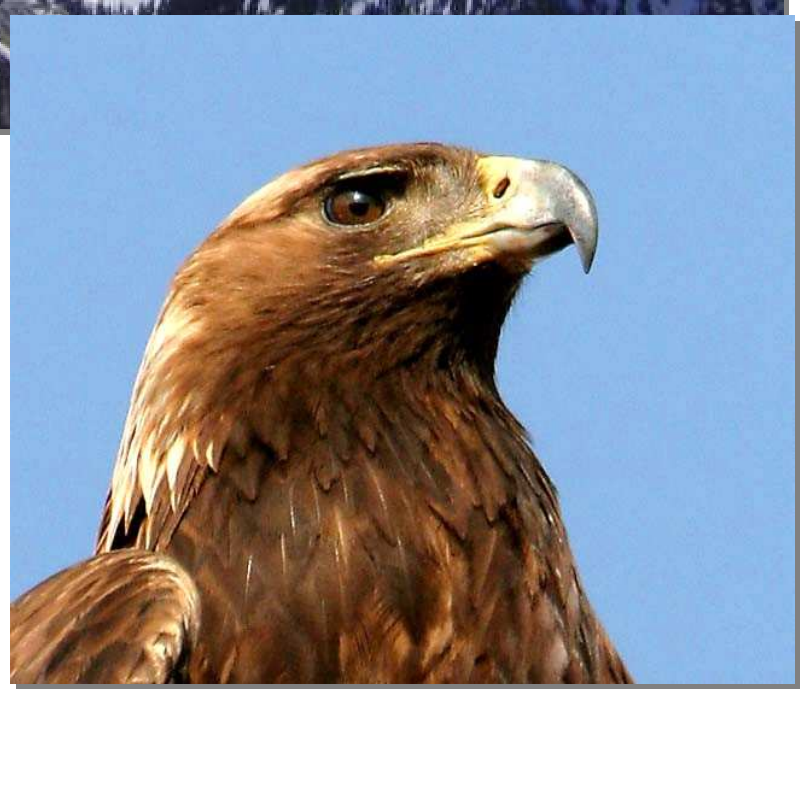
Investigating Potential Effects of Heli-Skiing on Golden Eagles in the Wasatch Mountains, Utah



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Final Report to the Wasatch-Cache National Forest

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EXECUTIVE SUMMARY

Implementing further research was beyond the scope of the U.S. Forest Service's 2004 Final Environmental Impact Statement (FEIS) and 2005 Wasatch Powderbird Guides (WPG) Special Use Permit Renewal process for heli-skiing in the Tri-Canyon Area in the Wasatch Mountains, just east of Salt Lake City, Utah. However, in their Record of Decision the Wasaatch-Cache (WCNF) and Uinta National Forests expressed full support for undertaking a comprehensive study to more intensively examine helicopter-golden eagle interactions. This research project is a result of that commitment, with a goal of gathering more specific information on the potential effects of heli-skiing operations on golden eagles occupying territories or actively nesting in the Tri-Canyon Area, while evaluating the effectiveness of current mitigation and management practices identified in the FEIS. Of necessity, this 2006-2007 research project focused primarily on the helicopter aspects of heli-skiing. It was jointly funded by the U.S. Forest Service WCNF and Rocky Mountain Research Station, the U.S. Army Corps of Engineers Construction Engineering Research Laboratory, and Clemson University. Objectives included a golden eagle occupancy survey, experimental helicopter testing, and a recreational analysis.

To establish the context for WPG operations in the Tri-Canyon Area, we collected data on levels or recent trends in recreational use, avalanche control, population growth, and other helicopters operating in the area. We surveyed as many historical golden eagle nest sites as possible between Parley's and Provo Canyons, as well as monitored a number of lower elevation sites west and south of Salt Lake City used in our experimental testing. Historical records for golden eagle nesting in the Tri-Canyon Area, as well as WPG operational records for 1974-2007 were reviewed. In the field, we recorded nesting golden eagle responses to Utah National Guard Apache AH-64 attack helicopters, WPG's Eurocopter AS350-B3 AStars and Bell 206L4 Longranger, Cirque Lodge's Eurocopter EC140 B4, plus other passing civilian helicopters as they occurred. Data were collected actively through controlled experimentation, and passively, or opportunistically as circumstances permitted.

In total, we observed 303 helicopter passes near ≥30 individual golden eagles in 22 breeding areas, with 227 passes from the Apache experimentation which was designed to approximate WPG normal operations in pattern, timing, and duration. In 2006, 8 active nest sites were tested with Apaches, 4 sites per day, 2 days per week for 2 weeks between 11-20 April. In 2007, 15 sites (including 6 from 2006) were tested, following the same pattern, during 4 weeks between 03-26 April. Scheduled flight paths for flyby's included distances of 800, 400, 200, and 100 m. In addition, we tested approach's and popout's where the helicopter flew straight towards, or popped out from behind, active nest cliffs as it passed directly overhead. Sound levels were recorded during 7 of 15 separate helicopter tests in 2006 and during 15 of 31 tests in 2007. We also compared sound levels of the Apache with the other 3 helicopters involved in this research.

Historical records on golden eagle nesting, plus continued sightings from a variety of sources, as well as current observations during this project, all indicate golden eagles have continued to occupy the Tri-Canyon Area for decades, despite the dramatic population growth along the Wasatch Front approaching 2 million people, and significant increases in recreational activity over the same time period. In the Cottonwood Canyons alone, there are more than 1.5 million skiers visiting the 4 major resorts and over 15,000 avalanche control explosions per year. Nearly 10,000 vehicles per day enter those 2 canyons. There are also a minimum of 8 different non-military organizations flying ≥17 different helicopters in and around the Tri-Canyon Area, excluding WPG.

Historical records for Tri-Canyon Area golden eagle nesting are sketchy at best, wtih only 8 years of confirmed nesting between 1981-2007. During each of those years, WPG operated in the same drainage 10-37 days between 15 December and 15 April, flying 108-2,836 separate helicopter flights. The frequency and timing of these flights evidence a lack of effect on subsequent nesting activity or success, even though many of those flights occurred during early courtship and nest repair. During the 34 year period from 1974 through 2007, WPG annual trends in operating days (average, 62.4) and total helicopter hours (average, 210.6) have remained essentially level, while skier days (average, 761.0) have gradually increased.

Multiple exposures to helicopters during our experimentation in 2006 and 2007 had no effect on golden eagle nesting success or productivity rates, within the same year, or on rates of renewed nesting activity the following year, when compared to the corresponding figures for the larger population of non-manipulated sites. During our active testing and passive observations, we found no evidence that helicopters bother golden eagles nor disrupt nesting. In 303 helicopter passes near eagles, we observed no significant, detrimental, or disruptive responses. 96% of 227 experimental passes of Apache helicopters at test distances of 0-800 m from nesting golden eagles resulted in no more response than watching the helicoper pass (30%). No greater reactions occurred until after hatching when 4 (possibly 3) golden eagles accounted for 5 flatten and 3 fly behaviors at 3 nest sites. None of these responding pairs failed to successfully fledge young, except for 1 nest that fell later in the season. For WPG observations, 2 eagles accounted for 2 fly behaviors, 1 of which appeared totally unrelated, at 2 locations. All other fly's for both types of helicopters were interpreted as the aircraft precipitating an imminent departure, more than eliciting an excited, startled, avoidance reaction, which was never observed. Non-attending eagles or those perched away from the nests were more likely to fly than attending eagles, but also with less potential consequence to nesting success. Golden eagles appeared to become less responsive with successive exposures.

Apache helicopters were about 3x louder than the civilian helicopters used by WPG. Sound decreased with distance, and most dramatically when flights were perpendicular to cliff and ridge lines. Much of helicopter sound energy may be at a lower frequency than golden eagles can hear, thus reducing expected impacts. We found no relationship between helicopter sound levels and corresponding eagle ambient behaviors or limited responses, which occurred throughout recorded test levels (76.7-108.8 dB, unweighted).

Results of this research speak directly to considerations important to establishing site-specific buffers, such as type and duration of anthropogenic activity, intervening topography and vegetation, habituation to existing activities, and local population density of the species in question. A typical WPG heli-skiing operation may only have a helicopter at any 1 location for a few min during any given hour, and this usually only happens limited times in any given day, and rarely on consecutive days. The rugged, high-relief topography of the Tri-Canyon Area significantly reduces buffer distance requirements because of inherent line of sight and sound buffering across intervening ridges. Plus, golden eagle nests in the area are typically on tall cliffs well below ridges where their natural placement provides an inherent buffer from helicopters landing nearby, and skiers navigating adjacent runs. Between all the other aircraft and human activities occurring in the Tri-Canyon Area, as well as their long term coexistance with WPG and apparent indifference to current operations, golden eagles in the area appear acclimated to current levels of activity. The limited number of their nest sites under consideration in the Tri-

Canyon Area is only a portion of a larger, continuous golden eagle population of 20-22 recent breeding areas along the Wasatch Front, all the individual sites of which appear to be intermittently occupied, active, and successful related more to natural phenomena than human interference.

The most recent federal bald and golden eagle management guidelines further accomodate possible habituation by excepting recommended helicopter buffers where eagles have a demonstrated tolerance to such activity, which appears to be the case in northcentral Utah and the Tri-Canyon Area. Our direct and indirect observations indicated no avoidance behavior nor even concern by golden eagles to helicopters. Tri-Canyon Area eagles actually exhibited a casual interest in WPG helicopters and their heli-skiing operation. Finally it should be noted the only reactions by nest-attending eagles recorded during this entire project occurred after hatching, which in the Tri-Canyon Area does not happen until approximately 4-6 weeks after WPG's season ends on 15 April. Thus, our results indicate: 1) there is minimal overlap between golden eagles and WPG, with nesting at higher elevations occurring later than may have been thought previously; 2) when there is simultaneous presence, golden eagles do not seem to be bothered or disrupted by WPG activities; and 3) should egg-laying occur while WPG is still operating, incubating golden eagles do not normally react other than to watch the aircraft. For the specific question of WPG operating in the Tri-Canyon Area without potentially impacting nesting golden eagles, we found no evidence that special management restrictions are required.

(*Authors' Note: The results of this research were very much unexpected since helicopters are usually considered more disruptive to bald eagles than any other type of aircraft. Plus, golden eagles are traditionally thought to be more sensitive, and therefore more responsive, to human intrusions than bald eagles. However, we found the golden eagles studied during this project to be just as adaptive, tolerant, and acclimated to human activities as any bald eagles in our rather considerable, collective experience with this species. We hypothesize this may at least be in part due to the proximity of the large, growing, and outdoor-oriented population of the Salt Lake Valley and Wasatch Front. It is unlikely any golden eagles within our study area and beyond are truly naive to anthropogenic influences, no matter how remote their nesting locations appear to be. Even so, despite this apparently high tolerance, we would still point out that <u>any</u> activity, initially tolerated or not, <u>in excess or extreme</u>, can cause negative impacts. Nonetheless, with that said, we found nothing to suggest current levels of WPG heli-skiing operations in the Tri-Canyon Area have any detrimental effect on resident golden eagles.)*

ACKNOWLEDGEMENTS

This research project was jointly funded by the Wasatch-Cache National Forest, Rocky Mountain Research Station, U.S. Army Corps of Engineers Construction Engineering Research Laboratory, and Clemson University. In addition, the WCNF Supervisor's Office and Salt Lake Ranger District provided vital administrative and logistical support throughout the project, especially Diane Probasco, Richard Williams, and Steve Scheid who have been involved with the project throughout. Jeff Walkes, Fire & Aviation Staff for the WCNF in 2006, prevailed over nearly insurmountable odds to obtain authorization for research personnel to fly with WPG on a limited basis. There would have been no experimental helicopter testing without the enthusiastic and invaluable cooperation of the Utah National Guard 211th Aviation Attack Helicopter Unit, based in West Jordan, Utah, and the special assistance of senior pilots CW5 Don Jacobson and CW3 Mike Pluim. Doug Johnson, Resource Specialist for the National Guard's Camp Williams also helped with access and field support during both years of the study. Wasatch Powderbird Guides facilitated our efforts with an open-door policy and full access to their operational records, in addition to providing helicopter support for mitigation surveys and several experimental flights. WPG owners, guides, and pilots provided valuable insight into their operations and interactions with golden eagles over the years. Classic Helicopters Head Pilot, Mario Nicolette, and Cirque Lodge's Pilot, Andy Oprie, generously arranged for sound testing of their respective helicopters, plus the Cirque helicopter gave us experimental data for sites in Provo Canyon. Kent Keller, local raptor specialist and golden eagle expert, acquainted research personnel with all of the active golden eagle nest sites used in this study beyond the Tri-Canyon Area historic locations. He shared historical records, monitored manupulated and non-manipulated sites each year, and was always available for expert counsel throughout the project. Finally, Mike Wierda from Clemson University, stepped in during the second year of the project to offer exceptional field, office, and research assistance. Individuals who participated in recording helicopter test observations at golden eagle nest sites include: Angela Gatto, Karen Hartman, Doug Johnson, Kent Keller, Roy Lopez, Bob Piscapo, David Probasco, Steve Scheid, Cecily Smith, Zach Todd, Mike Wierda, and Richard Williams. This has obviously been a cooperative project, and the contributions of all who have participated are deeply appreciated.

Cover photo credits: Heli-skiing Scene, courtesy of Wasatch Powderbird Guides
Golden Eagle, courtesy of Kent Keller

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IN MEMORIUM

In Memory and Honor of the Pilots and Men of the Utah National Guard 211th Aviation Attack Helicopter Unit, Past and Present.

INTRODUCTION

Since 1973, Wasatch Powderbird Guides (WPG) has operated a helicopter skiing outfitter and guide service under USDA Forest Service (FS) special use permits from the Wasatch-Cache (WCNF) and Uinta (UNF) National Forests. Much of WPG's use has historically occurred in the Tri-Canyon Area of Utah's Wasatch Mountains, consisting of Big and Little Cottonwood Canyons and Mill Creek Canyon. This area is adjacent to the Salt Lake City metropolitan area and is heavily used for various forms of winter recreation, particularly on weekends and holidays. A substantial portion of the area has been designated as wilderness, allocated to ski area development, or closed to helicopter skiing operations. WPG's operation shares the remaining terrain with ski mountaineering, cross-country skiing, snowmobiling, snowshoeing, snowboarding, snow play, and winter sightseeing. These multiple uses are in line with management direction for the area as detailed in the Revised Forest Land and Resource Management Plans for the WCNF and UNF. Both Forest Plans provide for continued heli-skiing recreational opportunities consistent with resource capability, other land uses, and other resource management goals. However, increasing winter backcountry use has fueled the inherent conflict between these other types of recreation and current heli-skiing operations, as authorized under the FS WPG Special Use Permit (2005).

Thus, the Forest Service as required under the National Environmental Policy Act (NEPA) developed an Environmental Impact Statement (EIS) as part of the process for renewing WPG's permit. An analysis for the Final Environmental Impact Statement: WPG Permit Renewal (October 2004; FEIS), as well as available anecdotal records, indicate golden eagles (*Aquila chrysaetos*) have co-existed with heli-skiing in the permit area for more than 30 years. However, for unknown reasons, no successful reproduction has been documented in the Tri-Canyon Area in recent years. As part of the latest FEIS and WPG permit renewal process, previously established, 0.5-mi (800 m) buffers were maintained at 4 historic golden eagle nest sites (Mineral Fork, Reed & Benson North, Reed & Benson South, and American Fork), and dropped from 2 inactive, apparently abandoned sites (Silver Fork and Honeycomb Cliffs, no activity recorded since 1993 and 1992, respectively). Within these buffers, in effect 1 February-31 August unless sites are determined unoccupied earlier, helicopters are not authorized to fly at <1,000 ft above ground level (AGL) or at <30 mph. The only remaining flight and landing variances in effect, excepting a flight path and 2 landing spots within a 0.5-mi buffer zone, are at Reed & Benson South. In accordance with NEPA, mitigation measures were required and included buffers, variances, and monitoring flights, which were originally developed by the FS in conjunction with the U.S. Fish & Wildlife Service (FWS), Utah Division of Wildlife Resources (UDWR), and World Center for Birds of Prey (Boise, Idaho) in 1997, and later corroborated with FWS's most recent published raptor protection guidelines for Utah (Romin and Muck 2002).

Although golden eagles are not a Federally listed species under the Endangered Species Act (ESA), they are protected by the Bald and Golden Eagle Protection Act (BGEPA). Under the Act, it is prohibited to "knowingly, or with wanton disregard for the consequences of this act take, possess, sell, purchase or barter... any golden eagle..." Further, the Act notes the term "take" includes "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, or molest or disturb..." (see Literature Review for more details). Thus, the basic FS responsibility under this Act is to ensure that the agency's activities and those that it authorizes, do not result in a "take" of any golden eagles. Based on a thorough analysis of available information, legal requirements, and documented concerns, the FEIS concluded that, with recommended mitigation measures in place, the Proposed Action and action alternatives would have little or no long-term effect on golden eagles nesting in the permit area. Implementing further research was beyond the scope of the FEIS and WPG permit renewal process. Nonetheless, in the Record of Decision for WPG Special Use Permit Renewal (ROD, September 2004), the WCNF and UNF expressed full support for undertaking a comprehensive study to more intensively examine helicopter-golden eagle interactions. This research project is a result of that commitment, with a goal of gathering more specific information on the potential impacts of heli-skiing operations on golden eagles occupying territories or actively nesting in the Tri-Canyon Area, while evaluating the effectiveness of current mitigation and management practices identified in the FEIS. Of necessity, this project focused primarily on the helicopter aspects of heli-skiing.

The FEIS also identifies potential noise from heli-skiing helicopters as one of two major points of conflict with backcountry users seeking a quiet "wilderness experience" (the other being competition for undisturbed snow conditions). However, there are minimal data on specific and comparative sound levels of WPG and other helicopters operating within or around the Tri-Canyon Area, on how these sound levels attenuate over distance, especially under the rugged local terrain conditions, or on the actual sound levels reaching potentially affected golden eagles. Although not included as a stand alone objective or priority, noise is a critical component of any assessment of potential helicopter impacts on wildlife and was therefore included in this research.

OBJECTIVES

Occupancy Survey, or monitoring - Determine current occupancy, nesting activity, and productivity of golden eagles within the Tri-Canyon Area and immediate vicinity; and passively assess the potential impacts of heli-skiing and any other human winter activities that occur during the nesting season.

Experimental Testing - Experimentally test the effectiveness of current buffer and variance distances by controlled helicopter flights of simulated and/or actual heli-skiing operations near golden eagles nesting within the Tri-Canyon Area, or at active nest sites near the Tri-Canyon Area, and/or at naive, unexposed lower elevation sites farther out in the Salt Lake Valley to the west and south of Salt Lake City.

Recreational Analysis - Analyze any available, direct or indirect, recreational use data for assessing recent and long term trends in winter backcountry recreation and other related human activities, as potential factors influencing golden eagle nesting activity and habituation within the Tri-Canyon Area.

LITERATURE REVIEW

Golden eagles, although not a federally listed threatened or endangered species, are none the less included under several federal laws, the most significant of which are the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, and the Endangered Species Act, mentioned previously. Collectively this legislation provides a framework within which federal agencies assess management decisions that may adversely affect golden eagles and their habitat. While it has long been established that various forms of human disturbance can negatively impact birds of prey (Mathisen 1968, Fyfe and Olendorff 1976), research targeting potential aircraft impacts on raptors is relatively limited. Even fewer studies have specifically addressed the effects of any kind of anthropogenic activity on golden eagles. Research results vary, depending on an array of factors including but not limited to the type, severity, timing, duration, frequency and proximity of the stimulus, and the activity, location, and buffering associated with the target species (Grubb and King 1991). Individual behavioral tendencies and previous experience/exposure can also affect the type, severity, and duration of response.

Any single anthropogenic activity in excess can ultimately lead to nesting failure or in some cases, even death. Short of that, terrestrial activities, especially pedestrian forms, have tended to elicit higher responses in nesting bald eagles than aerial forms of disturbance (Fraser *et al.* 1985, Grubb and King 1991). Helicopters resulted in the highest frequency of response (47%) when compared to low-level jets (31%) and light planes (26%) in a comparative study of bald eagle response to aircraft disturbance in Arizona and Michigan (Grubb and Bowerman 1997). Median distance to aircraft for flight response for all 3 aircraft types was 200 m, although frequency of flight from helicopters (11%) was more than 3 times that from jets and light planes (3% and 1%, respectively). A 600 m exclusion buffer for all aircraft was suggested, but given the value of helicopters for raptor surveys, the authors recommended single overflights >150 m and < 1 min duration to minimize potential disturbance.

Golden eagles, among several other raptor species, were also more likely to flush when approached by a pedestrian than a vehicle. Of 18 golden eagles tested with pedestrian disturbance, 100% flushed. Only 19% of 16 eagles exposed to vehicle disturbance flushed. Ninety-seven percent of all raptors approached on foot (162 birds) flushed at a mean distance of 118 m; whereas of the 164 raptors exposed to vehicle disturbance, only 38% flushed at a mean distance of 75 m. In a comparison of golden eagle response to vehicles on paved versus gravel roads, there was less response to the former, implying both potential habituation to the frequent traffic associated with paved roads, and a lesser perceived threat from the faster moving vehicles under possibly quieter conditions of paved versus gravel roads. Raptors perched closer to the ground, such as American kestrels (*Falco sparverius*), flushed at greater distances than those perched higher, indicating that tolerance of disturbance relates to relative position as well as distance. Management buffer zones of 300 m around foraging areas of wintering raptors, including golden eagles, were recommended to avoid the energy expenditure associated with flushing (Holmes *et al.* 1993).

During an evaluation of raptor survey techniques, Steenhof and Kochert (1982) noted that golden eagles and red-tailed hawks (*Buteo jamaicensis*) exposed to human intrusions during early incubation had significantly lower reproductive rates than individuals exposed later in the season (45% golden eagle and 57% red-tailed hawk success versus 71% and 74%, respectively). However, Kochert *et al.* (2002) reported no adverse effects from 900 helicopter flights near active golden eagle nests during nesting surveys to check on eggs and nestlings. In another study, nesting red-tailed hawks showed slight declines in reproductive success (80% down from 86%) after helicopter disturbance (Anderson *et al.* 1989). Yet, after extensive controlled experimentation with military jet helicopters over Mexican spotted owls (*Strix occidentalis*), manipulated and non-manipulated sites did not differ in reproductive success or number of young fledged (Delaney *et al.* 1999).

Few studies have measured the time adult raptors are away from a nest due to human disturbance, even though it may be a very important effect of disturbance (Fyfe and Olendorff 1976). Holthujzen et al. (1990) found that frequent blasting during dam construction and experimentally controlled blasting did not significantly influence nest attendance during incubation by prairie falcons (*F. mexicanus*). In the Wrangell-St. Elias National Park and Preserve, Alaska, humans camped 400 m and 800 m from golden eagle nests caused decreased feeding, nest maintenance, and preening at the nearer sites. Time spent brooding, shading or protecting nestlings increased at those sites. However, overall time of nest attendance by adults did not differ between test groups (Steidl *et al.* 1993). Nesting ospreys (*Pandion haliaeetus*) showed no startle or flush reactions to low-level jet overflights between 0-0.75 nautical miles, but did exhibit an orienting response. Nest attendance behavior did not differ between pre- and post-overflight and normal observations periods during the study. However, nesting adults reacted strongly with agitation, flight, and/or aggressive behavior to infrequent helicopters, float planes, and humans outside blinds (Trimper *et al.* 1998).

Raptors are more susceptible to disturbance early in the breeding season because parents have little energy invested in the nesting process (Awbrey and Bowles 1990). The tendency to flush from the nest appears to decline with experience (i.e., habituation), and individual responsiveness is thought to decline as the breeding season progresses through its early to mid-stages (Knight and Temple 1986). Fraser *et al.* (1985) found incubating and brooding bald eagles less likely to flush once incubation began. However, the pattern reverses later in the nestling cycle as the nestlings mature and the requirement for nest attendance diminishes. Bald eagles exposed to helicopters, jets, and light planes showed increasing alert and flight responses as the nesting season advanced from February to June. Distance between eagle and aircraft, duration of overflight, and number of aircraft or passes were the most important characteristics influencing eagle responses (Grubb and Bowerman 1997).

