12). How to handle birds correctly is best learned in the field from someone with experience.

Miscellaneous Considerations

A number of precautions can help reduce disturbance to raptors by observers, researchers and managers. These include using teams of two people instead of single individuals and giving special care to banding and marking of raptors. Using two workers enhances safety both for the researchers and birds, and permits greater efficiency in note-taking and carrying equipment, which, in turn, reduces the amount of time spent in the area. In addition, Speiser and Bosakowski (1991) noted that two or more observers elicited milder, less aggressive encounters with nesting adult goshawks (which sometimes strike researchers).

When trapping breeding adult raptors, some researchers advocate using mist nets rather than dho-gazas (see Chapter 12). The use of mist nets probably lowers time spent at the nest because they do not collapse after a strike and, therefore less time is needed to reset the net. Contact between a lure owl and a trapped bird rarely occurs with mist nets, a possibility that often is uncontrollable with the dho-gaza (Steenhof et al. 1994, Erdman et al. 1998). We recommend using broadcasts of conspecific calls while conducting adult trapping activities at nests — especially in wooded areas where visibility is limited — because they often more quickly draw attention of parents to a decoy and can reduce time spent at the nest (Erdman et al. 1998, R. Rosenfield, unpubl. data). Steenhof et al. (1994) reported that broadcasting Great Horned Owl calls did not expedite trapping American Kestrels.

Many species of nesting raptors are surveyed or studied from fixed-wing aircraft or helicopters without adverse disturbance effects (e.g., Grier et al. 1981, Kochert 1986, Andersen et al. 1989, Watson 1993, McLeod and Andersen 1998, Kochert et al. 2002). Knowledge of a species' tolerance to low-level flying aircraft is critical and researchers should use only experienced pilots when surveying raptors (Kochert 1986). In a novel study, White and Nelson (1991) monitored habitat use and the hunting behavior of a male Peregrine Falcon and a female Gyrfalcon by following these nesting adults (even in hunting stoops!), with helicopters at a distance of 30–50 m. They emphasized that despite the potential lethal threat of doing so, both to the birds and the human observers (some Gyrfalcons attack helicopters), the technique produced information almost impossible to collect by more conventional methods (see Chapter 5). The young at one of their study nests, however, were depredated about 3 weeks after the project ended. But either the same adult pair or another used the same eyrie the following year.

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