White and Thurow (1985) reported approximately 30% of ferruginous hawks (*B. regalis*) abandoned their nests after being exposed to various ground-based disturbances. Anderson *et al.* (1989) noted 2 of 29 red-tailed hawk nests were abandoned after being flushed by helicopter overflights, compared with 0 of 12 control nests. Ellis (1981) found only 1 abandoned nest out of 19 nests of various species of raptors that were exposed to frequent low-altitude, jet overflights throughout the nesting season. Platt (1977) reported a significant tendency for gyrfalcons (*F. rusticolus*) to relocate to nearby nests following the year of close disturbance by helicopters. Of 6 peregrine falcon (*F. peregrinus*) nests that Windsor (1977) exposed to helicopter overflight, only 1 abandoned, apparently as a combined result with inclement weather, compared with 0 of 3 control nests. In the year following their jet overflight study of 5 osprey nests, Trimper *et al.* (1998) reported continued nesting activity and no changes in nest location.

Although reactions of adult raptors at the nest can influence hatching rates and fledgling success (Windsor 1977), flush duration of adult raptors off the nest has not been well quantified (Fraser *et al.* 1985). In the few studies that have examined raptor responses at specific aircraft approach distances, flush rates (percent flushed at each distance) were high if the raptors were naive (Platt

1977). In studies reporting stimulus approach distance, over 60% of the birds flushed at 50 m or less (Carrier and Melquist 1976, Anderson *et al.* 1989). Some species are very difficult to flush, particularly incubating and brooding bald eagles (Craig and Craig 1984, Fraser et al. 1985). Mexican spotted owls exposed to military helicopters flushed more frequently as distance to overflights decreased, but no flushes were recorded until the post-fledging period. In 58 helicopter overflights, 7 flushes resulted in 0% spotted owl response beyond 105 m, 14% within 105 m, 19% within 60 m, and 50% within 30 m (Delaney *et al.* 1999).

Holthuijzen *et al.* (1990) found similar prairie falcon flush rates during construction blasting and controlled blasting events. Falcon reactions to blasting also decreased as the breeding season progressed. One important determinant of habituation is the amplitude of the stimulus. Higher vertebrates exhibit an acoustic startle, an innate physiological and behavioral response to a loud noise with a rapid onset rate (Peeke and Herz 1973). At some stimulus levels the startle cannot be eradicated completely by habituation (Hoffman and Searle 1968). The startle response is a powerful mechanism for avoiding predators, so some degree of startle is always likely after a sufficiently loud sound. The effect of a startle can be severe if it results in flushing a female from the nest for an extended period of time. The most severe startles occur when a bird is approached within 10-50 m from above without warning (Fyfe and Olendorff 1976).

Recovery times (i.e., the time for the bird to return) for raptors following a flush from the nest are rarely reported. Holthuijzen *et al.* (1990) calculated a mean recovery time of 6.5 min for prairie falcons flushed by blasting noise. Overt behaviors in ospreys responding to helicopters, float planes, and pedestrians diminished within 5 min of these events (Trimper *et al.* 1998). Most raptor responses last less than 1 min, with a median recovery time of 4.5 min (Awbrey and Bowles 1990). Delaney *et al.* (1999) discovered nesting Mexican spotted owls required 10-15 min to return to pre-manipulation levels of ambient behavior after helicopter overflights. Median response duration for bald eagles to aircraft was 1 min, with no difference between aircraft types, while median response duration to pedestrian activity was 8 min (Grubb and King 1991).

Raptors may become sensitized or habituated to human intrusion (Fraser *et al.* 1985). Grubb *et al.* (1992) found a pair of bald eagles nesting near a military air base experienced the most human activity of 6 nest sites in northcentral Michigan but showed the least response. In areas with a low overflight frequency, nesting red-tailed hawks exposed to helicopter flyovers tended to flush, whereas in other areas with frequent flyovers, the hawks exhibited little or no response (Andersen *et al.* 1989). A population of bald eagles on the lakes of Voyageurs National Park in northern Minnesota has been exposed to heavy boating recreation for years, but has continued to thrive and grow. Research has shown these eagles are relatively tolerant of aquatic disturbance up to a threshold, beyond which typical response behaviors occur (Grubb *et al.* 2002), suggesting despite habituation, there remains a threshold beyond which the tolerated activity may become disruptive. In studying the effects of camping near bald eagle nests in Alaska, Steidl *et al.*(2000) reported short term desensitization to disruption of normal behaviors over 48 h test periods; however, that desensitization was not cumulative or retained across 3-4 week intervals between trials. Each period of habituation was independent of the next exposure.

Despite the fact that raptors may be able to habituate, if exposed to human disturbance during times of low prey densities, stress levels are increased and the effects of human disturbance may be exacerbated. Normal perching, hunting, and flight behaviors of hawks, falcons, and eagles within a military training area in Idaho were significantly altered during years of low prey densities (Schueck *et al.* 2001). Similarly, species on the periphery of their breeding range, elevationally or latitudinally, are more vulnerable to the effects of environment, prey availability, and competition (Newton 1979). One way to compensate for the lack of resources in these circumstances is to have larger breeding areas or home ranges. Disturbance may cause a similar accommodation. Andersen *et al.* (1990) observed that several species of Buteo hawks, as well as nesting golden eagles, in southeastern Colorado made more out-of-area flights, shifted centers of home ranges away, and increased size of those home ranges in response to military training activity, which included helicopter overflights.

In summary, this abbreviated literature review clearly shows that assessing the effects of human disturbance on raptors, or wildlife in general, is a complex, multivariate problem, with highly variable results depending on the circumstances and characteristics of both the stimulus, or anthropogenic activity, and the responding target species. In their Utah Field Office Guidelines for Raptor Protection from Human and Land Use Disturbances, Romin and Muck (2002) recommend generic 0.5 mi (800 m) buffers with a 1000 ft (300 m) AGL minimum for aircraft passing overhead but describe these guidelines as "optimal stipulations" that are not site-specific. Critical considerations for determining site- or circumstance-specific buffers include type and duration of the proposed activity, position of topographic and vegetative features, habituation of breeding pairs to existing activities, and local population density. In addition, buffer distances are adjustable (none, half, full) depending on timing, type, and frequency of the potentially disturbing activity. The National Bald Eagle Management Guidelines published by the FWS (2007), also stated to include golden eagles, recommend 1000 ft as a buffer for helicopters around bald eagle nests during the breeding season *except where eagles have demonstrated tolerance for such activity*, 330 ft (100 m) for off-highway vehicles (OHVs) and foot traffic, and 660 ft (200 m) to buffer such activities as construction, mining, drilling, shoreline development.

Although the golden eagle is neither threatened nor endangered, most resource agencies in assessing disturbance accept the ESA definition of "*take*" which means to "harass, harm, pursue, hunt, shoot, wound, kill, poison, capture, collect trap, molest, or disturb, or to attempt to engage in any such conduct." "*Harass*" is further defined by the FWS to include an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The BGEPA, as quoted again in the 2007 Bald Eagle Guidelines, explicity defines "*disturb*" as meaning "to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

STUDY AREA

Location - The primary study area was located on the Wasatch-Cache National Forest, and to a lesser extent on the Uinta National Forest to the south, in the central Wasatch Mountains, immediately east of Salt Lake City, Utah, in Salt Lake, Utah, and Wasatch counties (Figures 1 and 2). The focus of this research was on the Tri-Canyon Area, which includes Little and Big Cottonwood Canyons and Mill Creek Canyon. However, the region from Parley's Canyon on the north to Provo Canyon on the south was also considered part of the general Tri-Canyon Area for surveying and monitoring purposes. Secondarily, for the experimental helicopter testing, the research area was expanded to include active golden eagle nests in Tooele and Box Elder counties, to the south and west of Salt Lake City, and west of the Great Salt Lake (Figure 3).

General Environment - Two of the 3 physiographic provinces found in Utah are included within this broader study area: the Basin and Range Province, which includes lower elevation Salt and Northern Desert vegetation types found in the Lakeside and Grassy Mountains, and the Rocky Mountain Province, which includes Upper and Lower Montane vegetation types found in the higher mountains of the Wasatch Front, including portions of the Tri-Canyon Area. Plants range from Upper Sonoran sagebrush (*Artemisia* spp.) grasslands, through Transition (Foothill) sagebrush, juniper (*Juniperus* sp.), and pinyon pine (*Pinus edulis*), to Canadian (Montane) pockets of aspen (*Populus tremuloides*), spruce (*Picea* spp.)and fir (*Abies* spp.) at higher mountain locations. Interior basins are commonly around 4,000 to 5,000 ft above sea level with mountainous terrain ranging as high as 10,000-12,000 ft in elevation (Utah History Encyclopedia, historytogo.utah.gov website). Centrally located within the heart of this study area lie the Salt Lake Valley and Wasatch Front (Ogden to Provo) with a rapidly growing population of more than 1.7 million people (Travel and Visitor Center at saltlakecityutah.org).

Figure 1. A map of the Central Wasatch Mountains, Utah, showing the extent of Wasatch Powderbird Guides heli-skiing operational areas permitted by the Forest Service. The Tri-Canyon primary study area includes Little Cottonwood Canyon (forming the boundary between Lone Peak and Twin Peaks Wilderness areas), Big Cottonwood Canyon (forming the boundary between Twin Peaks and Mount Olympus Wilderness areas), and Mill Creek Canyon (forming the northern border of Mount Olympus Wilderness). Parley's Canyon is the next canyon to the north; and Provo Canyon to the south lies between the Mount Timpanogos Wilderness and Cascade Mountains (Figure courtesy of Wasatch-Cache and Uinta National Forests, Final Environmental Impact Statement: Wasatch Powderbird Guides Permit Renewal, October 2004).

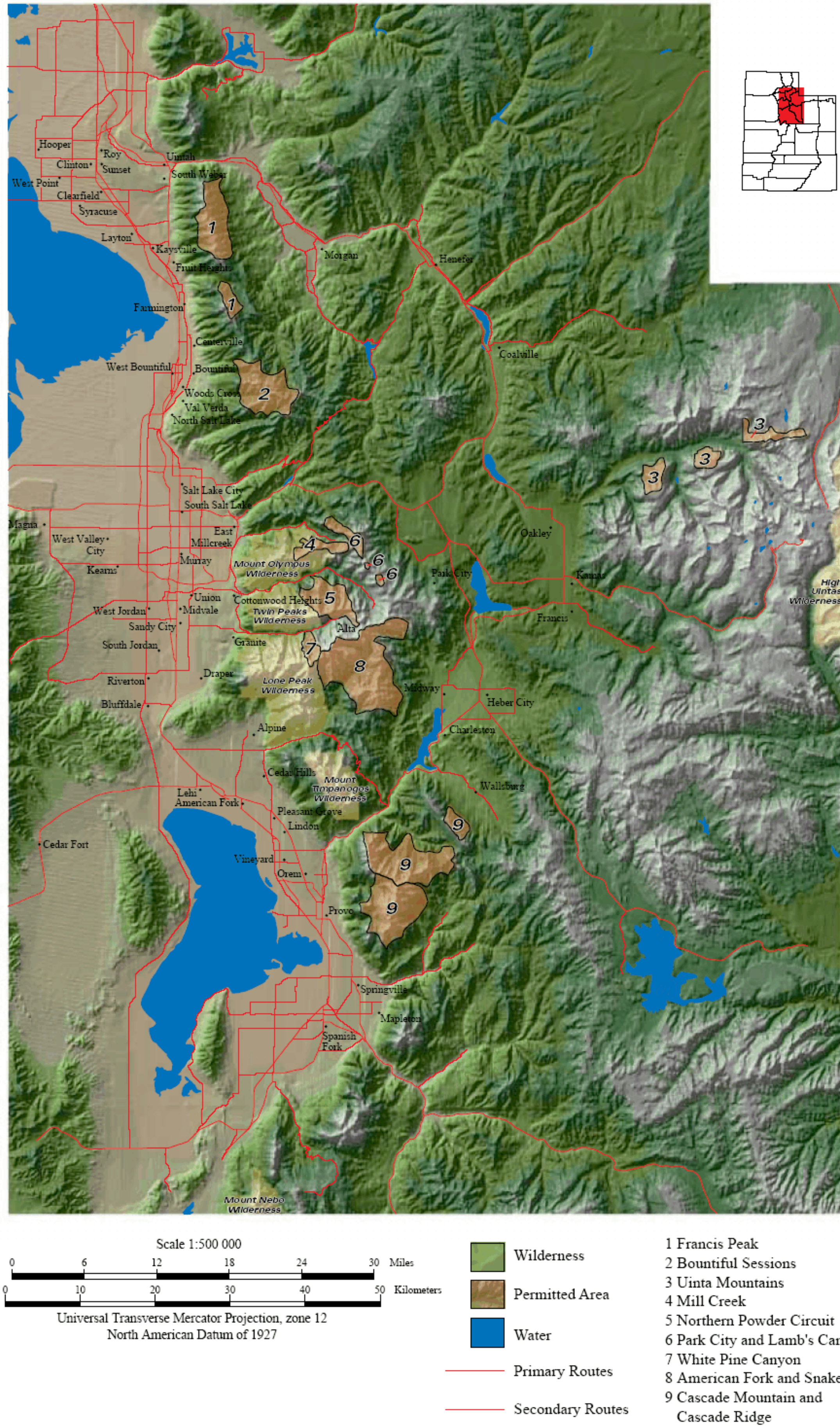


Figure 2-1 Permitted helicopter skiing circuits.

Figure 2. A map of the Tri-Canyon Area of the Wasatch Mountains, Utah, showing wilderness areas, Wasatch Powderbird Guides permitted heli-skiing operational areas, and designated ski areas (Figure courtesy of Wasatch-Cache and Uinta National Forests, Final Environmental Impact Statement: Wasatch Powderbird Guides Permit Renewal, October 2004).

Figure 2-2 Permitted helicopter skiing terrain in the Central Wasatch Mountains.

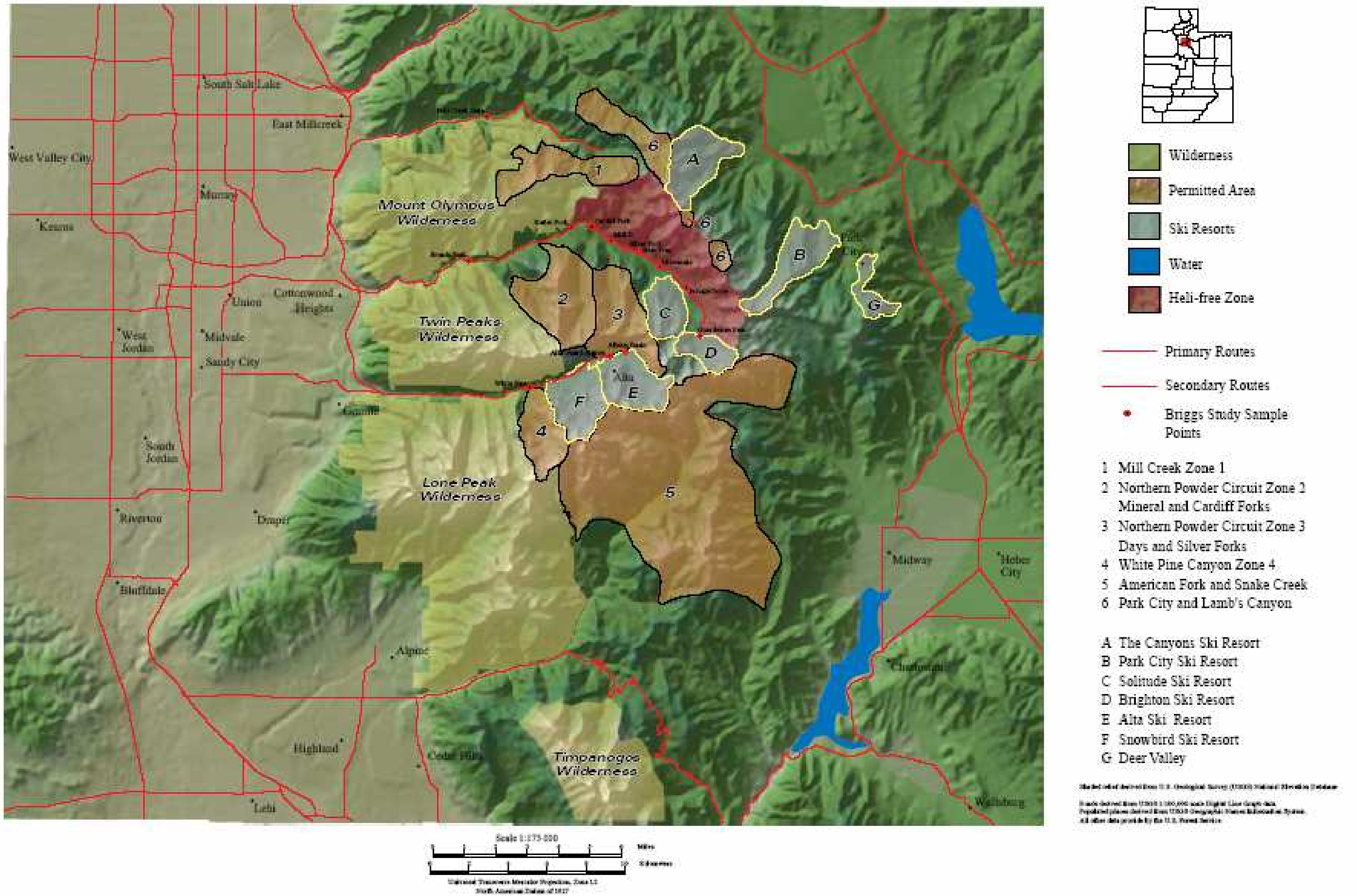
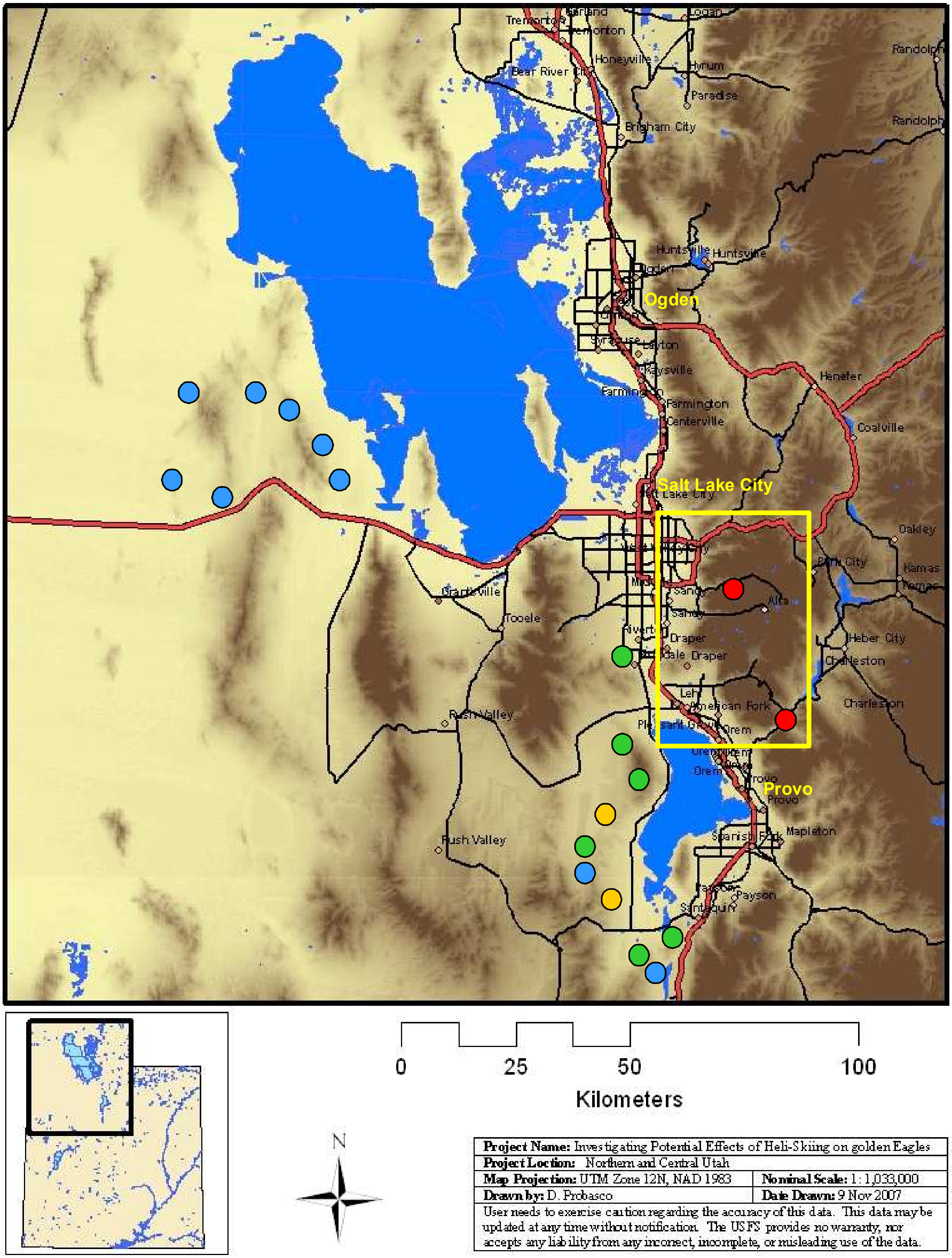


Figure 3. A map showing the distribution of Apache helicopter-golden eagle test sites in northcentral Utah, with the area from Parley's Canyon to Provo Canyon, including the Tri-Canyon Area, outlined in yellow, and colored circles marking approximate test locations: green sites were included in 2006 and 2007 experimentation; blue sites, in only 2007; yellow sites, in only 2006; and red sites were tested only once in 2007.



Tremonton
Logan
Honeyville
Bear River City
Hyrum
Paradise
Brigham City
Randolph
Huntsville
Ogden
Layton
Kaysville
Farmington
Centerville
Henefer
Coalville
Salt Lake City
Oakley
Park City
Kamas
Sandy
Alta
Draper
Heber City
Charleston
Grantsville
Tooele
Lehi
American Fork
Orem
Provo
Rush Valley
Spanish Fork
Mapleton
Payson
Santaquin
0
25
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100
Kilometers
N
Project Name: Investigating Potential Effects of Heli-Skiing on golden Eagles
Project Loction: Northern and Central Utah
Map Projection: UTM Zone 12N, NAD 1983
Nominal Scale: 1:1,033,000
Drawn by: D. Probasco
Date Drawn: 9 Nov 2007
User needs to exercise caution regarding the accuracy of this data. This data may be updated at any time without notification. The USFS provides no warranty, nor accepts any liability from any incorrect, incomplete, or misleading use of the data.

METHODS

Recreation and Other Tri-Canyon Area Activities

To help establish the context for WPG operations in the Tri-Canyon Area, we collected data from a variety of sources, detailed below, on levels or recent trends in recreational use, avalanche control, population growth, and other helicopters operating in the area.

Ski Area Visitation - Snowbird and Alta in Little Cottonwood Canyon, and Brighton and Solitude in Big Cottonwood Canyon provided data on skier visitation, 1984 to 2005.

Utah Transit Authority (UTA) - UTA provided data on the number of passengers using various ski bus routes accessing the Cottonwoods, from 1987 through 2005.

Utah Department of Transportation (UDOT) - UDOT provided average daily counts of vehicles by month for Little and Big Cottonwood Canyons between 1996-2005.

Avalanche Control Data - UDOT also provided number and type of charges/ammunition, locations, and means of projection from 1984 through 2005 for the Cottonwoods. No current avalanche control data were available from the 4 major Ski Areas in the Cottonwoods. Data from the 1999 FEIS: Wasatch Powderbird Guides Permit Renewal were the most recent figures available to approximate current levels of avalanche control in these Ski Areas.

Mill Creek Fee Booth – The FS Mill Creek Fee Booth provided data for 2002 through 2005 on vehicle counts, broken down by occupant or destination category.

Salt Lake Area Population Growth - Current population size and recent growth trends for the Wasatch Front and greater Salt Lake City metropolitan area were obtained from the Internet using the CensusScope.org and the Travel and Visitor Center (saltlakecityutah.org) websites, as well as data from Census 2000.

Helicopters in Tri-Canyon Area - All civilian organizations flying helicopters within the Tri-Canyon Area were contacted for information on the type of aircraft being used, frequency of flights in the area, and general areas of operation: LifeFlight, AirMed, KUTV Channel 2, KSL Channel 5, Aero Bureau of the Utah Department of Public Safety, Classic Helicopters, Park City Helicopters, and Cirque Lodge. Response was limited and variable, and specific types and number of aircraft may have changed by the time of this report. However, the data are thought to be representative. WPG was not included in this summary.

Unfortunately, because of an unexpected change in research personnel between 2006 and 2007, in combination with limited time and resources during the second field season, no further data on recreation and human use trends were collected in 2007. Plans were aborted that would have included a) conducting a blanket mailing to retail ski and snowboard shops in the Salt Lake City area requesting information on recreational use and recent sales trends; b) pursuing contacts with the Sheriff's Department for Tri-Canyon Area rescue data and recent user trends; c) exploring indirect measures of backcountry use such as hiking, climbing, backcountry snowshoe/ski, and snowmobiling published maps, routes and/or websites; and d) adding another 1-2 years to existing data sets in order to bring trends current.

Golden Eagle Surveying and Monitoring

Field Surveys - As many of the historical sites as possible between Parley's and Provo Canyons were visited on the ground, via vehicle, foot, snowshoe, and cross country or alpine ski. Spotting scopes and binoculars were used by 1-3 observers for 2-6 h at each site, during multiple visits to most sites, to determine site occupancy and nesting activity.

Test Site Surveying and Monitoring – Kent Keller surveys and monitors over 200 golden eagle territories in central Utah each spring as part of a long term study begun in 1977. Based on his familiarity with site histories, current nesting status, and general accessibility, he helped with selection of potential test sites along the west side of Utah Lake and in the Goshen Valley in 2006 and additional sites in the Lake and Grassy Mountains west of the Great Salt Lake in 2007. Keller monitored all test sites before and after our experimentation with helicopters. In addition to the initial guided visit and actual days of testing, research personnel revisited all test sites 2-4 times to plan observation points, microphone positions, and helicopter flight paths.

With the notable exception of Mineral Fork and Reed & Benson (via Cardiff Canyon), survey and monitoring efforts beyond the Apache helicopter test sites were de-emphasized during the second field season due to limited time, funds, and personnel. Under these constraints, the logistically difficult and often time consuming surveying required a disproportionately high, and therefore impractical, use of limited resources.

Mitigation Flights – "Monitoring of all golden eagle nest sites will be conducted twice a year by aerial surveys to determine nest occupancy and the number of young produced. The first survey will be conducted during the early part of the incubation period, and the second, follow-up survey will be conducted in the latter half of the nesting period, when eaglets are large enough to be seen and counted from the air. Standard aerial survey protocols will be followed, and minimal time will be spent over the nest sites to minimize potential disturbance" (Wasatch Powderbird Guides Operating Plan 2005-2010). In the past, these mitigation flights have traditionally been scheduled for the first week of February and first week of April. In 2006, research personnel accompanied the SLRD biologist on mitigation survey flights of the historic Tri-Canyon Area nest sites on 9 February and 19 April. During these flights several other reported nest sites in the Cottonwoods were also surveyed. Research personnel did not participate in 2007 mitigation flights.

Historical Record Search - Historical golden eagle nesting records for the Tri-Canyon Area are sketchy at best. Until 1999, coverage was limited, voluntary, and not a priority among resource agencies. Historic golden eagle sightings and records of nesting activity in the Tri-Canyon Area were compiled from files at the Salt Lake Ranger District (SLRD) relating to the 1999 and 2004 Final Environmental Impact Statements, background analyses, for permitting WPG operations. Sources included both FS and a variety of civilian observers (including Ellie Ienatch, Steve Schuler, and Kent Keller). Some historic sightings were also taken from WPG records. Keller provided historical nest site and nesting activity data for several additional sites between Parley's and Provo Canyons.

Unfortunately, the data compiled in 1999 and 2004 by the USFS are inherently ambivalent and unclear as to exactly what happened at the various Tri-Canyon Area nest sites each nesting season between 1981-2003. Although dedicated, conscientious, and enthusiastic, some early observers (both FS and civilian) were apparently unfamiliar with standardized terminology for recording and reporting raptor reproductive performance (Postupalsky 1974, The Wildlife Federation 1987). Nesting, nested, and nest attempt, all appear to have included behaviors more properly described as presence and attributed to an "occupied" nest. Egg-laying, which defines an "active" nest, is required for confirmation of an actual nesting attempt, or nesting. (See definitions below.)

Additionally, Mineral Fork, Reed & Benson North and South, Silver Fork, and Honeycomb were all assumed to be alternate nests occupied by 1 "Big Cottonwood" pair of nesting golden eagles, with American Fork representing the only other pair of concern in the Tri-Canyon Area. However, almost certainly these nest sites represent at least 4 separate golden eagle breeding areas (pers. obs.; Kent Keller, pers. comm.). The 2 Reed & Benson sites being in the same drainage and <1 mi apart are likely alternates for 1 pair; but it would be highly unusual for 1 pair of golden eagles to have alternate nests in entirely different drainages, miles apart, especially in such high-relief terrain where intervening ridges serve as natural territory boundaries.

This multiple territory concept has several direct confirmations including: a) simultaneous observations of pairs of eagles in separate drainages in some of the early surveying and monitoring notes in the SLRD EIS background files; b) several observations of territorial, boundary-marking, undulating flights by different eagles above the Mineral Fork and Reed & Benson Ridges, which can imply territorial boundaries; and c) an immature male as part of the 2006 Mineral Fork pair while paired adults were observed on more than 1 occasion at Reed & Benson South. Nonetheless, the errant assumption that there was only 1 pair to be located and monitored during the early years leaves uncertainty as to the status of the other sites away from where eagles were first observed.

WPG Historical Records/Trends

Historical Records - Data were compiled from 34 years of WPG records, 1974-2007, on numbers of operating days, ski runs, guests, helicopter drops, lifts (groups) per drop, and helicopter operating time per day.

To test the hypothesis that heli-skiing operations preclude golden eagle nesting within the same drainage, we determined the number of individual helicopter flights within the same drainage for the 6 years from historic records, plus the 2 years of this study, when golden eagle nesting was confirmed within the Tri-Canyon Area.

WPG flights were not calculated for any other years than these 8 when chicks were present because: 1) confirmed nesting, i.e. egg-laying or incubation, is undocumented for any other "nest attempt" years; 2) subsequent success or failure for most of those sites is unknown; and 3) any myriad of other factors could have influenced whether there was nesting or not, and whether a site was successful or not, even if it was active. The only remaining absolutes are the years with young, which are significant because after hatching, whatever potentially disturbing activities that may have occurred beforehand have a diminishing likelihood of effecting ultimate nesting success. Furthermore, to underscore the conservative nature of this approach, hatching at elevations typical of the Tri-Canyon Area nest sites does not occur until about 4-6 weeks following the 15 April end of the WPG operating season. During that period, those same myriad "other" factors could have caused nesting failure independent of any helicopter activity.

Helicopter Flights and Trend Variables - To calculate flights, the number of WPG runs in each nest drainage for any given year was multiplied by 4, because for each recorded run, there was: first, a drop-off at the top of the run with 1 approach flight and 1 departure flight; and second, a pick-up at the bottom of the run with 1 approach flight and 1 departure flight. Since ~70% of WPG's runs involve 2 lifts, or helicopter loads, per drop-off and pick-up (Rusty Dassing, pers. comm.), that total was multiplied by 1.7.

Operating days per year, skier days per year (8 runs by 1 skier comprise a skier day), and total helicopter time per year were used to show annual variation and long term trends in WPG operations between 1974-2007. Because the focus of concern relating to potential golden eagle disturbance has been centered on the helicopter dimension of heli-skiing, operating days and helicopter time, as well as numbers of helicopter flights used above, are more direct measures of that potential impact than skier days. Skier days were not included in the same drainage as historic nesting analysis.

Combined Helicopter Methods

Study Design - We recorded golden eagle responses to 4 different groupings of helicopters: Utah National Guard Apaches, WPG's AStars and Bell L4, Cirque Lodge's Eurocopter, and other civilian helicopters. We recorded data actively, i.e. with controlled experimental flights plus observations from mitigation survey flights, and passively, i.e. opportunistically as circumstances presented. Examples of the latter group include extra passes by Apaches, usually coming or going to or from other test sites; observations of WPG operations in same drainages where eagles were being observed independently; and occasions when civilian helicopters flew near nests being watched for Apache trials. The initial priority was to passively observe WPG operations whenever and wherever golden eagles were present, but this soon proved to be an unviable approach due to the emphemeral and unpredictable nature of such opportunities. As discussed elsewhere in this report, we discovered minimal overlap between WPG's operations and nesting golden eagles. Therefore, emphasis was shifted to maximizing Apache experimentation at lower elevation active nests, where overflights could be planned and controlled, and eagle presence was assured until well into the nestling phase of the nesting cycle.

Testing after incubation has been established does not address the concern that helicopter activity prior to egg-laying, i.e. during courtship and nest repair, may disrupt or preclude subsequent nesting. Within the scope of this study, the passive data for WPG flights in the vicinity of Tri-Canyon Area active nest sites address this issue. However, even if testing with Apaches or WPG were to be scheduled during pre-nesting courtship and nest repair, collecting meaningful data would remain improbable because breeding eagles' presence is never certain nor predictable, nor is their location within the nest area, making it nearly impossible to reliably coordinate test overflights. On the positive side, nearly all of the nest sites selected for testing should have been naive to helicopters in general, and certainly to the proximity and frequency of test flights.

Units of Measure and Definitions - For the purposes of all data summaries and analyses that follow, an observation, or helicopter-golden eagle response data point, is defined as 1 helicopter pass by 1 eagle. Thus, for example, 1 helicopter flying past an incubating eagle on the nest and an attendant male perched nearby would count as 2 observations, passes, or data points. For the frequency distributions of test distances and of eagle nest status, activity, and response by helicopter type, we tallied total observations for all helicopters (N=303). For the sections dealing with the Apache testing, only data from the Apache trials were included (N=227). In this report 1 meter (m) is considered equivalent to 1 yard (yd). Elevations and altitudes (AGL) are reported in feet (ft) for ease of interpretation, consistent with conventional useage. Definitions for the terminology describing golden eagle nesting status, ambient activities or behaviors, and responses to helicopters are listed in Table 1.

Aircraft Types - Four specific types of aircraft were used in this study: the Utah National Guard AH-64 Apache attack helicopter; WPG's Eurocopter AS350-B3s (AStars) and Bell 206L4 Longranger; and Cirque Lodge's Eurcopter EC130-B4 (Figures 4-7, respectively). WPG leases its helicopters seasonally from Classic Helicopters, Woods Cross, Utah. During 2006-2007, WPG operated two AStars, and only used the Bell L4 late in the 2006 season when one of the AStars was deployed elsewhere. The AStars are currently WPG's primary aircraft. Sound levels associated with each of these 4 aircraft were measured to provide a means for relative comparison (see Sound section below). Table 2 shows comparative gross specifications, and illustrates how much larger, heavier, and more powerful the Apache helicopter is than WPG's AStars or Bell L4.

Table 1. Terminology used in describing golden eagle nesting status, activities, and responses recorded during helicopter passes near active eagle nests in northcentral Utah, 2006-2007.

Terminology for Golden Eagle Nesting Status, Activities, and Responses	
Nest Status	
Eggs	- Incubation phase of nesting cycle.
Chicks/Young	- Nestling phase, between hatching and fledging.
Golden Eagle Activity	
Copulating/Mating	- When male mounts perched female briefly, then typically flies off.
Incubating	- Low on the nest, warming and protecting eggs, performed by both members of nesting pair, but predominantly by the female.
Brooding	- Higher in the nest than incubating, warming and protecting young chicks. Usually only occurs while young are very small.
Standing at nest	- When attending adult remains on nest with chicks, but stands off to side. Common as chicks get older, or during warm weather.
Tending young	- Includes feeding young when discernible, or otherwise 'poking into center of nest' after hatching.
Tending nest	- Includes 'house cleaning' or removing old prey items from nest, plus manipulating nest materials.
Preening	- Self-grooming activities including preening feathers, scratching, stretching, etc.
Prey delivery	- An eagle returning to the nest carrying a prey item.
Nest exchange	- When 1 eagle returns to nest and changes places with attending eagle, which then departs. Common during incubation.
Returning	- Used to describe an eagle returning to an unattended nest, which can occur after young are old enough to be left alone.
Perching	- Used for eagles not on nest, either 2nd member of pair or eagles observed elsewhere.
Soaring/flying	- Usually an activity of 2nd pair member near nest, sometimes both eagles, often associated with nest exchange, also applied to eagles observed elsewhere.
Out of view	- Recorded when eagles in area immediately before or after, but out of observer's view during recorded event.
Golden Eagle Responses	
None	- No interest, reaction, response, nor any apparent deviation from previously observed ambient behavior.
None observed	- Distinction for those times when eagle on nest not fully in view, or any other eagles were out of view. On nest, subtle movements may not have been discernible but the absence of a flush or exaggerated body movements was clearly evident.
Glance	- A brief, quick, literal glance, and immediately focusing attention elsewhere. Totally casual, disinterested response.
Look	- A longer, more directed view, slower to change focus of attention. A response that reflects at least passing interest.

Terminology for Golden Eagle Nesting Status, Activities, and Responses

Track	- A look that extends into following the stimulus movement, with a clear turning of head to compensate. Suggests concentrated, focused attention, but indiscernible whether a result of boredom, fascination with the movement, or an indication of alert concern.
Flatten	- Protective, defensive measure taken by a brooding or chick-attending eagle standing on nest, where the eagle literally flattens out across nest, covers young, with head, tail, and body low, to the extent that it nearly disappears from a lateral viewpoint.
Fly	- Taking flight from nest or perch, no implied distinction between disturbed and undisturbed flight. However, as documented in following sections, most fly's recorded during helicopter tests appeared to be less startled "flushes" than where the helicopter simply precipitated an imminent departure.

<u>Additional Terms</u>

Breeding area	- Identifies entire area used by nesting eagles including active nest site, alternate unused nests, defended territory, and surrounding area frequented during normal diurnal activities.
Territory	- Defended area around an active nest site, usually includes alternate nests, sometimes used to represent breeding area..
Nest site	- Commonly used to represent breeding area or territory.
Nest	- Specific structure where eggs are laid and chicks raised.
Occupied	- Breeding area, territory, or nest where eagles are present.
Active	- Breeding area, territory, or nest where egg laying and/or incubation are confirmed.
Successful	- Breeding area, territory, or nest where chicks successfully fledge.
Fledging	- Term for chicks successfully flying from nest.
Attending	- Eagle on nest, or perched nearby if only adult present.
Non-attending	- Usually male, pair member not on nest, or observed elsewhere.

Figure 4. Utah National Guard AH-64 Apache Attack Helicopter.

Figure 5. Wasatch Powderbird Guides Eurocopter AStar B3s (AS350-B3).

Figure 6. Wasatch Powderbird Guides Bell 206L4 Longranger.

Figure 7. Cirque Lodge's Eurocopter EC130-B4 with fenestron tail rotor.

Table 2. Comparative specifications for the 4 helicopter models used to fly near golden eagle nests in northcentral Utah, 2006-2007.

Specification	**AH-64 Apache**	**Eurocopter AS350 B4**	**Eurocopter EC130-B4**	**Bell 206 L4**
Rotor length (ft)	48.0	35.1	35.1	37.0
Fuselage length (ft)	49.4	35.9	35.0	36.4
Overall length with both rotors (ft)	58.0	42.5	41.5	42.4
Empty weight (lbs)	11,387	2,707	3,018	2,327
Powerplant	twin turboshaft	single turbine	single turbine	single turboshaft

Apache Helicopter Testing

Apache Test Patterns - Working with the Utah National Guard 211th Aviation Attack Helicopter Unit, we were able to develop a controlled testing program to evaluate potential effects of Apache helicopters near nesting golden eagles. A comparison of size and sound characteristics between the AH-64 Apache helicopter and the AStar's and Bell operated by WPG are presented in Table 2 above, Table 17 and Figures 20 and 21 in the Results section below. The test scenario for the Apache was also designed to as closely as practical simulate the timing and duration of typical WPG backcountry operations (see Tables 13 and 14 in Results section). We began in 2006 with an array of distances starting with the 800 m current buffer recommendation, then testing 400 m, 200 m, and 100 m. All flights were flyby's, i.e. flight paths were preplanned to take the aircraft on a course parallel to the nest cliff at the predetermined distance from the nest, at an altitude equal to or slightly above the nest elevation. Apache helicopters were scheduled to fly past 4 nest sites on a circuit, with 2 passes per visit, then the circuit was reflown a second time with 2 more passes per nest. In 2006, 8 active nest sites were scheduled to be flown, west and south of Utah Lake (Figure 3), 4 sites per day, 2 days per week for 2 weeks between 11 April-20 April. We accomplished 15 of the 16 scheduled tests in 2006.

In 2007, 100, 200, 400 and 800 m distances were again tested with flyby's, but 2 more aggressive test patterns were added - approach's and popout's. During an approach, the experimental helicopter flew straight toward the nest on a course perpendicular to the nest cliff, from a point 800 m in front of the nest to a point 800 m behind it, passing directly over the nest just above cliff height. During a popout, the experimental helicopter flew on a course perpendicular to the nest cliff, from a point 800 m behind the nest to a point 800 m in front of it, passing directly over the nest just above cliff height, popping out suddenly from behind. Unlike flyby's, approach's and popout's were only flown once during each circuit. Testing ran between 3 April-26 April, following the same pattern of 4 sites per day, 2 days per week, but in 2007, there were 4 weeks of testing. Six nest sites from 2006 were tested again in 2007, with 2 new sites added to replace the 2 that were not active in 2007. Eight additional sites were added from the Grassy and Lakeside Mountains west of the Great Salt Lake (Figure 3) to expand our sample size. Unfortunately 1 site was vandalized by sheepherders before our first test and had to be dropped. We accomplished 31 tests in 2007. In total, over the 2 year study, we tested 19 golden eagle nest sites with Apache helicopters, with the addition of single trials during the last week of testing in 2007 at Mineral Fork, and a Provo Canyon nest site previously exposed to only the Cirque Eurocopter.

Within limitations of practicality and unforeseen schedule modifications, we tried to randomize the assignment of test distances among nest sites. We also tried to avoid repetition of the same test distance at any given site within the same season. Actual distances between the helicopter and nests sometimes deviated from what was planned because of miscommunication, errors in navigation points, and variable flight conditions. Our final analysis distances were adjusted accordingly. In addition, there were occasionally fewer, but frequently more than the scheduled number of passes, the latter often a result of the helicopter maneuvering into position for test patterns, as well as flying to and from other test sites. The number of passes, or observations, also increased when >1 eagle was present, as each eagle was recorded separately. There were a total of 227 controlled, experimental passes of Apache helicopters near nesting golden eagles, with 89 in 2006 and 138 in 2007.

Observing Golden Eagle Responses - In order to monitor golden eagle behavior patterns before and after helicopter exposures, observers with spotting scopes were located at each nest site, where they recorded eagle ambient activities for at least 1 hour prior to the first scheduled helicopter test, monitored activity during and between tests, and then continued to record eagle activity for at least 1 hour following the helicopter's final departure from the test site. Most field notes were orally recorded in real time on digital tape recorders (DATs) with internal clocks synchronized among all test site and sound recording units. Observers were asked to record eagle behaviors and helicopter flight characteristics according to the checklists shown in Tables 3 and 4. This approach facilitates using manipulated sites as their own controls for measuring frequency, type, and severity of behaviors before, during, and after experimentation. One casualty of limited resources and personnel was only having 1 observer per test site, who had to concentrate on eagle behavior, whereas a second observer would have facilitated better information on helicopter maneuvers.

Variable Grouping - Variables used to describe nest status, golden eagle activity and responses are defined in Table 1 above. For most of the Apache data analyses, responses were regrouped into 3 or 4 categories: none and none observed combined into none; glance, look, and track combined into watch; with flatten and fly remaining separate or combined into respond. To consolidate small or single samples into meaningful groups for the Apache analyses, several recorded distances for all helicopters were also grouped at 2 intervals: 900 and 1200 m were combined at 1000 m; and 1800 and 3000 m were combined at 2000 m. Both of these groupings were well beyond the range of any expected significant response so should not have influenced results.

Test Week Analyses - We analyzed variation in response rates by test week in 2 ways. First strictly by exposure, i.e. combining the 1st trial weeks and the 2nd trial weeks for all sites regardless of dates. In 2006 these weeks were consecutive, in 2007 there were 2 weeks between 1st and 2nd trial weeks. The second way combined test weeks by their occurrence during the month of April. In 2006, testing occurred the 2nd and 3rd weeks of the month; in 2007, testing occurred through all 4 weeks of the month. Thus the 2nd and 3rd weeks for both years were combined. As a result the 1st and 2nd weeks in this analysis represented 1st exposure weeks, and the 3rd and 4th weeks were 2nd exposure weeks.

Software and Data Analyses - Microsoft Excel 2002 (Microsoft, Inc.) spreadsheet analytical tools and SPSS 10.1 (SPSS, Inc.) were used to calculate quantitative data summaries, frequencies and exploratory crosstabulations. All charts but the sound graphs, which were created in Sigma Plot (Systat Software, Inc.), were also created in Excel. Terrain Navigator 2001 (Maptech, Inc.) was used to plan helicopter flight paths, print field and flight coordination maps, and facilitate distance measurements of flight paths, microphones, and observer positions after the field tests.

Table 3. Behavior checklist for recording responses to experimental Apache helicopter testing near nesting golden eagles in northcentral Utah, 2006-2007.

Golden Eagle Behavior/Response Checklist
Reference Eagle(s) Nesting, i.e. incubating or brooding, remains on nest at length Nest Attending, i.e. perched close to nest when no eagle on nest, <50 m Sentinel A, perched >50-100 m from nest or flying, usually the male Sentinel B, later in season both adults will typically be found away from nest **Location** ***On the Nest*** Orientation, i.e. compass alignment of body axis, eg. head NW-tail SE ***Off the Nest*** On a perch Flying Relative to nest (distance, direction to or from the nest, relative height from the nest) **Behavior** ***On nest or perch*** Preening Fluffing Defecating Stretching Scratching Gaping/panting Casting Head turn (directions) Stand up Feeding self/young Changing positions on nest Poking around nest with head down Rolling eggs or manipulating small chicks Rearranging nest material ***If flying*** Soaring Directional flight Displaying, i.e. undulating flight Direction and distance relative to nest

Golden Eagle Behavior/Response Checklist

<u>Responses</u>

- Flatten body position on nest, hunker down
- Repositioning on nest or perch
- Tracking, i.e. head will gradually turn to follow stimulus movement
- Orienting, i.e. a change in body position clearly toward or away from stimulus
- Vocalizations
- Flush (distance of flush, direction of flush, duration of flush)
- Direction relative to helicopter
    - Fly towards, away, with, beside, or stoop/attack
- Change in type of flight
- Undulating flight
- OOS (Out of Sight)

Table 4. Helicopter flight data checklist for recording experimental Apache helicopter testing near nesting golden eagles in northcentral Utah, 2006-2007.

Helicopter Data Checklist

Record best estimates, map on provided topo sheet, and/or draw separately the following, after the fact, as accurately as possible for each flight test (usually 2 separate flight tests per site per day, each consisting of 2 passes), using all available landmarks, terrain features, etc., as cues.

Flight path

- Into and out of the nest area
- Path of flight while in the nest area
  - May be either circles [first 2 test days in 2006] or straight line [all subsequent test days 2006 and 2007] – if vary among individual passes, show separately
- End result should be continuous line on a map for any given flight test

Distance

- Particularly interested in closest distance to nest during flight test
- Any other distances relative to nest or terrain features helpful
- Estimate in yards or meters (for this study both considered to be 3 ft)

Altitude

- Difficult, but often can relate to nearby terrain features
- Estimate in feet above ground level
- Also may vary during course of test, record where can, but again most valuable to know altitude when nearest the nest

Duration of flight near nest

- Note time approaching helicopter is first heard by observer, AND
- Time when departing helicopter is last heard

Regardless if it is not possible or there is insufficient information to map flights, try to describe as many details as possible onto the DAT note tape while recording eagle behaviors.

Sound Analysis

Sound Measurements - Sound was measured during our controlled, experimental testing with Utah National Guard AH-64 Apache helicopters in an effort to determine noise levels to which nesting golden eagles were exposed. We attempted to place microphones and DAT recorders on the same elevational contour and at the same distance from the flight line as targeted nests, but at a sufficient distance, and where possible out of the eagle's view, to minimize potential extraneous disturbance. Sound recording equipment was deployed during 7 of 15 separate helicopter tests in 2006 and during 15 of 31 tests in 2007.

We also compared sound levels among the 4 helicopters flown near nesting golden eagles during this research -- the Utah National Guard Apaches, WPG's AStar's and Bell L4, as well as Cirque Lodge's Eurocopter. We tried to measure the 3 civilian airframes under similar, standardized conditions. Each was flown at 300 ft AGL and at an airspeed of 60 knots, directly overhead, i.e. directly above the sound recording equipment, and then on a parallel flyby at the same altitude and speed, 100 m from the microphone. This pattern was designed to simulate the overhead and 100 m profiles flown by the Apache helicopters, at approximately the same altitude and airspeed, during our golden eagle field testing. We did attempt to record the Apaches with the same, more controlled simulated test scenario as the civilian helicopters, but we were unsuccessful in getting a representative range of sound levels because of other aircraft in the flight pattern. Unfortunately, there is inherent variation each time a sound event is recorded, even for the same stimulus. With helicopters, topography, weather conditions, distance, and variations in the airframe and flight characteristics can all change from one pass to the next. For an absolute and accurate comparison of sound levels, all 4 aircraft should be tested at the same location, with the same recording equipment, under the same ambient conditions, and at as close to the same time as possible. Even though such formal testing was well beyond the scope of this project, our results provide a reasonable approximation of the comparative sound levels of the Apache versus the civilian aircraft, and in particular those types operated by WPG.

Sound Instrumentation and Recording - Sony TCD-D8, Digital Audio Tape (DAT) recorders were used to record all sound events, along with exact time and date. Observers' real-time, oral, field notes were also recorded on time synchronized DATs. Bruel & Kjaer (B&K) Type 4149, 1.3-cm Condenser Microphones with 7.5-cm wind screens were attached to B&K Model 2639 Preamplifiers. Microphones were mounted on tripods at an approximate height of 1 m and placed along the flight line near targeted golden eagle nest locations. A 1.0 kHz, 94-dB calibration signal (20 micro-pascal reference) from a B&K Type 4250 Sound Level Calibrating System was recorded before and after each recorded manipulation. This signal provides an absolute, standardized reference point for sound levels and spectra when data are later reduced using a Rion NA-27 Sound Level Meter. All sound data were analyzed at ERDC/CERL.

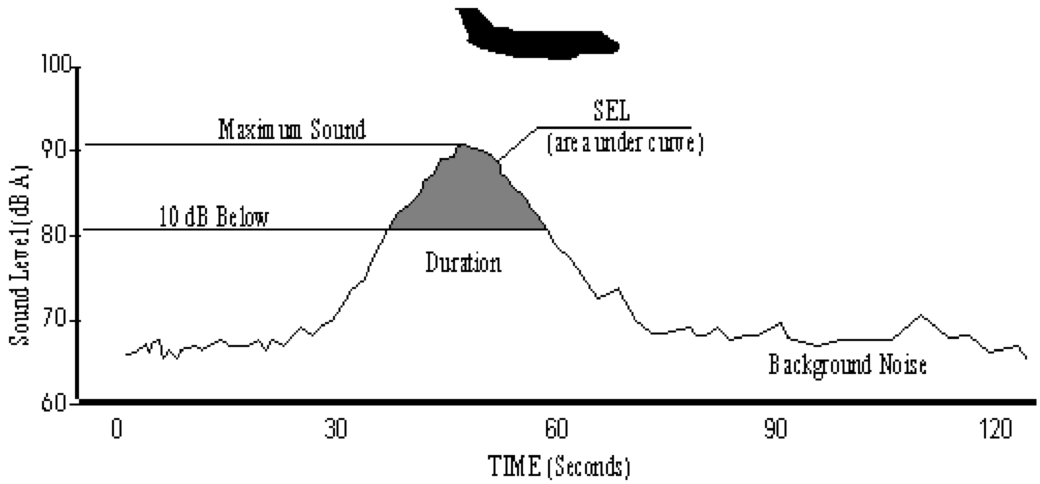
Sound Metrics - Noise is defined as sound which is undesired or which constitutes an unwarranted disturbance, and can alter animal behavior or normal functioning (ANSI S1.1-1994). Appropriate sound metrics and frequency weighting are essential to adequately quantify sound impact for each type of sound. A sound metric is chosen to measure sound dose in a way that meaningfully correlates with subject response. Frequency weighting is an algorithm of frequency-dependent attenuation that simulates the hearing sensitivity and range of the study subjects. Only sound that is audible to the study species should be accounted for in the metric used to quantify sound level. The commonly used “A” frequency weighting (ANSI S1.40-1983) attenuates sound energy according to human hearing range and sensitivity, and generally will not be appropriate for animal species. However, it is useful to present “A” weighted sound levels (dBA) because they occur on sound level meters and are widely used. It should be noted that neither flat (also termed unweighted) nor A weighting accurately reflect the way a golden eagle perceives sound.

Nonetheless, the current project requires specialized metrics and techniques to meaningfully measure the overall potential effects of sound on golden eagles. We measured sound events in terms of unweighted one-third-octave-band levels, applied "A" type frequency weighting to the resultant spectra for general reference, and then calculated the appropriate overall metric. We used 2 sound metrics in this study: (1) SEL, which is the sound exposure level, and represents the total sound energy recorded (Figure 8), and (2) $LEQ_{avg\ 10\text{-}sec}$ which is the 10-sec average equivalent energy level for measuring ambient sounds (EPA 1982, Figure 9). All sound levels presented hereafter are flat or unweighted, unless otherwise indicated.

An audiogram describes hearing range and sensitivity and provides information on which a frequency weighting algorithm can be based for a specific species. Figure 10 shows a composite average audiogram of 7 orders of birds (i.e., “average bird,” Dooling et al. 2000), with an approximate representation of a human audiogram and the “A” weighting curve included for comparison (ANSI 1969). The owl audiogram, based on data from Trainer (1946) and Konishi (1973), and the woodpecker audiogram from Delaney et al. (2002), further illustrate how audiograms can vary among taxonomic groups (Delaney et al. 1999). These data suggest golden eagles may have a much narrower frequency range of sensitivity than humans, and therefore may not perceive helicopter 'noise' as loudly or over as wide a range as humans.

Selection of sound impact criteria, or response measures, is another critical issue that must be taken into consideration for sound analyses. For humans, the response criterion is typically annoyance. For animals, the ultimate concern is long-term survival of the species, or often a specific population, such as in this project. The challenge is to develop a relatively short term procedure for inferring impact on long term survival. A proximate response is the direct and immediate response of an animal to a stimulus; such as behavioral responses like our watching, flattening, or flying variables. However, such proximate responses may not necessarily impact individual fitness, which is typically evaluated in terms of adult and juvenile mortality, or reduced reproductive performance. Yet, only these more critical factors influence population viability over the long term.

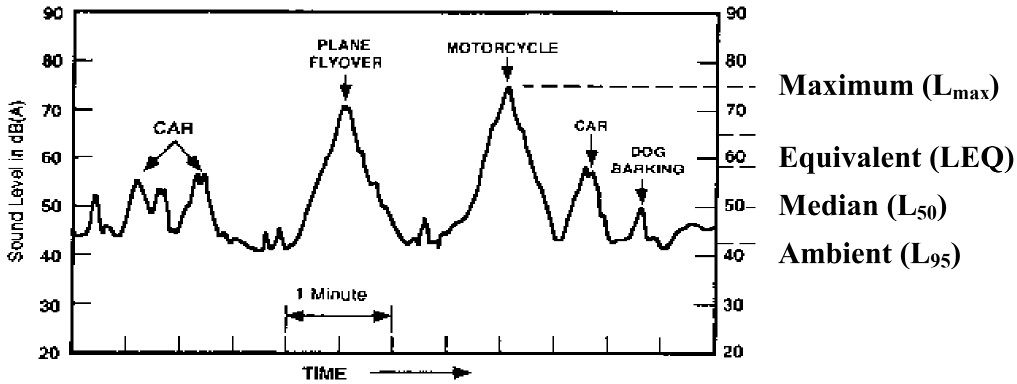
Single Event Sound Exposure Level (SEL)



This graph shows how SEL takes the whole noise event into account rather than just the peak , or maximum noise level (L_{max}). The entire shaded area of the graph comprises SEL level; as a result, SEL is usually about 10 dB higher than L_{max}.

Figure 8. A graphic explanation of Sound Exposure Level (SEL).

Continuous Event Equivalent Sound Level (LEQ)



Maximum (L_{max}) . . . The maximum value of the sound over the period.
Equivalent ($_{LEQ}$) . . . The level of a continuous sound with equal energy.
Median (L_{50}) . . . . . . Median sound level (average sound level is not appropriate because peak information is lost and loud events are over emphasized).
Ambient (L_{95}) . . . . . Natural background sound level.

Figure 9. A graphic explanation of Equivalent Sound Level (LEQ).

EXAMPLE AUDIOGRAMS

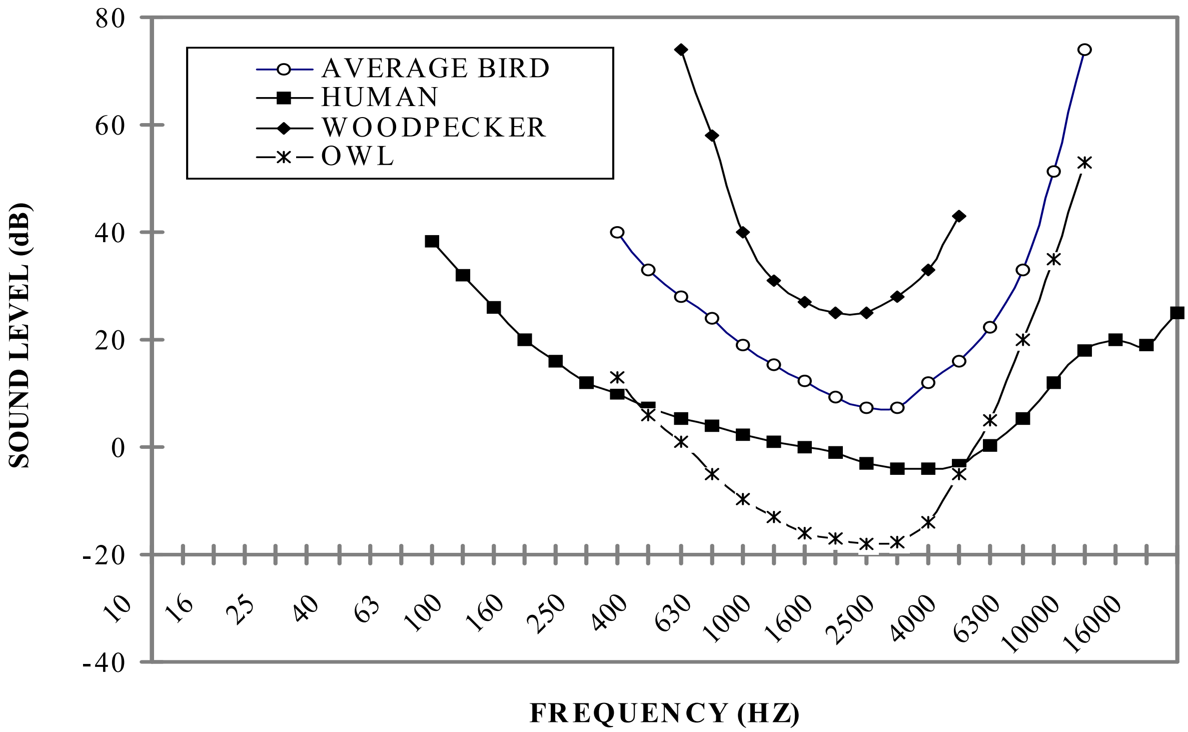


Figure 10. Examples of audiograms and frequency weighting, illustrating that birds may perceive sound much differently than humans.

RESULTS

Recreation and Other Tri-Canyon Area Activities

Recreation and Other Activities - Table 5 summarizes the various data obtained from our 2006 contacts. These data suggest >1.5 million skiers visit the 4 major resorts in the Cottonwoods. Nearly 10,000 vehicles per day enter those 2 canyons, where over 15,000 explosions per year occur for avalanche control. Even the non-commercialized, much less developed Mill Creek Canyon averaged >79,000 vehicles per year 2002-2005, with a trend indicating that the current annual figure is >100,000. There are also a minimum of 8 different non-military organizations flying ≥17 different helicopters in and around the Tri-Canyon Area on at least an occasional basis (Table 6). None of these aircraft are operationally restricted, beyond normal, generally applicable FAA regulations.

Historical records on golden eagle nesting and site occupancy (detailed in the following section), plus continued sightings from a variety of sources, as well as current observations by research personnel, all indicate golden eagles have continued to occupy the Tri-Canyon Area for decades, despite the dramatic population growth along the Wasatch Front and significant increases in recreational activity over the same time period that have contributed to the current levels of human activities documented above. The designated wilderness areas along the Wasatch Front and at the base of the Tri-Canyon Area may also partially mitigate nearby anthropogenic impacts through the preservation of quality, limited access habitat for golden eagles and their prey.

Population Growth - The Wasatch Front is approximately 80 mi long extending from Ogden ~40 mi north of the Salt Lake Valley to Provo the same distance south (Figure 3). It lies immediately adjacent to the Tri-Canyon Area, encompassing the mouths of the various canyons running east into the mountains along its entire length. In 2007 the population of this area reached 1.7 million. The Salt Lake City-Ogden area alone grew from 910,222 in 1980 to 1,333,914 in 2000, an increase of over 46% (Census 2000). At the same time, and not represented in the figures presented above, there has been a generally recognized, corresponding increase in backcountry recreation, fueled by the growth of traditional and "extreme" skiing, snowboarding, and snowmobiling, and facilitated by recent dramatic advances in equipment technology. It has become easier for more recreationists to get farther into the backcountry on the ground, which may pose a greater potential threat to golden eagles in the Tri-Canyon Area than heli-skiing.

Table 5. Various indications of human activity levels within Little and Big Cottonwood Canyons, 2 of the 3 canyons within the Tri-Canyon Area, Utah. (Note: some figures may be overlapping and therefore are not additive.)

Type Activity	Averages	Source	Years Data	Time Period
Skier Visitation	**1,320,915/year** range ~1.1 - 1.6 million	Alta, Snowbird, Brighton, Solitude Ski Areas	21	1985-2005
Bus Passengers	**250,809/year** range 200,718 - 347,343	Utah Transit Authority	10	1996-2005
Daily Traffic Counts	**9,710/day** range 9,249 - 10,059	Utah Department of Transportation (UDOT)	10	1996-2005
Avalanche Control Rounds (highways)	**706/year** range 404 - 878	Little Cottonwood (UDOT) Big Cottonwood (UDOT)	25 8	1981-2005 1994-2005
Avalanche Control/ Stability Testing Rounds/Charges (ski areas)	**7,680-11,200/year** hand charges **2,240-3160/year** avalauncher rounds **170-223** military rounds	Alta, Snowbird, Brighton, UDOT[1]	-	prior to 1999
Estimated Totals	**>1.5 million skiers per year** **~10,000 vehicles per day** **~350,000 bus passengers/year** **>15,000 explosions per year[2]**			

[1] Data from 1999 Final Environmental Impact Statement: Wasatch Powderbird Guides Permit Renewal. Years used in averages were not mentioned in original document.

[2] Most of these data are from pre-1999, and also did not include any figures for Solitude.

Table 6. Other civilian helicopters operating in and around the Tri-Canyon Area, Utah, 2006, excluding Wasatch Powderbird Guides. Numbers and types of aircraft may be outdated, but these data provide an indication of other helicopters flying in the area unrestricted.

Organization	**Helicopter Type**	**Number**	**Notes**
LifeFlight	Bell 407 Agusta A109-K2	1 1	Can fly anywhere in state.
AirMed	Bell 206 L3 Bell 407 Bell 430	1 1 2	Can fly anywhere in state. Helicopters fly 6-10 times per day.
KUTV Channel 2	Bell 206 L4	1	News and traffic helicopter.
KSL Channel 5	*no information*	1	News and traffic helicopter.
Aero Bureau, Utah Department. of Public Safety	Eurcopter AS350-B2	2	Fly all over state. Every time flying to eastern part of state fly across Tri-Canyon Area. Also service communications towers head of Big Cottonwood Canyon.
Classic Helicopters	Bell 206 L3, L4 Eurocopter AS350 B2, B3	≥2 ≥2	Fly as often as weather permits, usually only in Tri-Canyon Area when flying resource agency charters.
Park City Helicopters	Huges 500B Eurcopter EC-130	1 1	Fly as often as weather permits, occasionally fly all 3 Tri-Canyon Area canyons as well as Parley's Canyon, occasionally land ski resorts and work on UDOT transmission towers.
Cirque Lodge	Eurocopter EC130-B4	1	On average, fly once per month in Wasatch. Typically 50 of 60 flights per year in Provo Canyon [past 2-3 recently occupied/active golden eagle territories].
≥8 Organizations	**≥17 Helicopters**		**Frequent Tri-Canyon Area in addition to WPG**

Golden Eagle Surveying and Monitoring

Tri-Canyon Area Nesting - Between and including Parley's and Provo Canyons, there are approximately 20-22 documented golden eagle breeding areas along the Wasatch Front, of which about 15 were surveyed by project personnel or Keller in 2006. Golden eagles were present at most sites (occupied territories), but nesting was only confirmed at 4 sites (active territories), with nesting suspected at 2-3 other sites. Nest locations, historic information, including several simultaneous sighting records, and traditional territory characteristics throughout the golden eagle's range suggest the 6 historic Tri-Canyon Area nest sites (including American Fork) reflect use by 4-6 separate pairs of golden eagles in the past.

Mitigation Flights - No golden eagle activity was recorded during the early, 9 February 2006 mitigation flight. Most nests were still snow-covered and in a state of disrepair. Incubation was documented at the Mineral Fork nest on the second, 19 April flight, and also at the Coalpit Gulch site in Little Cottonwood Canyon. A confirmed occupied site (by research personnel and by Keller) at the mouth of Little Cottonwood could not be located from the air.

Test Site Surveying and Monitoring - Keller's annual reports to UDWR detail his central Utah population-wide survey and monitoring efforts during our 2-year Tri-Canyon Area study (Keller 2006, 2007). A comparison of reproductive performance between our test, or manipulated, breeding areas and the rest of the surveyed population shows no significant differences (Table 7). However, percent success in 2007 and productivity-per-active-nest for both years were higher at test sites. Eight of the 12 (67%) 2006 active nests were also active in 2007, which is comparable to population figures showing 60 of 95 (63%) breeding areas active in 2006 were also active in 2007 (Keller 2006, 2007).

Timing of Nesting - From direct observations, historic records, and discussions with Keller and others, it appears that golden eagle egg-laying in northcentral Utah does not begin until: late February to early March at lower elevation sites, ≤5000 ft.; mid to late March at mid elevation sites, between 5000 and 7000 ft.; late March to mid April at higher elevation sites, ~7000-9000 ft; and perhaps not until May at highest elevation sites like Silver Fork and Honeycomb. Confirming this trend, we saw the Reed & Benson South pair copulating on 24 March, and did not record the onset of nest repair at the Mineral Fork site until 25 March, where egg laying did not occur until sometime between 02 April and 19 April 2006.

Historic Nesting Records - Excluding American Fork and considering Reed & Benson North and South as potentially 1 territory, there are a minimum of 92 (23 years x 4 territories) nest outcomes reportable for the period 1981-2003 (Table 8). Yet, the only reasonably certain information on nesting outcomes was for the 6 years when chicks were confirmed. Otherwise there simply is insufficient information to determine non-nesting or failure, or even occupancy in most other years. This problem is exacerbated by early thinking that there was only 1 pair of eagles in the area outside of American Fork, plus an apparent tendency to expect the onset of incubation too early. A final complicating factor is the fact that fewer golden eagles nest at higher elevations such as these; they do so less frequently than at lower elevations; and they are much less successful when they do nest (Kent Keller, pers. comm.). Golden eagles in the Tri-Canyon Area are on the elevational periphery of their local range. There have probably never been very many pairs, and those have probably never been consistently active or successful.

Table 7. Comparative activity, success, and productivity between manipulated sites in northcentral Utah, and the rest of the surveyed population of golden eagle nests in central Utah, 2006-2007.[1]

	Manipulated Nests				**Surveyed Nests**			
Year	**Active Nests**	**Success Nests (%)**	**Prod/ Active Nest**	**Prod/ Success Nest**	**Active Nests**	**Success Nests (%)**	**Prod/ Active Nest**	**Prod/ Success Nest**
2006	12 [2]	8 (75%)	1.25	1.50	101	76 (75%)	1.13	1.50
2007	17 [3]	14 (82%)	1.29	1.57	81	56 (69%)	1.11	1.61

[1] Keller, K.R. 2006. Golden eagle nesting survey report for the central Utah study area, February - July 2006. *Report to* Utah Division of Wildlife Resources, Salt Lake City.

Keller, K.R. 2007. Golden eagle nesting survey report for the central Utah study area, February - July 2007. *Report to* Utah Division of Wildlife Resources, Salt Lake City.

[2] Includes 8 Apache test sites with multiple trials over a 2 week period, plus 2 WPG Bell L4 sites surveyed during mitigation flights, and 2 Cirque Eurocopter EC130-B4 flyby sites.

[3] Includes 15 Apache test sites with multiple trials over a 4 week period, plus 2 Apache 1 time test sites, 1 of which also was exposed to a WPG AStar.

Table 8. Golden eagle nesting history for the Tri-Canyon Area; compiled by the U.S. Forest Service from a variety of external sources (including Ellie Ienatch, Steve Schuler, and Kent Keller) as part of the 2004 EIS background process. (*Question marks and footnotes are by the current authors. The only years of certain nesting are shown in red.*)

Year	Nest Location[1]	Nest Attempt[2]	Young Produced	Young Fledged	Comments
1981	Reed & Benson North	yes	1	unknown	
1982	Mineral Fork	yes?	unknown	unknown	"nested"
1983	Silver Fork	yes?	unknown	unknown	"nested"
1984	Reed & Benson South	yes?	unknown	unknown	"nested"
1985					
1986					
1987	Silver Fork	yes?	unknown	unknown	"nested"
1988	Honeycomb	yes?	unknown	unknown	"nested"
1989	Mineral Fork	yes	2	2	
1990					only female seen
1991	Silver Fork	yes?	unknown	unknown	new immature male
1992	Honeycomb	yes	1	1	died after early fledging
1993	Silver Fork	yes	1	1	
1994	Mineral Fork	yes	1	0	disappeared from nest during unusually hot Jun
1995	Mineral Fork	yes?	none	none	"nesting" late Mar, but nest abandoned mid-Apr[4]
1996	Mineral Fork	yes?	none	none	courtship, nest repair by early Apr, successful nesting never confirmed
1997	Mineral Fork	yes?	none	none	
1998	Mineral Fork	yes?	none	none	
1999	Mineral Fork	yes?	none	none	
2000	Mineral Fork	yes	1	1	incubation last wk Mar
2001	Reed & Benson	no?			courtship till late Mar, obs 3/30-4/13[4]
	Silver Fork	no?			obs 3/30-4/13[4]
	Mineral Fork	no?			courtship till late Mar obs 2/5-4/27
	American Fork	yes	unknown	unknown	adult on nest mid-Apr
2002	Reed & Benson	no?			courtship/territorial late Mar to 12 Apr[4]
	American Fork	yes?	unknown	unknown	nest appeared "occupied" early Apr
2003	Reed & Benson	no?			obs 3/26-4/14[4] eagles around Mineral Fork mid-Apr[4]
	Silver Fork	no?			
	Mineral Fork	no?			
	American Fork	unknown	unknown	unknown	eagles in vicinity mid-Mar
	6 yrs confirmed nest 17 yrs uncertain		**6 yrs chicks**	**≥3 yrs fledge**	

[1] Mineral Fork, Reed & Benson North and South, Silver Fork, and Honeycomb were historically thought to all be alternate nests occupied by 1 pair, when almost certainly these nest sites represent at least 4 separate golden eagle breeding areas (pers. obs.; Kent Keller, pers. comm.). The assumption that activity in 1 of these areas precluded activity elsewhere undermines effective interpretation of these already sparse historical nesting data.

[2] Traditionally, a nest attempt, or using the term "nested," means at least confirmed egg-laying and incubation [i.e. definition of an *active* nest]; however, old records are unclear as to whether this term may have also been applied to pair presence, courtship, and/or nest repair [i.e., indications of an *occupied* nest], none of which can be interpreted as evidence of egg laying, incubation, or an actual nest attempt.

[3] Among possible explanations for the chick's disappearance are predation, starvation, parasites, or injury.

[4] Timing of nesting by the Mineral Fork pair in 2006 and 2007 indicates incubation may not begin until as late as mid-April at the high elevations found in the Tri-Canyon Area, so it is possible that earlier observations might not have detected the onset of incubation.

WPG Historical Records/Trends

Heli-skiing Operations Near Active Nests - During each of the 8 years of certain nesting with confirmed chicks in the Tri-Canyon Area (Table 8, plus 2006 and 2007), WPG operated in the same drainage 10-37 days between 15 December and 15 April, flying 108 to 2,836 separate helicopter flights (Table 9). Following hatching, any pre-nesting or incubation phase potential impacts of heli-skiing would have little or no affect on subsequent nest success. Because 4 different nest sites are represented over a 27 year period, there can be little doubt that multiple golden eagle individuals and pairs were exposed to WPG helicopter flights before and during their successful nesting, which argues against heli-skiing activity having a detrimental or disruptive effect during courtship, nest repair, and egg-laying at these sites. Even if better data were available to confirm years of non-nesting, it is unlikely with the range of flights to which active nests were exposed, that any detrimental effect could be established.

The fact that golden eagles are still nesting in the Tri-Canyon Area and have been documented doing so for nearly the full length of WPG's operating history (1981-present, 1974-present, respectively) argues against any significant detrimental impact. Historical nesting records are too sketchy to draw any conclusions about years without confirmed nesting.

Long Term Operating Trends - During the 34 year period from 1974 through 2007, WPG averaged per year 62.4 operating days (range 24-86), 761.0 skier days (range 161.1-1,256.4), and 210.6 h total helicopter time (range 49.8-310.1). Trends in operating days and total helicopter time have remained essentially flat and unchanging over the period, while skier days, which fluctuates greatly from year to year, has shown a gradual increase over the years (Figure 11). (The slight rise in the trend for helicopter time evident in the figure is an artifact of 3 of the first 4 years of WPG's operations being well below the longer term average; a 30-year trend line for helicopter time actually declines slightly.) The increase in skier days while operating days and helicopter time have held relatively steady is related to improved operating efficiency and improved helicopter technology (Rusty Dassing and Mike Olson, pers. comm.). The relatively flat trends in operating days and helicopter time are consistent with the continued recorded presence of golden eagles over the years, and they contraindicate any major change in WPG operations having affected nesting golden eagles in the Tri-Canyon Area.

Table 9. WPG operating days and helicopter flight activity in years with golden eagle nesting in the same Tri-Canyon Area drainage, Utah.

Year	Nest Site	WPG Days [1]	WPG Flights [2]	Golden Eagle Nesting [3]
2007	Mineral Fork	29	1,508	1 ~8-wk chick, fledging likely
2006	"	36	2,836	≥ 1 chick fledged
2000	"	26	1,312	1 chick fledged
1994	"	37	1,972	1 chick, died? during hot wx
1993	Silver Fork	16	292	1 chick fledged
1992	Honeycomb	10	108	1 chick fell at fledging
1989	Mineral Fork	24	452	2 chicks fledged
1981	Reed & Benson	26	1,626	1 chick, fledging unknown
8 years	**4 nest sites**	**10-37 operating days**	**108-2,836 flights**	**5 likely successful fledges 1 unknown outcome 2 unrelated mortalities**

[1] Number of days WPG flew in nest drainage, 15 December-15 April or through end of season.

[2] Number of WPG runs in nest drainage x 4 (for each recorded run, 1 drop-off at top of run with 1 flight in and 1 flight out, plus 1 pick-up at bottom of run with 1 flight in and 1 flight out) x 1.7 (~70% of runs have 2 lifts, or helicopter loads, per drop-off and pick-up).

[3] The only years on record when any of the 6 protected nest sites in the Tri-Canyon Area were confirmed active and later hatched young (Table 8), the point beyond which any previous winter activities are unlikely to have an effect on ultimate nesting success or failure.

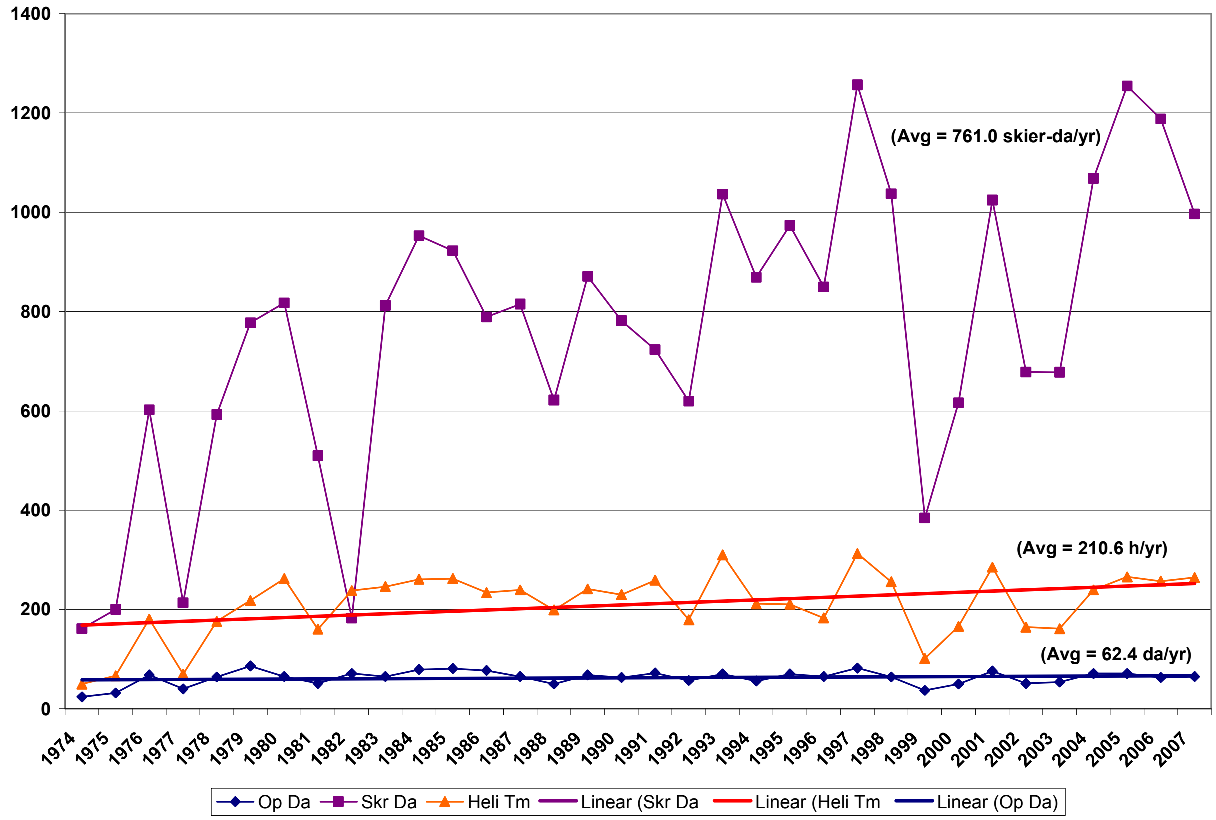


Figure 11. Long term trends, 1974-2007, in WPG operating days, helicopter time, and skier days per year.

Combined Helicopter Summary

During the 2006-2007 winter/spring field seasons, we recorded 303 helicopter passes near approximately 30 individual golden eagles, associated with 21 active nest sites and 1 occupied territory. The estimated number of eagles is conservative because it first assumes the same individuals occupied the same nest sites in both years. It also assumes that when the 2nd eagle of a pair was out of the observer's view, it was not present nor close enough to be exposed to the helicopter test.

Observations by Helicopter Type and Distance - Table 10 presents the freqeuency distribution of all distances for all observations of helicopters flying near nesting golden eagles in northcentral Utah, 2006-2007, including experimental passes and all passive, opportunisitic observations (1 observation = 1 helicopter pass by 1 eagle). There were a total of 227 controlled, experimental passes of Utah National Guard AH-64 Apache helicopters; with 89 observations on 4 test days over 2 weeks, 11-20 April 2006; and 138 observations on 8 test days over 4 weeks, 03-26 April 2007. In addition we recorded 53 passes (directed, including mitigation survey flights, and passive) by WPG's 2 AStars, their Bell L4, and Cirque Lodge's Eurocopter. WPG observations include hovering and close, slow passes during mitigation and survey flights on 3 occasions; 2 controlled flyby's and 1 simulated skier drop and pick-up; and passive observations on 5 days, during which WPG also made 15, 28 and 31 drops and pick-ups within the observed drainage. However, since the latter flights were out of the observers' view, they were not included in the tallies. Cirque data resulted from coordinated flyby's and a popout at 2 nest sites along Cirque's regular route in Provo Canyon. Finally we recorded 23 passive observations of civilian helicopters in the vicinity of nests being observed for the Apache trials.

Observations by Helicopter Type and Eagle Parameters - The frequency distribution of golden eagle nest status, activity at the time of the helicopter pass, and response to that pass are summarized in Table 11 for the 303 helicopter observations recorded during 2006-2007. 114 passes (38%) took place at nests with eggs, or during incubation, and 147 (48%) occurred after hatching. Non-nesting eagles were exposed to 42 passes (14%). At least 236 (78%) observations occurred when the attending eagle was incubating, brooding or standing at the nest with young, yet there were only 10 responses (3%). There was no response on 217 occasions (72%), with some degree of watching the helicopter 76 times (25%). The 5 flattens were exhibited by 2 eagles at different sites, on 2 and 3 successive helicopter passes during the same trial in both cases. 1 non-nesting, 2 perched, and 1 returning male eagle accounted for 4 of the 5 fly's. Only 1 fly was from the nest and it appeared to be where the helicopter precipitated an imminent departure. All pairs that showed either a flatten or fly response successfully fledged young except for 1, where the nest fell after hatching. All responses are detailed in context in the following sections, along with a more exhaustive analysis of the 227 experimental Apache helicopter passes.

Mineral Fork Helicopter Exposure Summary - Table 12 is a compilation of entries from other Tables throughout this report. It is provided as a convenience to illustrate the levels of helicopter activity this high profile pair of golden eagles experienced just during the 2 years of this research, when the site successfully hatched chicks in both years and very likely fledged them.

Table 10. Frequency distribution of distances for observations of helicopters near nesting golden eagles in northcentral Utah, 2006-2007 (1 observation = 1 helicopter pass by 1 golden eagle).

Distance/Profile (meters)	**UNG Apache**	**WPG AS350-B3**	**WPG Bell L4**	**Cirque EC130-B4**	**Passive Civilian**	**Distance Subtotals**
Approach[1]	9					**9**
Popout[2]	12			1		**13**
50		1	3	1		**5**
100	39	3	2	1		**45**
200	47	6	2		2	**57**
300	23					**23**
400	30	1				**31**
500	16					**16**
600	9	2			1	**12**
700	4				1	**5**
800	20	16			2	**38**
900	2				1	**3**
1000	4		1		6	**11**
1200	1				2	**3**
1400					1	**1**
1600					1	**1**
1700		12				**12**
1800	1				2	**3**
2000	9	1			3	**13**
3000	1				1	**2**
Aircraft Totals	**227**	**42**	**8**	**3**	**23**	**303**

[1] Experimental helicopter flies straight toward nest location on a course perpendicular to the nest cliff, from a point 800 m in front of the nest to a point 800 m behind it, passing directly over the nest just above cliff height. (0 m horizontal distance from nest as helicopter passes directly overhead.)

[2] Experimental helicopter flies on a course perpendicular to the nest cliff, from a point 800 m behind the nest to a point 800 m in front of it, passing directly over the nest just above cliff height, popping out suddenly from behind. (0 m horizontal distance from nest as helicopter passes directly overhead.)

Table 11. Frequency distribution of golden eagle nest status, activities, and responses for observations of helicopters near nesting eagles in northcentral Utah, 2006-2007 (1 observation = 1 helicopter pass by 1 eagle; see Table 1 for definitions of parameters).

Golden Eagle Parameter	Apache	WPG/Cirque	Other Civilian	Category Totals
Nest Status				
Eggs	84	13	17	**114**
Young	143		4	**147**
Non-nest		40	2	**42**
Eagle Activity				
Copulating		2		**2**
Incubating	72	13	17	**102**
Brooding	102		1	**103**
Standing at nest	12		3	**15**
Tending young	5		2	**7**
Tending nest	4			**4**
Preening	7			**7**
Prey delivery	2			**2**
Nest exchange	3			**3**
Returning	3	1		**4**
Perching	7	5		**12**
Soaring/flying	6	29		**35**[1]
Out of view	4	3		**7**
Eagle Response				
None	107	34	12	**153**
None observed	43	11	10	**64**
Glance	25	1		**26**
Look	33	4	1	**38**
Track	11	1		**12**
Flatten on nest	5			**5**[2]
Fly	3	2		**5**[3]
Helicopter Totals	**227**	**53**	**23**	**303**

[1] 24 observations are Mineral Fork pair, soaring in vicinity of nest cliffs prior to egg-laying, before and during WPG's 6 drop-offs and 6 pick-ups (2 flights each) in main drainage (see 02/23/06 entry, Table 15).

[2] Flatten behavior exhibited by 2 eagles (see Table 16).

[3] 4 fly's by non-attending or perched eagles, 1 by eagle from nest. Only latter and 1 non-attending fly were likely result of helicopter, which appeared to precipitate an imminent departure (see 02/07/06 and 04/19/06 entries Table 15, and Table 16).

Table 12. A summary and context of all recorded helicopter activities and associated golden eagle responses at the Mineral Fork nest site in the Tri-Canyon Area, Utah, 2006-2007.

Date	Helicopter Activity	GE	Notes (abbreviated entries)	Response
02/23/06	WPG AStar heli-skiing same drainage	2	Observers on ground below nest cliffs. Immature and adult GE (later confirmed as the nesting pair, immature was male) soaring above nest cliffs and W across and into main Mineral Fork basin, out of sight, 1200-1320. WPG (AStar) ~6 drop-offs and pick-ups on opposite ridge to W, skiing E facing slopes down into Mineral Fork, from 1110-1319. Eagles appeared unaffected, if not interested. Soared towards heli activity and associated skiers.	Soared towards heli activity Unaffected by heli-ski operation
04/19/06	WPG Bell L4 mitigation survey	2	Observers in WPG heli for mitigation survey, ~1545. Initially flew past nest cliff locating right drainage, <1 min to locate nest. Immature male already circling near nest cliff as heli approached, did not have prey. M landed edge of nest briefly then took off right away. Incubating female remained quiet on nest, appeared to look at heli, which hovering just above nest level at 48 m <1 min. Heli in nest area <2 min.	Incubating F looked Circling M landed nest then flew
04/19/06	WPG Bell L4 simulation flights	1	Observers in WPG heli for simulation flight, ~1700. First simulated drop-off by landing on ridge above nest cliffs for ~45 sec, ~1000 m away, then flew down to bottom of drainage passing ~100 m from nest. Circled back up to check nest and hovered ~15 sec at 47 m. No apparent responses throughout, incubating adult on nest remained in same position. Heli in nest area <1.5 min.	Incubating eagle may have looked Unaffected by heli-ski simulation
04/07/07	WPG AStar test flyby's	1	Observers in WPG heli for experimental flyby's. Hovered ~200 m and above at 45º angle, ~1 min while nest located. Passes at ~100 m SE-NW and at ~70 m NW-SE. During both passes and hovering search incubating adult did not move off nest nor respond in any distressed manner. On 100 m pass, adult briefly glanced up at heli, otherwise remained normal incubating position throughout.	Incubating eagle glanced Unaffected by flyby's
04/26/07	UNG Apache test flyby's	1	Observer on ground across from nest cliff. Heli in area 1138-1145, past nest at ~400 m 2x, another pass at 800 m as departs, incubating eagle does not look, track, nor respond.	Incubating Unaffected by flyby's

Date	Helicopter Activity	GE	Notes (abbreviated entries)	Response
2006	WPG AStar's, limited use Bell L4	2	Between 15 Dec 05 - 15 Apr 06, during normal heli-skiing operations, WPG had 2,836 separate heli flights within Mineral Fork drainage, most of which were during months of early courtship and nest repair, with no apparent impact on the active nest which later fledged ≥1 chick.	Unaffected by heli-ski operations
2007	WPG AStar's	2	Between 15 Dec 06 - 15 Apr 07, during normal heli-skiing operations, WPG had 1,508 separate heli flights within Mineral Fork drainage, most of which were again during months of early courtship and nest repair, with no apparent impact on the active nest which later had ~8 wk chick in Jul.	Unaffected by heli-ski operations

Helicopter Scenarios and Response Narratives

WPG Operational and Apache Test Scenarios - Table 13 provides an approximation of the timing, duration, and number of separate flights associated with a "typical" WPG backcountry heli-skiing operation, developed from conversations with Mike Olson and personal observations. This generalization is intended to facilitate an understanding of the ground and aerial activities associated with numbers of WPG flights in a drainage reported in an earlier section. It also serves as a frame of reference for comparing a similarly generalized approximation of a "typical" Apache helicopter test scenario, shown in Table 14. In making such a comparison, it must be remembered that the Apache is a larger and louder aircraft than WPG's helicopters (see Tables 2 and 17, and Figure 20). Nonetheless, aside from the difference of 8 versus 4 separate flights associated with any single event or trial, the 1.5 min/round trip or pass, and the 6-8 min total helicopter time per event or trial, over a comparable 40-60 min duration in both cases, indicates the Apache testing reported in the following section reasonably simulated WPG's operation.

WPG-Golden Eagle Observed Interactions - Because direct observations of WPG operations occurring in the presence of golden eagles were limited, all 11 circumstances (3 mitigation and survey flights, 2 controlled flyby's, 1 simulated skier drop-off and pick-up, and 5 occasions of passive observations) are detailed in Table 15. In most cases golden eagles appeared unaffected by heli-skiing operations. On 2 occasions eagles flew toward the helicopter activity as if interested, and on 1 of those times, flew in by the idling helicopter and landed on the ground within 200 m, remaining there while it took off, skiers made their run, and it returned making its first roundtrip pick-up flights below. Copulation on a ridgetop perch, possibly by the same eagles, was also noted while the WPG helicopter was circling in the drainage below, during another pick-up on a different day. The 2 fly's include 1 of the 2 eagles that flew in to the nearby ridgetop, leaving during the second pick-up but doing so in such an apparently leisurely way, that neither observer felt its departure had anything to do with the helicopter. The other fly by the immature male at Mineral Fork, may well have been in response to the helicopter approaching to hover <50 m away, but again unless this was a disrupted nest exchange, males typically do not remain long when delivering prey or temporarily visiting the nest. Regardless this pair was later successful in fledging their young, and was active again in 2007.

Apache Helicopter-Golden Eagle Responses - As mentioned earlier, the 5 flattens were exhibited by 2 eagles at different sites, on 2 and 3 successive helicopter passes during the same trial in both cases (Table 16). 1 of those eagles fed the chick soon after, then just looked at the helicopter on the next 3 passes. The other eagle, after 2 flattens, was the only one to fly from the nest, which it did on the 4th pass, after ignoring the helicopter entirely on the 3rd pass. This adult had been shading its eaglet for over an hour before the helicopter passes, and was seeking shade itself at the back of the nest cavity following the flattening behavior and during the 3rd pass. Even though it flew during the 4th pass in apparent response to the helicopter, once airborne it did not appear disturbed or agitated, or in a hurry to leave the area, before it soared off to go hunting. Reports from other studies where helicopters have forced reluctant eagles off their nests indicate those eagles usually return immediately when the helicopter leaves, further supporting the theory that the Apache likely precipitated an imminent departure in this case, perhaps out of annoyance, rather than caused a startled flush. Either way, this eagle returned with prey and began feeding its chick, which later fledged successfully. The other 2 fly's were from adults perched away from the nest, 1 attending (only adult near nest) and 1 not. For the attending adult, it is unclear whether that eagle flew because of the helicopter, or to join its mate, that was soaring in the vicinity of the helicopter. Neither subsequently paid any attention to the helicopter, which flew below the original perched eagle on its way by. Incubating eagles on the nest exhibited no responses beyond varying degrees of watching the helicopter. In all, 4 golden eagles (possibly only 3 as explained below) accounted for the 5 flattens and 3 fly's at 3 nest sites during our 2 year project.

Third Party Observations - Long time WPG guides indicated that one of their commonly used drop sites is on the same ridge within ~100 m of the juniper snag perch where copulation was recorded by researchers. Apparently both WPG and golden eagles have been simultaneously using these 2 adjacent locations for >20 years, based on the guides' personal observations. Moreover, the eagles rarely fly when the helicopter lands, or when skiers exit the aircraft. Another long time WPG guide recounted a 2006 encounter on the Periphery Circuit where their helicopter landed, and a golden eagle followed it in and landed 150 ft away. The eagle remained while 10 skiers made their run 1000 ft away and 200 ft above. The guide skied within 50 ft of the eagle on the way back to the helicopter before it flew off.

Interviews with WPG pilots, several WPG guests, as well as numerous other pilots from the Utah National Guard, Classic Helicopters, and Cirque Lodge, were all consistent in indicating in their collective experience, golden eagles do not seem to be bothered by their helicopters, but rather often seem to be curious, occasionally flying along with the aircraft. UDWR has been using helicopters on golden eagle nesting surveys for years in the Price, Utah, area, flying close enough to nests to see eggs or chicks. They have not found helicopters readily disturb nesting eagles, which are reluctant to flush and immediately return if they do. Plus, there has been no long term effect on productivity (Chris Colt, Nathan Sill, Kyle Bengley, pers. comm.). These observations are consistent with reports from other long time golden eagle researchers who use helicopters in their work, including Carol McIntyre from Denali National Park, Alaska, and Michael Kochert from the Snake River Birds of Prey Natural Area, Idaho.

Table 13. Generalized but representative, Wasatch Powderbird Guides backcountry helicopter skiing operation, drop-off and pick-up scenario, for any given ski run or specific location, on any given day, with a typical skier group consisting of 2 helicopter lifts (occurs ~70% of the time; 1 guide and 4 guests/lift). All times estimated and approximate.

Flight	Example Time (h.m.s)	Duration	Total Time (m.s)	Purpose
1a	10.00.00	15 sec	00.15	Fly into drop-off location
		< 1 min	01.15	Drop off 1st group skiers (≤5)
1b		15 sec	01.30	Fly away
	10.01.30			
		5-10 min		*Off picking up 2nd group*
2a	10.06.30	15 sec	01.45	Fly into drop-off location
		<1 min	02.45	Drop off 2nd group skiers (≤5)
2b		15 sec	03.00	Fly away
	10.08.00			
	10.08.00 – 10.38.00	*30-45 min*		*Off shuttling other groups while skiers making this run*
3a	10.38.00	15 sec	03.15	Fly into pick-up location
		<1 min	04.15	Pick up 1st group skiers (≤5)
3b		15 sec	04.30	Fly away
	10.39.30			
	10.39.30 – 10.44.30	*5-10 min*		*Off delivering 1st group to next location*
4a	10.44.30	15 sec	04.45	Fly into pick-up location
	10.44.45	<1 min	05.45	Pick up 2nd group skiers (≤5)
4b	10.45.45	15 sec	06.00	Fly away
	10.46.00			
4 round trips, or 8 separate flights	45-60 min duration	~1 min 30 sec per round trip ~3 min per 2-lift drop-off or pick-up	~6 min total time	

Table 14. Generalized but representative, Utah National Guard Apache helicopter operational scenario for experimental overflights near nesting golden eagles in northcentral Utah, 2006-2007. Tyically, 2 trials were scheduled for each test day at each nest. Each trial consisted of 2 passes, through established GPS coordinates.

Flight	**Example Time (h.m.s)**	**Duration**	**Total Time (m.s)**	**Purpose**
1a	10.00.00	45 sec	00.45	Approach to test pattern
		1 min	01.45	1st pass by nest
		30 sec	02.15	Turn around and set up for
1b		1 min	03.15	2nd pass by nest
		30 sec	03.45	Departure for next nset site
	10.03.45			
	10.03.45 – 10.37.45	*20-60 min (avg – 34 min)*		*Off flying past 3 other nests*
2a	10.37.45	45 sec	04.30	Approach to test pattern
		1 min	05.30	1st pass by nest
		30 sec	06.00	Turn around and set up for
2b		1 min	07.00	2nd pass by nest
		30 sec	07.30	Departure for next nset site
	10.41.30			
2 round trips, or 4 separate flights[1]	40-60 min duration	~1 min 30 sec per pass <4 min avg per trial	~7.5 min total time	

[1] Actual range, including additional opportunistic passes, 1-9 separate flights.

Table 15. Direct observations (including context of 2 flight behaviors) of Wasatch Powderbird Guides helicopter activities in the Tri-Canyon Area with golden eagles present, 2006-2007, including mitigation, survey, and experimental simulation flights.

Date	Nest/ Area	Notes (abbreviated)	GE	Activity/ Response
02/07/06	Days Fork	Observers in Days Fork. WPG heli (AStar) makes 2 drops of 5 each top of Reed & Benson ridge, ~1315. During 2nd, GE lazy flight parallel ridge, ~100' above idling heli, landed rock on ridge 200 m N. Joined by 2nd adult GE on rock within about 10 min, as skiers making way down. Both sat during first WPG flight down canyon opposite ridge to pick-up spot at bottom of run, ~45 min later. During 2nd pick-up ~10 min after 1st pick-up, 1st adult leisurely spread wings and flew off beyond ridge headed S. 2nd GE flew off within 5 min, same direction, neither in any apparent response to WPG activity.	2	Flew in & landed near idling heli **Flew**, but Unaffected by heli-ski operation
02/23/06	Mineral Fork	Observers in Mineral Fork. Immature and adult GE (later confirmed as Mineral Fork nesting pair, immature was male) soaring above nest cliffs and W across and into main Mineral Fork basin, out of sight, 1200-1320. WPG (AStar) ~6 drop-offs and pick-ups on opposite ridge to W, skiing E facing slopes down into Mineral Fork, from 1110-1319. Eagles appeared unaffected, if not interested. Soared towards heli activity as disappeared from view.	2	Soared towards heli activity Unaffected by heli-ski operation
03/04/06	Cardiff Fork	Observers in WPG heli (AStar) for survey flight. ~1500, during slow flight and hover off old Reed & Benson South nest, adult GE soaring up canyon to S, higher than heli, circling along Reed & Benson ridge, W facing slope. Appeared unaffected by heli activity.	1	Soaring Unaffected by heli survey
03/24/06	Cardiff Fork	Observers in Cardiff Fork, below Reed & Benson South nest cliff, ~1130-1400. WPG (AStar) consistently flying upper Cardiff and Mineral with few breaks, 0900-1330, ≥15 drop's and pick-up's in Cardiff. 1015-1300, male (M) and female (F) adult GE's intermittently soaring and perching above and on Reed& Benson ridge, mostly above and to S of nest cliff. 1310-13 M soared off above nest cliffs, undulating flight, landed ridgeline rock above nest cliffs. 1313-15 F reappeared soaring above M and nest cliffs, landed ridgetop snag perch used earlier by M. M flew over and joined, copulating briefly on snag perch, while WPG circling below low in Cardiff drainage during a pick-up. M immediately off after mating, to ridgeline rock perch used by F earlier. 1326 M off and re-perched upslope, then flew out of sight 1328. F remained on snag at last view ~1355.	2	Soaring, perching, copulating Unaffected by heli-ski operation

Date	Nest/ Area	Notes (abbreviated)	GE	Activity/ Response
03/27/06	Cardiff Forrk	Observers in Cardiff Fork, 1050-1420. Same and only adult GE shifting between snag perch, ridgetop knob, and rock break to S of copulation snag next to Days Draw, WPG drop site used twice 1245-1255 (AStar). Called for WPG flyby 1246, 2/3 up ridge face, ~75 m off face, 80 kts. Suspect A perched atop knob when WPG went by, but could not confirm perched there until from trail on way out.	1	Perching Unaffected by heli-ski operation
04/19/06	Mineral Fork	Observers in WPG heli (Bell L4) for mitigation survey, ~1545. Initially flew past nest cliff locating right drainage, < 1 min to locate nest. Immature male already circling near nest cliff as heli approached, no prey seen. Male landed edge of nest briefly then took off right away. Incubating female remained quiet on nest, appeared to look at heli, which hovering just above nest level at 48 m <1 min. Heli in nest area <2 min.	2	Incubating F looked Circling M landed nest then **flew**
04/19/06	Coalpit Gulch	Observers in WPG heli (Bell L4) for mitigation survey, ~1600. Made one pass to locate nest on cliff, <30 sec, then hovered ~30 sec, 52 m from nest, at approximately nest height. Adult on nest remained quiet with head and tail up, looking at heli. Heli in nest area <1.5 min.	1	Incubating looked
04/19/06	Mineral Fork	Observers in WPG heli (Bell L4) for simulation flight, ~1700. First simulated drop-off by landing on ridge above nest cliffs for 45 sec, ~1000 m away, then flew down to bottom of drainage passing 100 m from nest. Circled back up to check nest and hovered 15 sec at 47 m. No apparent responses throughout, incubating adult on nest remained in same position. Heli in nest area <1.5 min.	1	Incubating may have looked
03/23/07	Reed & Benson	Observers in WPG heli (AStar) observing operation, about 1000. Reed & Benson ridge S end, GE lazily soaring ridge line, after WPG helo dropped off at top of Powerline run upper end of Cardiff drainage, to SW. Appeared totally undisturbed, 2 more passes over Reed & Benson ridge by 2nd WPG heli. No apparent effect or reaction.	1	Soaring Unaffected by heli-ski operation
04/07/07	Mineral Fork	Observers in WPG heli (AStar) for experimental flyby's. Hovered 200 m and above at 45° angle, 1 min while nest located. Passes at 100 m SE-NW and at 70 m NW-SE. During both passes and hovering search, incubating adult did not move off nest nor respond in any distressed manner. On 100 m pass, adult briefly glanced up at heli, otherwise remained normal incubating position throughout.	1	Incubating unaffected glanced

Table 16. Context of 3 golden eagle flights and 5 flatten behaviors, observed during 227 Apache helicopter passes by individual eagles, northcentral Utah, 2006-2007.

Date	Nest	GE[1]	Notes (abbreviated entries)	Activity
04/13/06	6	A1	1003.00 Heli approaching.	
			1004.00 Brooding A1 on nest spotted approaching heli, flattened on nest, but watched as flew by.	**flatten**
			1005.00 A1 remain flattened, but head came up as heli on 2nd pass. Kept up on 3rd pass.	**flatten** **flatten**
			1018.00 A2 delivered rabbit to nest, remained only 30 sec, A1 began feeding self and chick.	feeding
			1035.00 Heli returned, circled past nest 3 times, A1 lay brooding with head up, probably looking heli, did not flatten.	look look
			1038.00 Heli finished passes and departed	look
04/05/07	14	A2	0926.00 Nonattending A2 perch on nest cliff to NW of incubating A1.	
			1041.45 A2 track heli as flew over nest [approach]. Flew after heli 50 m past on heading W and N. No response observed from incubating A1.	**fly**
			1051.30 A2 soar vicnity just NW of nest for about 10 min before fly NE.	
04/05/07	15	A1	1046.23 A1 standing on nest back to sun, appears shading chick, neck stretch then look into nest.	
			1049.06 A1 looking back over tail, orienting to sound of approaching heli.	
			1050.04 Loudest part of flyby, A1 dropped down to flattened position on nest covering chick as heli passed.	**flatten**
			1051.10 A1 remain flattened during 2nd pass.	**flatten**
			1058.35 Head up and begin looking around, body still flat.	
			1103.23 A1 standing body horizontal, scanning whole horizon.	
			1106.36 Walking around to back of nest, head and shoulders in shade, tail, wings, and back still in sun. Chick out in sun behind A, more in center of nest.	
			1114.58 Chick still exposed at A1's tail, A1 still standing faced back wall as heli approach for 3rd pass.	
			1115,10 3rd pass, A1 look out but not at chick nor heli. No change body position.	none
			1116.10 4th pass A appeared agitated, as walked carefully to edge of nest and took off.	**fly**
			1116.33 A1 circling in front of nest cliff as heli departs. Pays no attention to heli as circles.	
			1117.44 A1 flapping and circling higher, gliding and flying off to E. Heli noise appeared to bump off nest, but behavior before/after fly suggests A1 likely going soon anyway.	

Date	Nest	GE[1]	Notes (abbreviated entries)	Activity
			1214.20 A1 returned to nest, possibly with prey, 1229.25 A1 standing over chick and appears to be feeding it.	
04/26/07	6	A1	0932.40 A1 perched cliff, ~10 m from nest. 1020.20 Heli approaching, A1 preening, then looking around, looks heli. 1023.05 2nd pass, A1 looked up heli briefly but remain perched, continue looking around. 1024.10 Heli circling to depart 800 m off, A1 showing more interest, tracking. 1026.13 A1 more preening. 1046.33 Apache flying N up valley >2000 m, A1 glance. 1054.44 A1 still perched cliff as heli approaches. 1055.32 A1 turns head to look heli on 3rd pass. 1056.01 Heli past, prepping 4th pass. A1 ruffle shake, walks ledge, flies to S, direction of heli and A2 soaring near heli. 1057.23 Heli passes below soaring A1, which turns back to N. 1109.32 Both A's return to cliff perch above nest.	preening glance track glance look **fly** none none

[1] GE - Reference golden eagle. A1 primary nest-attending adult, i.e. adult on nest, or only adult present if perched nearby. A2 secondary non-attending adult, usually soaring or perched away from nest, also present during prey deliveries and nest exchanges.

Apache Helicopter Testing

In this section, we present the results from a variety of descriptive analyses intended to discover any patterns or relationships associated with nesting golden eagle responses to our experimental Apache helicopter overflights. We found no meaningful, quantitative relationships nor trends with nest attending versus non-attending eagles, first exposures versus subsequent helicopter passes, and planned helicopter passes versus unscheduled ones. There was an apparent tendency for non-attending eagles to watch less and be more apt to fly than their nest-attending mates but sample sizes were too small to establish the relationship. Also, regarding nest status, no incubating eagles flattened or flew; both behaviors only occurred after hatching when chicks were present.

Response Rates by Helicopter Distance - Of 227 Apache helicopter passes recorded in 2006-2007, nesting golden eagles exhibited no more response than watching the helicopter during 219 (96%, Figure 12). Figure 13 shows the component response frequencies for the grouped responses in Figure 12. For example, the grouped watch response was comprised of 25 (11%) glances, 33 (15%) looks, and 11 (5%) tracks. The 8 (4%) responses have already been detailed above and in Table 16. The 5 scheduled test flight distances from 0 (approach's and popout's) to 800 m accounted for 157 (69%) of the Apache passes, while unscheduled passes at other distances totaled 70 (31%, Figure 14) Replication of planned test distances ranged between 20-47 with the most passes occurring at 100, 200, and 400 m. Overall, 160 passes (71%) were at distances of ≤400 m, with 67 (29%) between 500-2000 m categories. All 3 flight responses occurred at ≤200 m and all 5 flatten responses, at ≤400 m (Figure 15). Otherwise, there was no pattern across distance for no response (range 46-100%) and watching (17-54%).

Response Rates by Nest Site - The number of Apache helicopter passes at any given nest site typically ranged between 7-26; but sites 15, 18, and 19 only received 1 day of testing (Figure 16). Site 15 was aborted on its second day of testing due to unexpected logistical difficulties; sites 18 and 19 were the Mineral Fork and Provo Canyon sites flown only the final day of testing in 2007. A total of only 4 (possibly 3) golden eagles at 3 nest sites (6, 14, and 15; Figure 17) exhibited behavioral responses (flatten or fly) during our 2 years of testing. A brooding adult on the 6 nest flattened during a 2006 trial, and a perched, attending adult flew in 2007 (see Table 16). Both birds are likely to have been the female by their behavior, but we have no way of knowing for certain. A non-attending male at nest 14 flew during a 2007 trial, while it was the nest-attending female at nest 15 that first flattened, then flew. The small sample size at this site accounts for the exaggerated percentages. If each of these responding sites is compared with the 2-4 sites of similiar sample size (6 with 2, 5, and 7; 14 with 9, 11, 16, and 17; 15 with 18 and 19), responses at these sites did not appear to be influenced by helicopter pass frequency.

Response Rates by Test Week - Data from the test week exposure analysis show no response increasing (59% up to 75%) between the 1st and 2nd test weeks, while watching (34% down to 24%) and responding (6% down to 1%) both declined (Figure 18). These trends suggest the possibility of conditioning or habituation to the Apache helicopter overflights. Golden eagle response rates across chronological test weeks (Figure 19) also show an increase in no response for weeks 1-3 (44% up to 77%) with a corresponding decline in watching (41% down to 23%) and responding (15% down to 0% in week 3, and 2% in week 4), again suggesting possible desensitization. The slight reverse trends between weeks 3 and 4 could be negligible or an indication of the increased responsiveness that would be expected as chicks get older and adults spend less time at the nest.

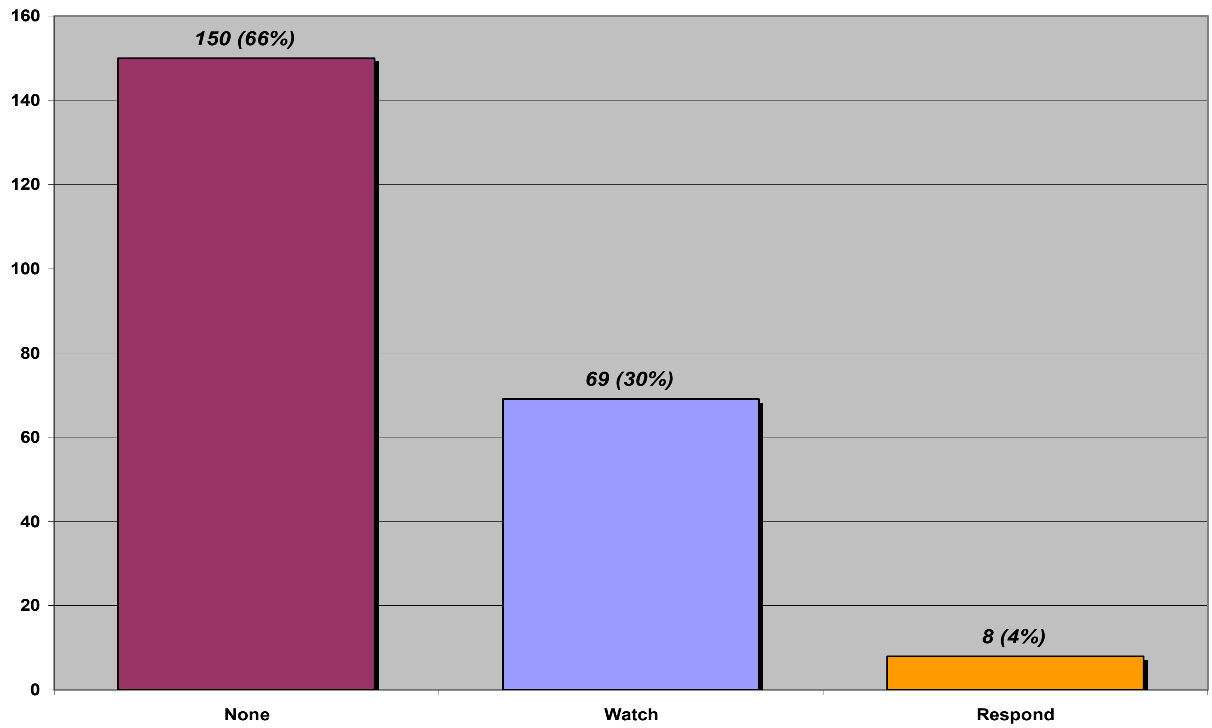


Figure 12. Frequency distribution of grouped golden eagle responses to Apache helicopters flown near nesting eagles (N=227) in northcentral Utah, 2006-2007.

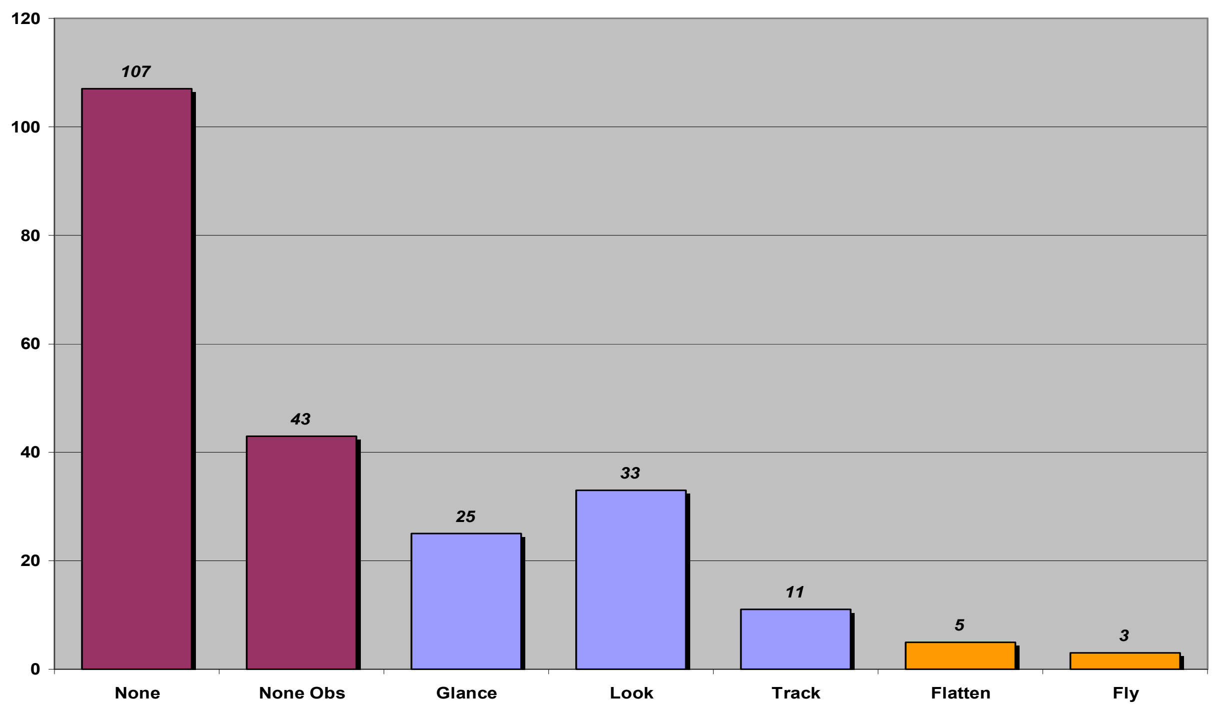


Figure 13. Frequency distribution of golden eagle responses to Apache helicopters flown near nesting eagles (N=227) in northcentral Utah, 2006-2007.

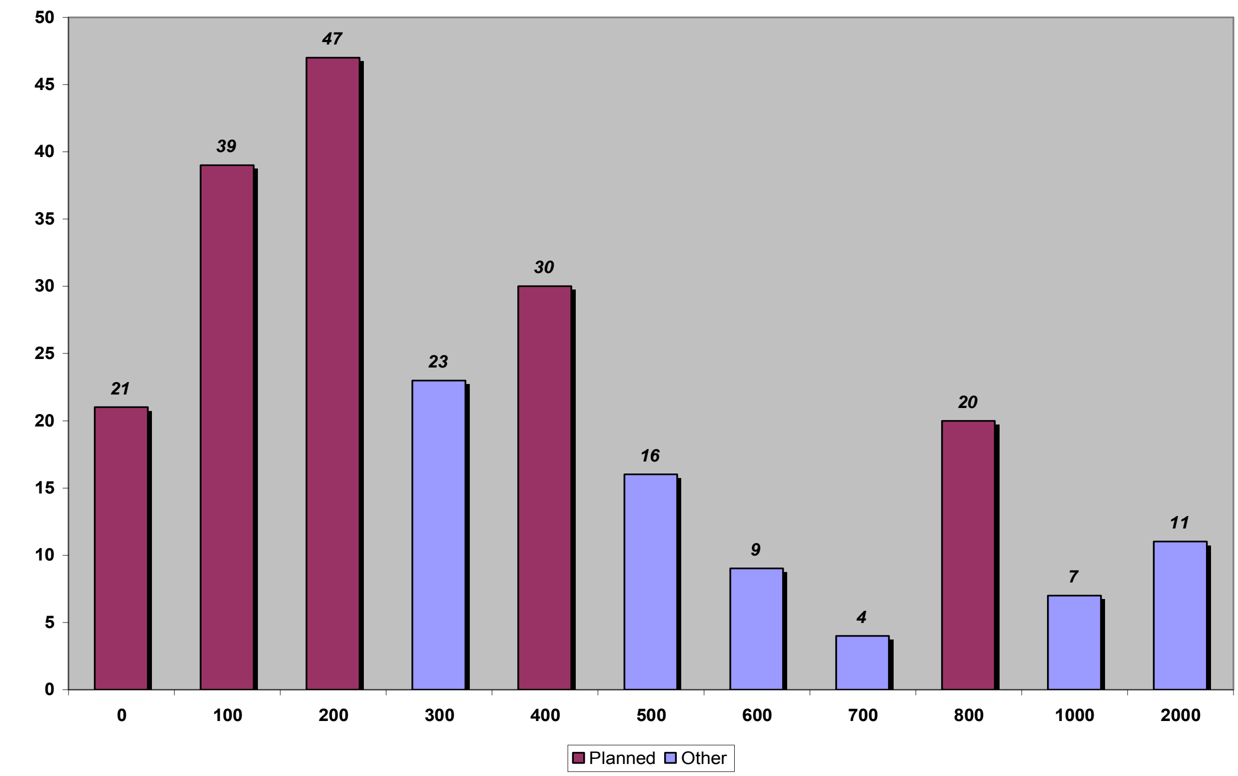


Figure 14. Frequency distribution of planned and opportunistic Apache helicopter test distances (m) near nesting golden eagles (N=227) in northcentral Utah, 2006-2007.

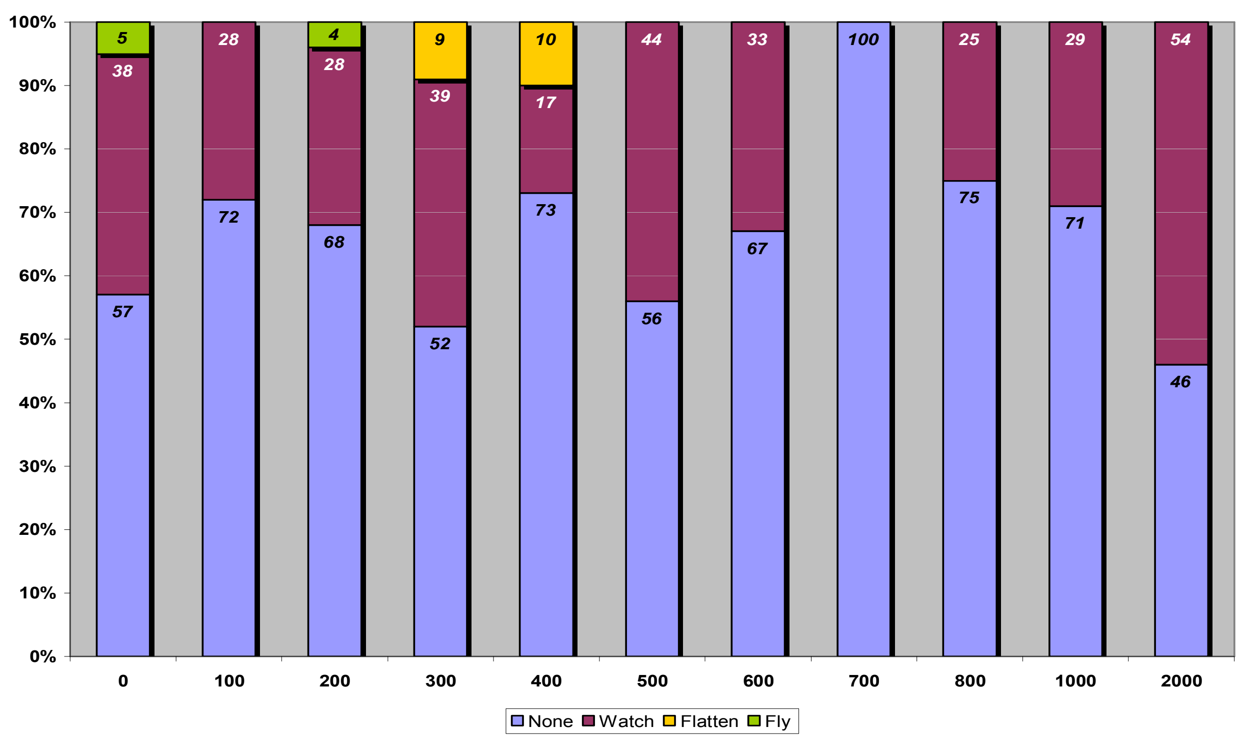


Figure 15. Golden eagle response rates (%) for Apache helicopter test distances (m) flown near nesting eagles (N=227) in northcentral Utah, 2006-2007. (Sample size for each distance shown as frequencies in Figure 14 above.)

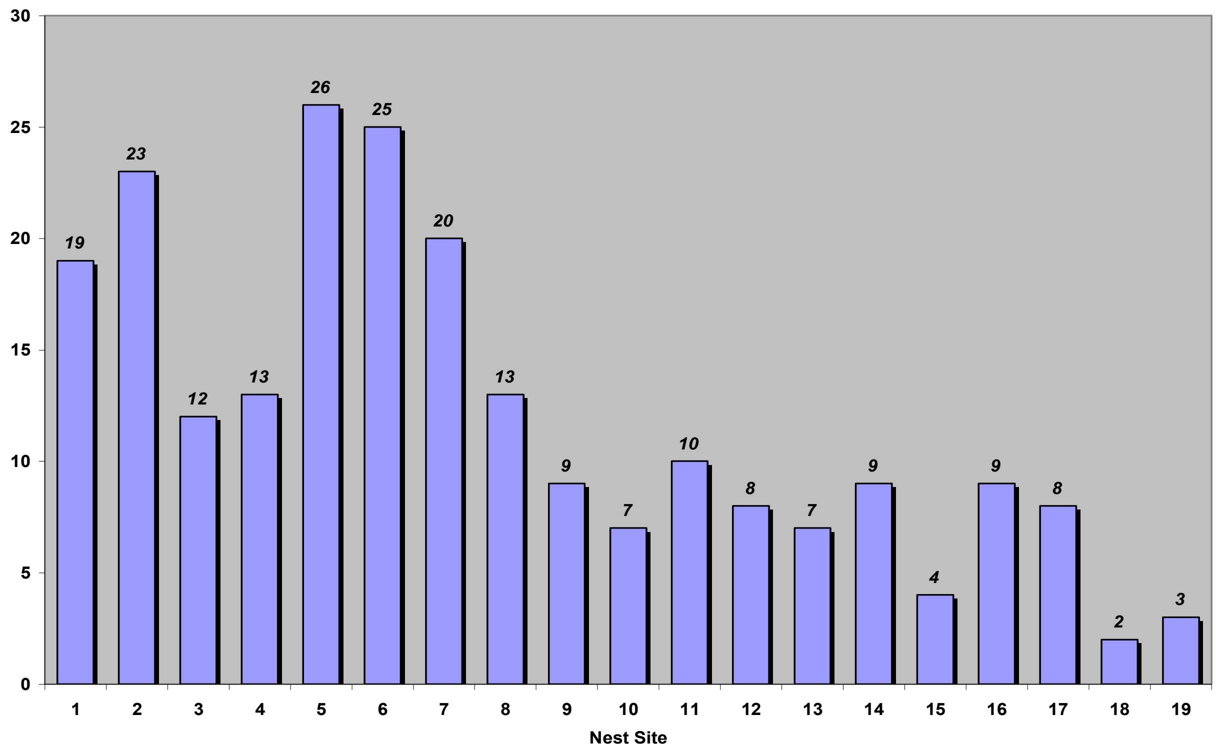


Figure 16. Frequency distribution of Apache helicopter-golden eagle observations among 19 nest sites (N=227) in northcentral Utah, 2006-2007.

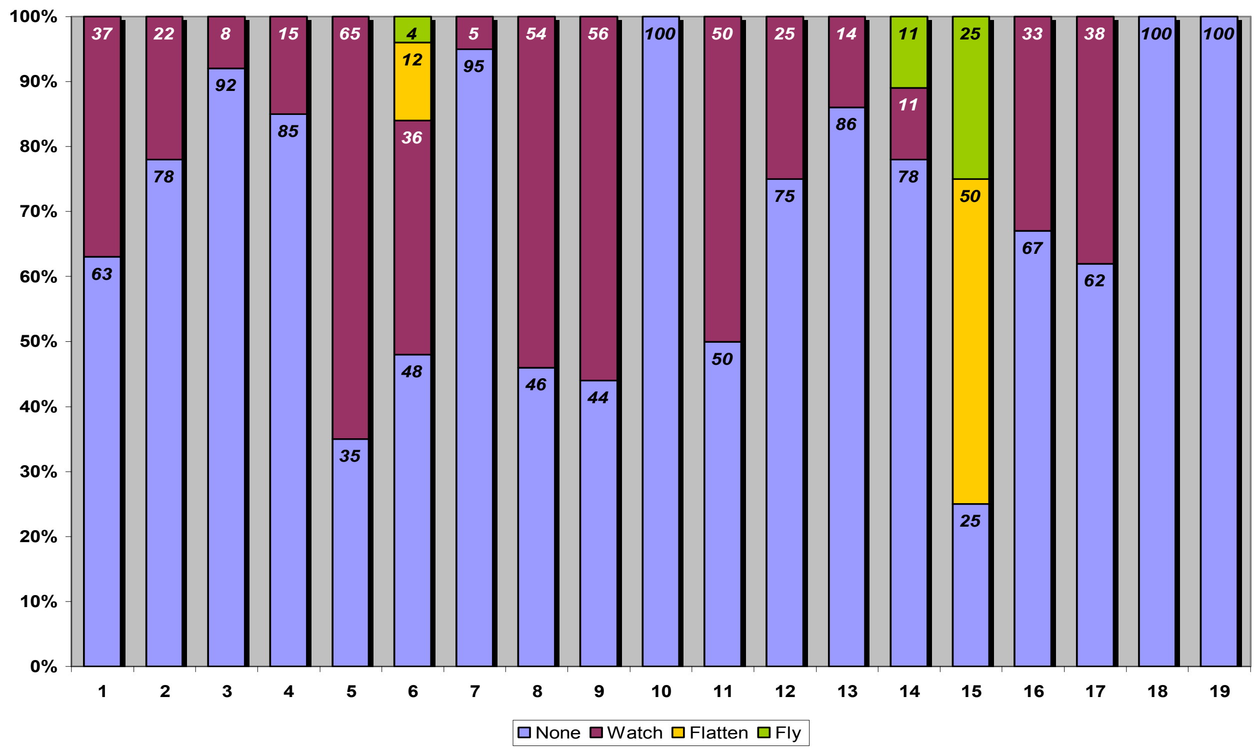


Figure 17. Vaiation in response rates (%) to Apache helicopters at 19 golden eagle nest sites (N=227) in northcentral Utah, 2006-2007. (Sample size for each nest shown as frequencies in Figure 16 above.)

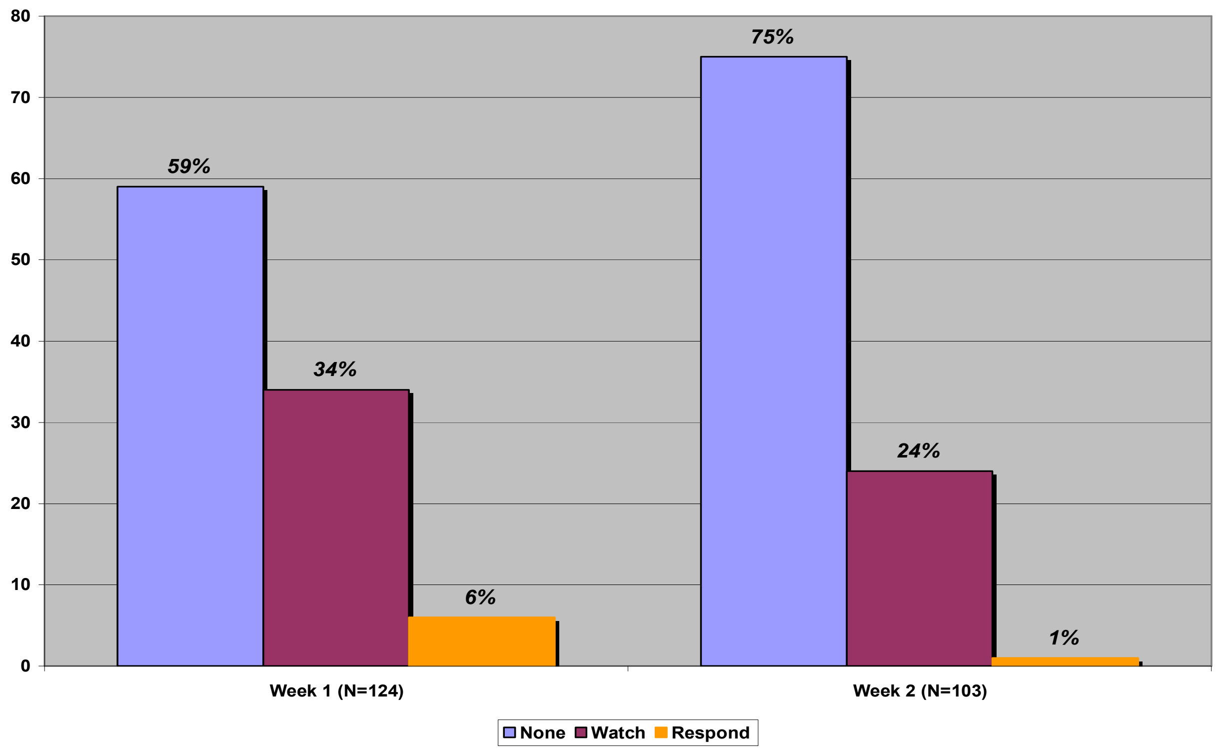


Figure 18. Grouped golden eagle response rates (%) by test week (exposure) durng Apache helicopter flights near nesting eagles (N=227) in northcentral Utah, 2006-2007.

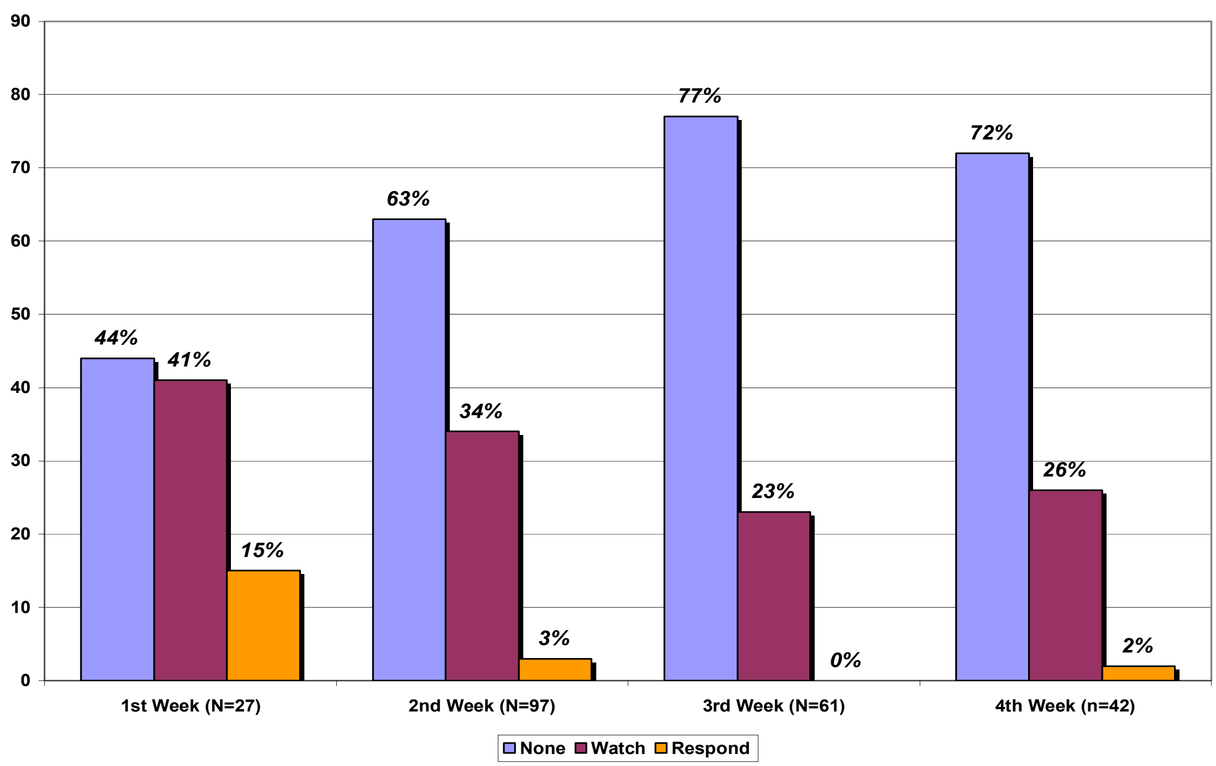


Figure 19. Grouped golden eagle response rates (%) by chronological test weeks in April, combined across years, for Apache helicopter flights near nesting eagles (N=227) in northcentral Utah, 2006-2007.

Sound Analysis

Sound Level Comparison of Helicopter Types - The sound level for all helicopters tested decreased with distance (Table 17, Figure 20). More detailed information on the inverse relationship between distance and sound level for the Apache helicopter is presented below. The Apache was loudest at both test distances, while the Cirque Eurocopter, with its fenestron (enclosed) tail rotor, was quietest. Because decibels are a logarithmic measure and not linear, perceived loudness roughly doubles for every 6 dB increase in sound level. Therefore, the Apache helicopter used throughout our testing was approximately 3 times louder (~9 dB) than a WPG AStar when overhead (108.5 vs 99.0 dB) and at 100 m (106.1 vs 97.2 dB). Ambient sound levels throughout our field testing and helicopter profiling ranged between 44-48 dB. A spectral analysis of the 4 helicopters also shows the Apache loudest throughout the frequency spectrum and the Cirque Eurocopter quietest, but at mid to upper frequencies, the Bell L4 falls between the 2 Eurocopters (Figure 21).

Sound Level Comparison of Apache Test Distances/Profiles - Frequency sprectra for 5 different Apache helicopter test distances (100, 400, and 800 m laterals, or flyby's) and profiles (approach and popout) show that sound energy from more distant flights decreases more rapidly at mid to higher frequencies than at lower frequencies (Figure 22). For all distances/profiles, the highest levels of sound energy occur below about 100 Hz, and thus may be below or at the lower, less sensitive reaches of a golden eagle's hearing sensitivity (Figure 10).

Figure 23, which is a plot of sound level versus time from peak for an Apache approach and popout, illustrates the difference between these 2 profiles. The approach is louder than the popout because the sound of the approaching helicopter is not blocked by the nest cliff; however, as a result, the popout has a much quicker, i.e., steeper, onset rate. After the peak sound when the helicopter passes approximately overhead, the situation reverses, so that the popout is louder longer, decreasing more slowly than the approach whose departing helicopter sound is immediately reduced by the nest cliff. The rapid onset of sound during a popout, coupled with the sudden appearance of the helicopter overhead, are the 2 main factors contributing to a potential startle response, which none of the golden eagles we tested ever exhibited.

Responses at Varying Sound Levels and Distances - We successfully recorded 90 Apache overflights (Figure 24) at known distances from the microphones. Sound level dropped off dramatically with increasing distance, falling from approximately 108.5 dB at 50 m to 81.3 dB at 1000 m. It should be re-emphasized sound levels vary with each specific set of field conditions, even when measuring the same stimulus. Thus, the trend depicted in Figure 24 is of greater value for illustrating the attenuation of Apache sound levels over distance than for offering specific decibel levels at each distance. Nonetheless, during our Apache trials, golden eagles continued to exhibit normal, ambient behaviors across the entire range of helicopter test distances: prey delivery between 0-50 m; tending young from 100 m to >1200 m; tending nests between 200-800 m; preening from 200 to >1200 m; and soaring between 100-400 m. Responses after hatching occurred between 300-400 m (flattening) and 0-200 m (flying). Only 39 of the recorded Apache overflights occurred when microphones were effectively positioned to yield representative sound levels at the nests (Table 18). Sound levels ranged between 76.7-108.8 dB and distances from 50-800 m with no greater recorded golden eagle response than watching the helicopter pass. Microphone placement was confounded by trying to find a location out of the target eagle's view, yet at the same elevation, contour, and equidistant to the intended flight path, all in the typically rugged and often inaccessible terrain around nest cliffs.

Table 17. A comparison of unweighted and "A" weighted SEL (dB) sound levels for 3 civilian helicopters flown at 300 ft AGL and 60 knots, directly overhead and 100 m away from sound recording equipment under simulated test conditions, and similiar flight patterns actually flown by Utah National Guard Apache helicopters at approximately the same altitudes and speeds, over sound recording equipment near nesting golden eagles in northcentral Utah, 2006-2007.

Flight Path	**Recording Scenario (# passes)**	**Helicopter**	**Unweighted SEL (dB)**	**"A" Weighted SEL (db)**	**Ambient "A" Weighted LEQ (dB)**
Overhead	Simulated (4)	Cirque EC130-B4	97.4-97.8	83.0-84.2	44-48
	Simulated (4)	WPG AStar	98.0-99.9	85.7-89.0	44-48
	Simulated (2)	WPG Bell L4	100.4-100.9	86.5-91.1	44-48
	Field tests (5)	*Apache AH-64*	*106.5-110.0*	*94.7-99.3*	*44-48*
100 m Flyby	Simulated (4)	Cirque EC130-B4	96.6-97.0	82.0-82.3	44-48
	Simulated (4)	WPG AStar	97.0-97.3	84.8-85.2	44-48
	Simulated (2)	WPG Bell L4	100.0	84.5-89.0	44-48
	Field tests (25)	*Apache AH-64*	*102.3-109.0*	*88.2-97.1*	*44-48*

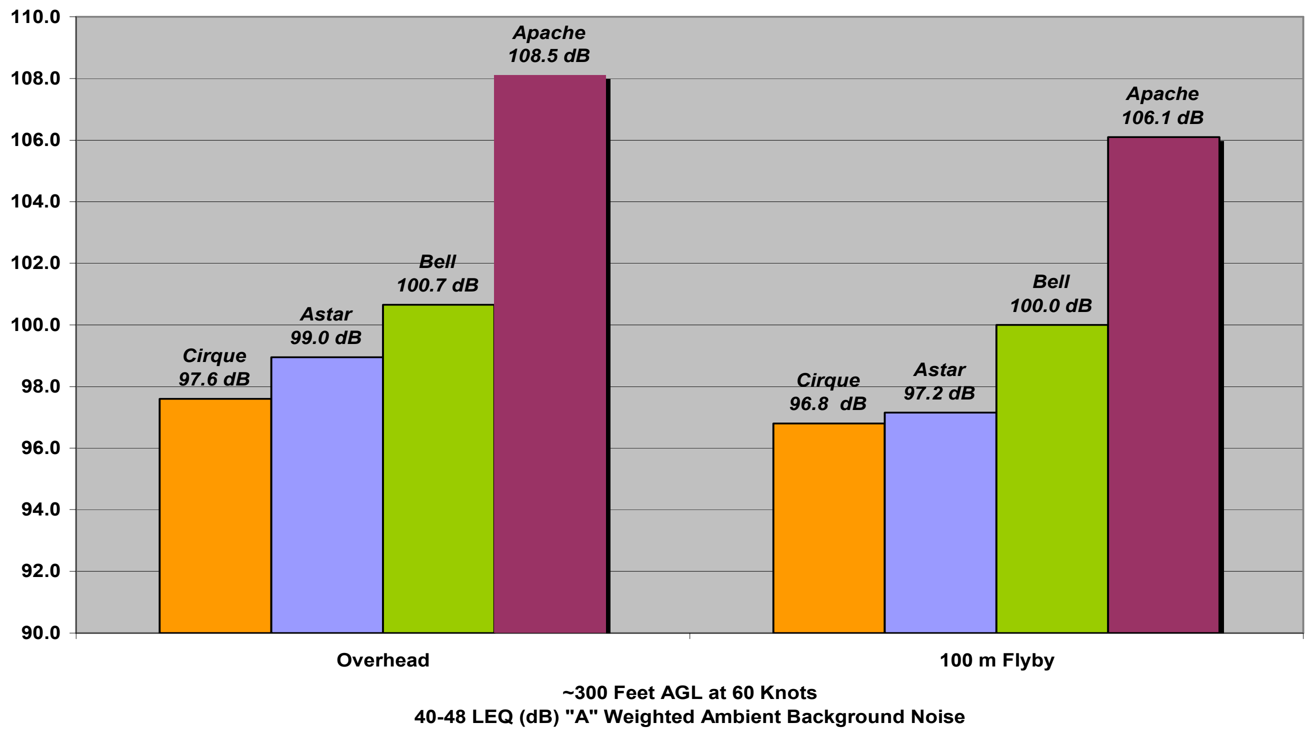


Figure 20. A comparison of mean unweighted SEL (dB) sound levels for 3 civilian helicopters flown at 300 ft AGL and 60 knots, directly overhead and 100 m away from sound recording equipment under simulated test conditions, and similar flight patterns actually flown by Utah National Guard Apache helicopters at approximately the same altitudes and speeds, over sound recording equipment near nesting golden eagles in northcentral Utah, 2006-2007. .

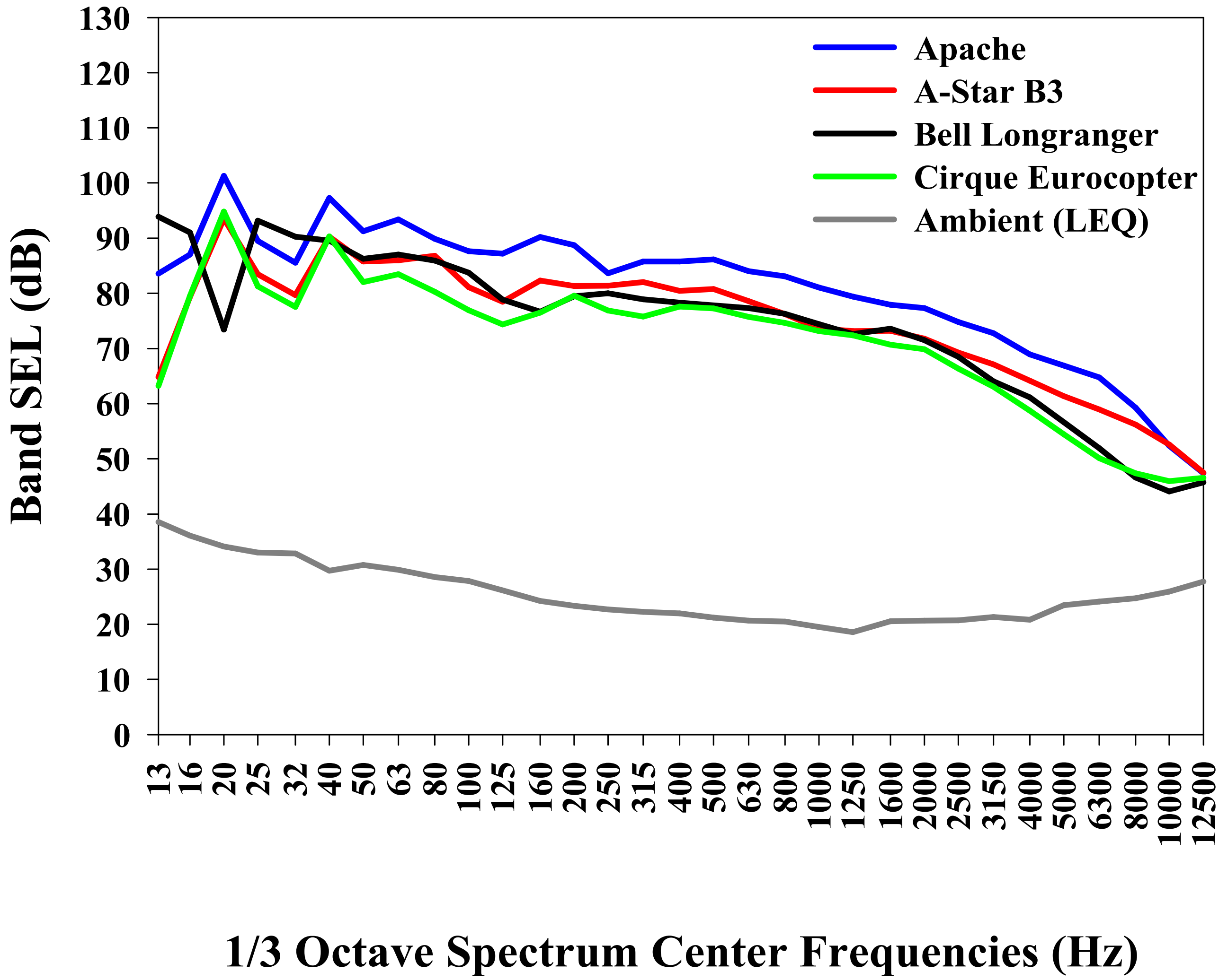


Figure 21. A comparison of unweighted SEL (dB) sound levels, during direct overhead flights at 300 ft AGL and 60 knots, of 4 different helicopters experimentally flown near nesting golden eagles in northcentral Utah, 2006-2007.

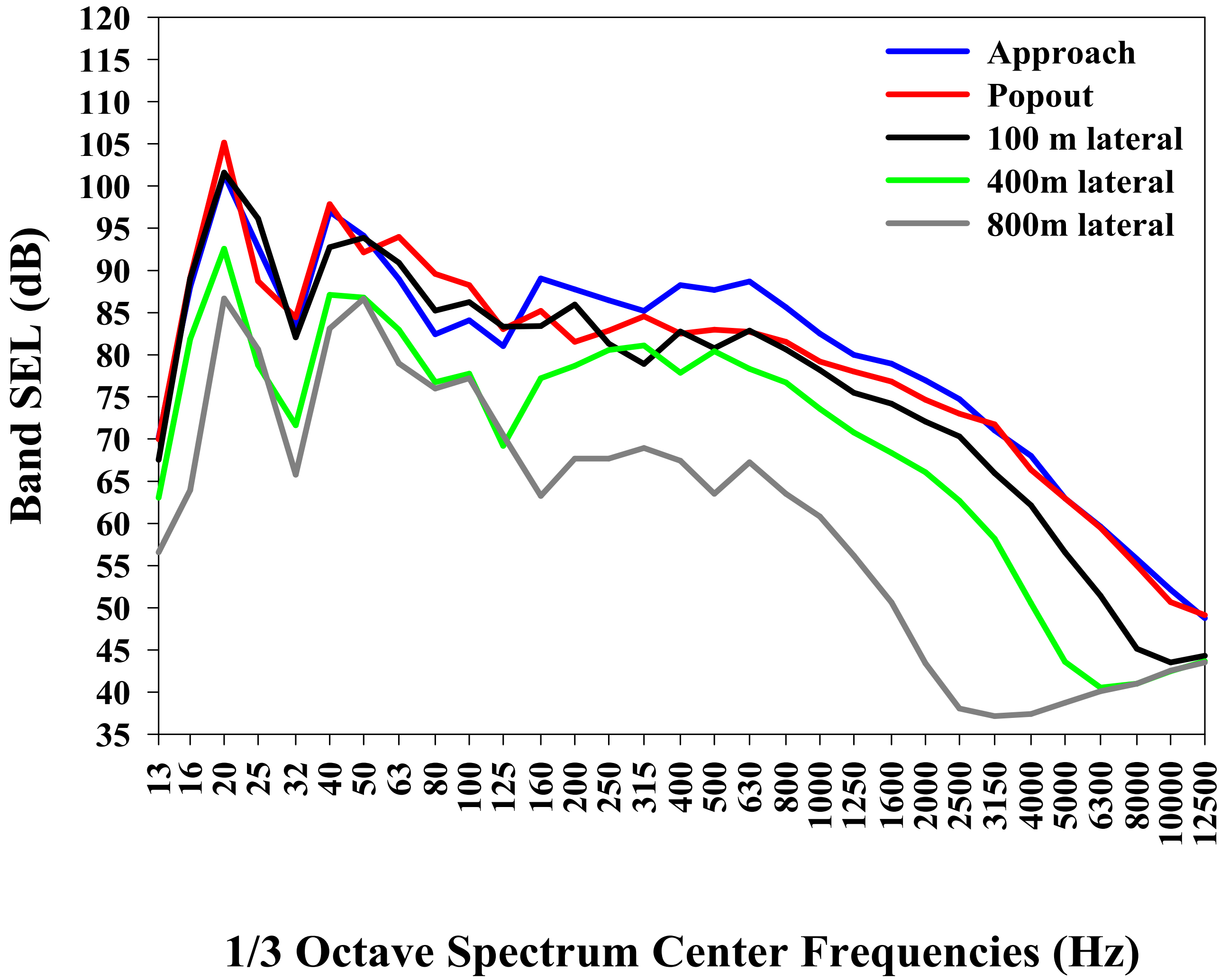


Figure 22. A comparison of unweighted SEL (dB) sound levels of Apache helicopters flying different test patterns and/or distances from golden eagle nests in northcentral Utah, 2006-2007. Observe that sound energy from more distant flights decreases more rapidly at mid to higher frequencies than at lower frequencies.

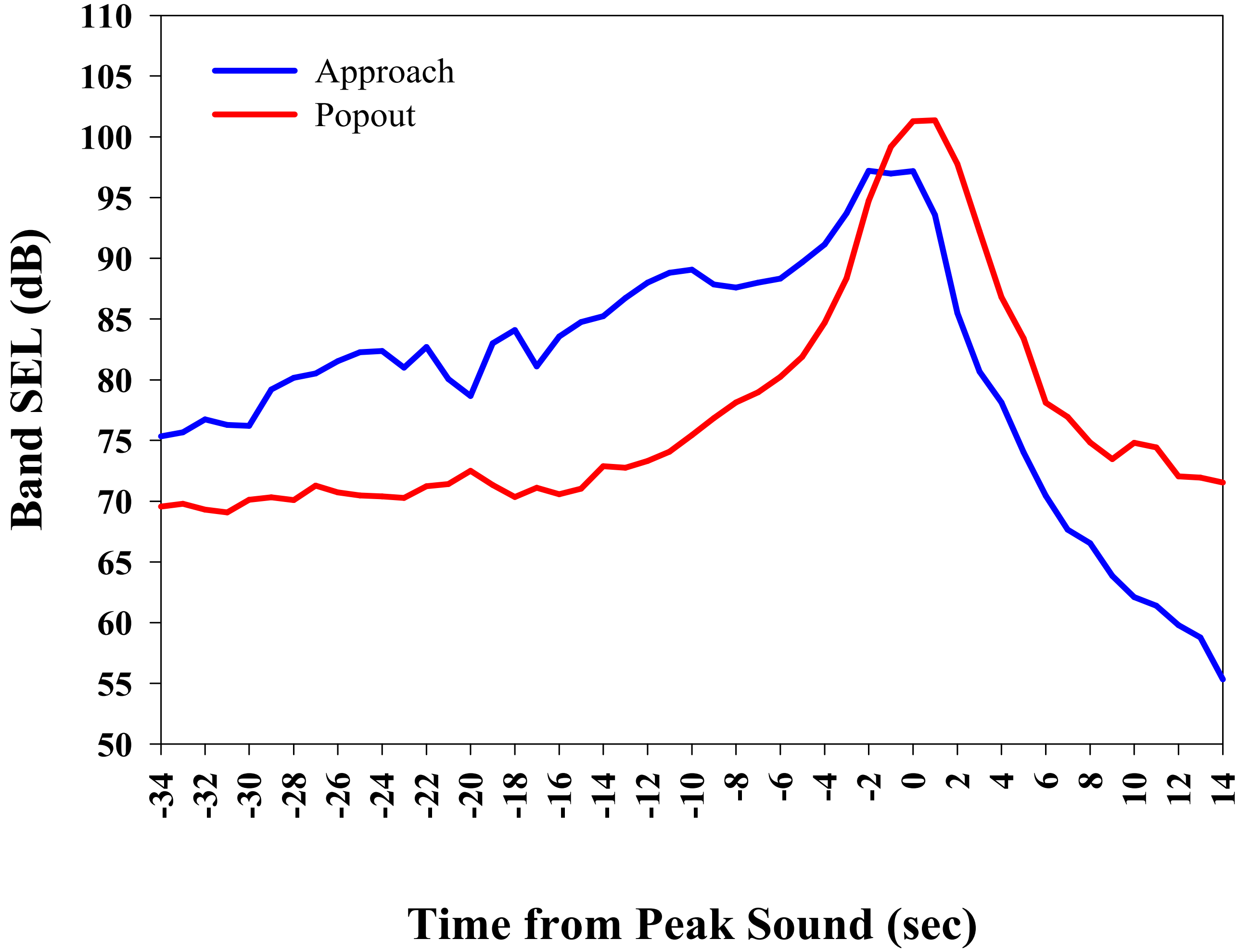


Figure 23. Comparison of unweighted SEL (dB) sound levels and onset times associated with Approach and Popout test flights by Apache helicopters near golden eagle nests in northcentral Utah, 2007.

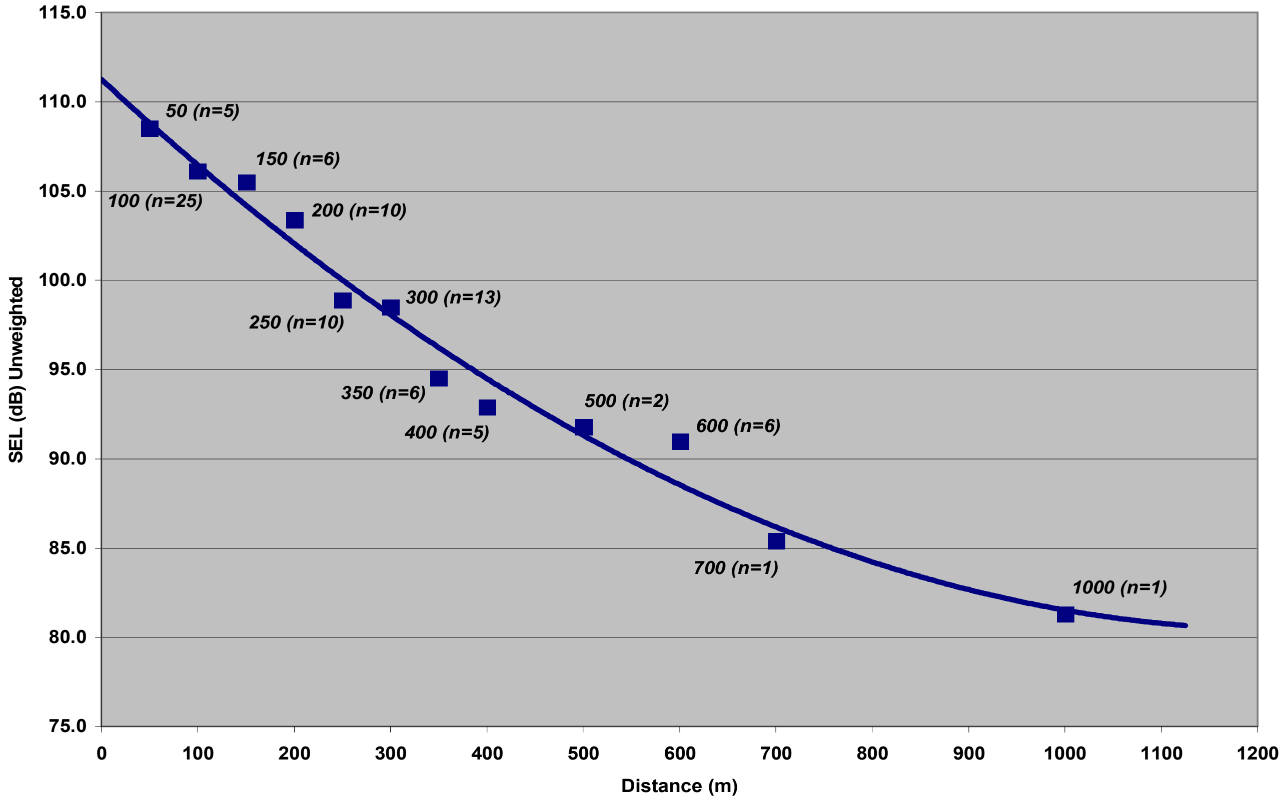


Figure 24. The inverse relationship (polynomial trend line) between sound level and distance as illustrated with average, unweighted SEL (dB) sound levels for 12 distances of Apache helicopters from field recording microphones during flights near golden eagle nests in northcentral Utah, 2006-2007. (dB levels of a representative Approach and Popout shown in Figure 23 were among the range of levels averaged for the 50 m point, which represents 0-50 m.)

Table 18. A list of 39 golden eagle responses and recorded sound levels, when distance between helicopter and microphone was within 50 m of distance between helicopter and observed eagle or nest, during helicopter testing in northcentral Utah, 2006-2007.

SEL(dB) Unwt	SEL(dB) A wt	Obs Dist (m)	Mic Dist (m)	Nest Status	Eagle Activity	Eagle Response
76.7	60.0	400	400	chicks	brooding	none
76.7	60.0	400	400	chicks	brooding	none
83.2	68.7	600	600	eggs	incubating	tracking
85.6	70.0	400	400	chicks	brooding	none
91.6	73.0	400	350	chicks	brooding	tending chicks
91.7	75.7	500	500	eggs	incubating	none
91.7	71.8	800	800	chicks	standing nest	none
92.7	78.2	400	350	chicks	brooding	none
93.7	78.5	500	450	eggs	incubating	look
93.8	84.1	200	250	chicks	brooding	none
95.4	80.0	400	400	eggs	incubating	none
95.8	81.1	300	300	chicks	brooding	none
95.9	86.1	400	350	eggs	incubating	none
96.9	78.7	300	300	chicks	brooding	none
97.3	78.1	250	300	chicks	brooding	glance
97.3	78.1	250	300	chicks	brooding	none
97.8	86.9	300	300	eggs	incubating	looking
98.0	84.3	400	350	eggs	incubating	tracking
99.6	89.9	200	200	chicks	brooding	none
100.1	86.1	300	250	eggs	incubating	none
100.9	89.0	300	250	eggs	incubating	look
101.6	88.8	200	200	chicks	brooding	none
101.6	92.5	200	200	chicks	brooding	none
101.7	84.9	500	500	chicks	standing nest	feeding chicks
102.7	89.7	200	200	chicks	brooding	none
103.1	91.1	100	150	chicks	brooding	none
104.4	92.9	200	250	chicks	standing nest	preening
104.7	91.7	100	100	chicks	brooding	glance
104.8	87.9	100	100	chicks	brooding	glance
104.8	91.5	100	150	chicks	brooding	none
105.1	91.8	100	100	chicks	brooding	none
105.3	90.6	100	150	eggs	incubating	looking

SEL(dB) Unwt	SEL(dB) A wt	Obs Dist (m)	Mic Dist (m)	Nest Status	Eagle Activity	Eagle Response
106.5	91.2	200	200	chicks	brooding	none
106.5	94.7	50	50	eggs	incubating	looking
107.1	92.5	200	150	chicks	standing nest	cleaning nest
107.4	89.9	200	100	chicks	brooding	none
108.2	92.8	200	150	chicks	standing nest	preening
108.5	94.0	200	200	chicks	brooding	none
108.8	92.5	100	100	chicks	brooding	none
76.7-108.8 dB		**50-800 m**		**11 eggs 28 chicks**		**24 none 10 watching 5 ambient behavior**

CONCLUSIONS

Recreation/Population - The size, proximity, and outdoor orientation of the Greater Salt Lake City/Wasatch Front population almost certainly has a pervasive, underlying effect on all golden eagles nesting not only in the Tri-Canyon Area, but throughout central and northern Utah. There are significant, if not amazing, levels of human activity in the Tri-Canyon Area itself, in addition to the WPG operations under current study.

Golden Eagle Surveys - Historic records for Tri-Canyon Area golden eagle nesting are sketchy at best, with only 8 years of confirmed nesting between 1981-2007. Observations during apparent non-nesting years are inconclusive. The 6 historic and originally buffered Tri-Canyon Area nest sites (Mineral Fork, Reed & Benson North and South, Silver Fork, Honeycomb, and American Fork) represent 4-5 separate golden eagle breeding areas, none of which have been consistently occupied or active over the last 30 years. This is most likely related to the fact that Tri-Canyon Area nest sites are on the elevational periphery of the golden eagle's breeding range in Utah, and are therefore subject to the exaggerated effects of harsh weather and ephemeral prey conditions. Nonetheless, there are approximately 20 documented golden eagle territories along the Wasatch Front from Parley's to Provo Canyons, of which the Tri-Canyon Area is a portion. Several of those sites, within or near the Cottonwoods, remain as intermittently occupied and successful as the Tri-Canyon sites, despite the higher levels of human activity and helicopter traffic associated with their closer proximity to the Salt Lake metropolitan area.

Manipulated versus Non-Manipulated Nest Sites - Multiple exposures to helicopters during our experimentation in 2006 and 2007 had no effect on golden eagle nesting success or productivity rates, within the same year, or on rates of renewed nesting activity the following year, when compared to the corresponding figures for the larger population of non-manipulated sites annually monitored by Kent Keller.

WPG Operating Trends - During the 34 year period from 1974 through 2007, WPG annual trends in operating days (average, 62.4) and total helicopter hours (average, 210.6) have remained essentially level, while skier days (average, 761.0) have gradually increased.

WPG Operations Near Golden Eagles - The frequency and timing of WPG helicopter flights in the same drainages as the only confirmed active golden eagle nests in the Tri-Canyon Area since 1981 evidence a lack of effect on subsequent nesting activity or success, despite many of those flights occurring during early courtship and nest repair. The continued, documented presence of breeding golden eagles in the Tri-Canyon Area for nearly as long as WPG has been operating (since 1974), plus the simultaneous, exponential growth in local human population and recreational activity over the same period, argues against a long term detrimental effect, while also implying a potential pattern of tolerance, adaptability, and habituation that may be atypical for this species.

Combined Helicopter Summary - During our active testing and passive observations in northcentral Utah, including the Tri-Canyon Area, we found no evidence that helicopters bother golden eagles nor disrupt nesting. In 303 helicopter passes near eagles, we observed no significant, detrimental, or disruptive responses, and the only reactions beyond watching the helicopter occurred after hatching. Incubating eagles if they responded at all, did no more than watch, regardless of distance or flight profile of the test helicopter.

Mineral Fork Helicopter Observations - Consolidated records of helicopter activity, including WPG normal operations, mitigation survey flights, simulated heli-skiing flights, and an Apache test, near the Mineral Fork nest during 2006-2007, indicate no effect on the successful nesting of this high-profile Tri-Canyon pair of golden eagles.

Specific Responses to WPG and Apache Helicopters - Our Apache helicopter testing approximated WPG normal operations in pattern, timing, and duration. During the Apache testing, 4 (possibly 3) golden eagles accounted for 5 flatten and 3 fly behaviors at 3 nest sites during this 2-year study. None of these responding pairs failed to successfully fledge young, except for 1 nest that fell later in the season. For WPG observations, 2 eagles accounted for 2 fly behaviors, 1 of which appeared totally unrelated, at 2 locations. All other fly's for both helicopters were interpreted as the aircraft precipitating an imminent departure, more than eliciting an excited, startled, avoidance reaction, which we never observed.

Apache Helicopter Testing - 96% of 227 experimental passes of Apache helicopters at test distances of 0-800 m from nesting golden eagles resulted in no more response than watching the helicoper pass (30%). No greater reactions occurred *until after hatching* when the 3 fly's occurred at ≤200 m helicopter distance, and the 5 flattens at ≤400 m. Non-attending eagles or those perched away from the nests were more likely to fly than attending eagles, but also with less potential consequence to nesting success. Golden eagles appeared to become less responsive with successive exposures.

Sound Analysis - Apache helicopters used in our experimental test flights near golden eagles were about 3x louder than civilian helicopters used by WPG. Sound decreased with distance, and most dramatically when flights were perpendicular to cliff and ridge lines. Much of helicopter sound energy may be at a lower frequency than golden eagles can hear, thus reducing expected impacts. We found no relationship between helicopter sound levels and corresponding eagle ambient behaviors or limited responses, which occurred throughout recorded test levels (76.7-108.8 dB, unweighted).

RECOMMENDATIONS

Primary Recommendation - Eliminate golden eagle considerations entirely from the WPG Special Use Permit, since there is no evidence that WPG interferes with successful golden eagle nesting in the Tri-Canyon Area, or in fact, that WPG heli-skiing bothers local eagles at all.

Alternative Recommendation - If this is not appropriate in light of recent FWS bald and golden eagle management guidelines, then reduce existing buffers to 100 m around recently occupied nest sites, which is consistent with those guidelines for the reasons outlined below. It is further recommended that these buffers either be made semi-permanent, contingent on a determination of continued site occupancy from the mitigation flights; or if applied seasonally, they need not be imposed before 15 March because of the late onset of egg-laying and incubation at the high elevations of the Tri-Canyon Area.

American Fork Recommendation - Contrary to all expectations and previous experience, we also found no evidence that landing atop the ridge near the American Fork nest cliffs, during normal heli-skiing operations, would have any effect on the occupancy, activity, or success of that nest site. If our Primary Recommendation is applied, then the question of a variance at this site is moot. If buffers are deemed appropriate, then our results indicate a variance permitting WPG access to Eagle Run would have no harmful effect on any potential golden eagle nesting, and is therefore recommended.

Mitigation Flight Recommendation - If mitigation flights to survey for occupancy/activity of historic Tri-Canyon Area golden eagle breeding areas are continued, their timing should be rescheduled so the first survey is flown during the first week of April, and the second, later follow-up survey is flown during the first week of June. This timing will better accommodate the later nesting of golden eagles in the rugged mountains of Tri-Canyon Area.

Background/Justification - For the specific question of WPG operating in the Tri-Canyon Area without potentially impacting nesting golden eagles, we found no evidence that special management restrictions are required. WPG and golden eagles successfully coexisting for more than 30 years in the same drainages argue against negative impacts. Our direct and indirect observations indicated no avoidance behavior nor even concern by golden eagles to helicopters; rather if anything, they seemed to show a casual interest in helicopters and heli-skiing. In addition, the lack of significant responses or detrimental effects on nesting success during our extensive testing with the bigger, louder Apache helicopters, which included flying directly towards, or popping out suddenly overhead from behind cliff nests, further reduces management concerns. Finally it should be noted the only reactions recorded during this project occurred after hatching, which in the Tri-Canyon Area does not happen until approximately 4-6 weeks after WPG's season usually ends on 15 April. Thus, to summarize: 1) there is minimal overlap between golden eagles and WPG at these higher elevations, with nesting occurring later than historically thought; 2) even when there is simultaneous presence, golden eagles do not seem to be bothered or disrupted by WPG; and 3) should egg-laying and incubation begin while WPG is still operating, incubating golden eagles are so reluctant to fly that they are not likely to do so even if they were disturbed by WPG's helicopters, which our findings say they are not.

Results of this research speak directly to the 4 considerations outlined by Romin and Muck (2002) important to establishing site-specific buffers (see Literature Review). A typical WPG heli-skiing operation may only have a helicopter at any 1 location for about 6 min during any given hour, and this usually only happens 1-2 times in any given day, and rarely on consecutive days. The rugged, high-relief topography of the Tri-Canyon Area should significantly reduce any proposed buffer distance requirements because of inherent line of sight and sound buffering across intervening ridges. Plus, nests in the Tri-Canyon Area are typically on tall cliffs well below ridges where their natural placement provides an inherent buffer from helicopters landing nearby, and skiers navigating adjacent runs. Between all the other aircraft and human activities occurring in the Tri-Canyon Area, as well as their long term coexistance with WPG and apparent indifference to current operations, golden eagles in the area seem well acclimated to current levels of activity. Finally, the number of breeding areas under consideration in the Tri-Canyon Area is but a portion of a larger, continuous golden eagle population along the Wasatch Front, all the individual sites of which appear to be intermittently occupied, active, and successful related more to natural phenomena than human interference. This broader context tends to lower the management priority for a limited number of selected sites.

Relating to the 2007 National Bald Eagle Management Guidelines (FWS), golden eagles in the area certainly have demonstrated a tolerance not only to WPG operations but to helicopters in general, given historical records and direct observations of WPG operations, as well as our Apache helicopter testing. Excepting recommended helicopter buffer distances based on this evidence, there remains then the 330 ft (100 m) buffer recommended for both OHVs, and non-motorized recreation and human entry, which given the other site-specific considerations mentioned above, may be appropriate for the present circumstances relating to WPG activities on the ground near golden eagle nests in the Tri-Canyon Area.

Direct observations and historic indications of the Reed & Benson golden eagles' tolerance to WPG helicopters frequenting the same ridge, Mineral Fork's continued success in the presence of WPG operations, our specific experimental testing with approach's and popout's, as well as overall project results, are the basis of our recommended variance for American Fork should buffers be retained.

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