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Abstract.—Studies of cliff-nesting raptors can be challenging because direct observations of nest contents are difficult. Our goals were to develop a protocol for installing motion-activated trail cameras at Golden Eagle (*Aquila chrysaetos*) nests to record diet information and productivity, and to estimate prey detection probability using different diet study methods. In 2014 and 2015, we installed cameras at 12 Golden Eagle nests with 18–42-d-old nestlings. Following installation, we monitored adult behavior using direct observation and post-installation image review. At two nests, adult eagles did not return to nests or exhibited behaviors suggesting avoidance of the cameras, but returned to the nests after cameras were removed. We visited the 10 remaining nests every 4 d to collect prey remains and pellets to generate prey-specific detection estimates for both images, and prey remains and pellets. Compared to inspection of prey remains and pellets, cameras recorded twice the number of prey (622 vs. 316), were more likely to detect the smallest and largest prey, and cost half as much. Cameras recorded productivity, fledging dates, and in one case, a nestling death. Trail cameras may be a reliable and cost-effective option to address clearly defined research goals and obtain required information about eagle behavior and nest contents. However, cameras should be used judiciously because installation creates a persistent manipulation at the nest. Camera appearance should be minimized, and post-installation monitoring that allows for timely responses to nest-avoidance behavior by adult eagles is important to prevent adverse effects on nesting success.

Key Words: *Golden Eagle*; Aquila chrysaetos; *behavior*; *diet*; *disturbance*; *methods*; *prey*; *raptors*; *remote-sensing*.

USO DE CÁMARAS DE FOTOTRAMPEO ACTIVADAS POR MOVIMIENTO PARA ESTUDIAR LA DIETA Y LA PRODUCTIVIDAD DE *AQUILA CHRYSAETOS* NIDIFICANDO EN ROQUEDOS

Resumen.—Los estudios de rapaces que nidifican en roquedos pueden representar un desafío debido a la dificultad de observar de forma directa el contenido de los nidos. Nuestro objetivo fue desarrollar un protocolo de instalación de cámaras de fototrampeo activadas por movimiento en nidos de *Aquila chrysaetos* para obtener información sobre su dieta y productividad y estimar la probabilidad de detección de presas comparado con diferentes métodos de estudio de la dieta. En los años 2014 y 2015 instalamos cámaras en 12 nidos de *A. chrysaetos* con polluelos de 18–42 d de edad. Tras la instalación, seguimos el comportamiento de los adultos usando observaciones directas y revisión de imágenes. En dos nidos, las águilas adultas no retornaron a los nidos o mostraron comportamientos de evasión de las cámaras, pero regresaron a los nidos tras la extracción de las cámaras. Visitamos los 10 nidos restantes cada 4 d para colectar egagrópilas y restos de presas para obtener estimaciones de detección específica por presa, tanto para las imágenes como para las egagrópilas y restos de presas. En comparación con la inspección de egagrópilas y restos de presas, las cámaras registraron el doble de presas (622 vs. 316), fueron más efectivas para detectar presas más pequeñas,

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y redujeron el coste a la mitad. Las cámaras registraron productividad, fechas de emplumamiento, y en un caso, la muerte de un pollo. Las cámaras de fototrampeo pueden ser una opción fiable y de bajo costo relativo para evaluar objetivos de investigación claramente definidos y obtener la información requerida sobre el comportamiento y el contenido de los nidos de las águilas. Sin embargo, las cámaras deber ser usadas con cuidado debido a que su instalación genera una manipulación persistente en el nido. Es fundamental minimizar la exposición de la cámara y su seguimiento tras su instalación, permitiendo una respuesta en tiempo y forma al comportamiento de evasión de los nidos por parte de las águilas adultas con el fin de prevenir efectos adversos sobre el éxito de cría.

[Traducción del equipo editorial]

Information on raptor diet, delivery of prey to young, and productivity are important for understanding basic ecological relationships and assessing possible threats to successful reproduction. Unfortunately, observation of nest contents and bird behavior in cliff nests can be challenging because it is often difficult to see into the nest without being in close proximity or directly accessing the nest. Repeated human visits may disturb adults leading to decreased nest attendance (Spaul and Heath 2017) or have negative effects on nesting success (Brambilla et al. 2004, Arroyo and Razin 2006, González et al. 2006, Martínez-Abraín et al. 2010). Cost-efficient methods that decrease researcher disturbance and accurately record bird behavior and nest contents are necessary for collecting valuable information on the ecology of cliff-nesting raptors.

One commonly used method to study raptor diets is inspection of pellets and prey remains collected at the nest (Simmons et al. 1991, Marti et al. 2007, Bedrosian et al. 2017). This approach requires repeated visits and may be biased towards large prey that have inedible parts (e.g., feathers; Marti et al. 2007). Other researchers have used a spotting scope or telephoto lens to take images of prey deliveries from a distance, but this method requires an observer to be present, and therefore is labor intensive (Jenkins 1978, Korňan and Macek 2011, Shafaeipour 2015a). Alternatively, remotely controlled or motion-activated cameras, or video-recording equipment, have been used to study diets of eagles (Dykstra et al. 2002, López-López and Urios 2010, Longshore et al. 2015), falcons (Booms and Fuller 2003, Robinson et al. 2015), vultures (Margalida et al. 2006), and accipiters (Miller et al. 2014), among others. This approach requires fewer visits to a nest but, in the past, the use of cameras in the field was limited because of the equipment expense and labor (e.g., repeated changing of heavy power sources). Technological advances have decreased the cost and improved the portability of video and motion-activated still cameras, making them an excellent option for remote monitoring via fixed installation at the nest or unmanned aerial vehicles. However, fixed camera installation creates a persistent change in the nest environment that may disturb nesting birds, so best practices for camera installation and use are necessary. Further, for diet research, understanding the accuracy of cameras relative to historical methods is important for comparing results across studies that use different methods.

Golden Eagles (*Aquila chrysaetos*) are a federally protected species under the Bald and Golden Eagle Protection Act (16 U.S.C. 668–668c) and the Migratory Bird Treaty Act (16 U.S.C. 703–711). In western North America Golden Eagles continue to face multiple threats including development (Hunt 2002, Smallwood and Thelander 2008), disturbance (Pauli et al. 2016) and habitat degradation or loss (Kochert and Steenhof 2002, Watson 2010). More information about diet and productivity is needed to understand how to best manage eagles in changing landscapes. Monitoring eagle diet and productivity can be difficult because Golden Eagles often nest on cliffs or rocky outcrops. Nests can be challenging to access, and adult eagles are sensitive to human disturbance and can be wary of changes in their environment (Takeuchi et al. 2006, Shafaeipour 2015b, Spaul and Heath 2016). Our objectives were to develop a minimally invasive method for installing motion-activated trail cameras at Golden Eagle cliff nests, evaluate the effectiveness of cameras for recording diet compared to inspection of prey remains and pellets, and use cameras to document fates of Golden Eagle nest attempts.

Methods

We conducted our study in the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho (43°08′N, 116°04′W) during the breeding seasons (March–July) of 2014 and 2015. During these months, minimum temperatures range from −1 to 13°C and maximum temperatures range from 12 to 34°C with 5 to 32 mm of rain (US Climate Data 2018). The native vegetation is characteristic of shrub-steppe and salt-desert shrub communities and the principal physiographic feature of the NCA is the Snake River Canyon where Golden Eagles nest on the steep canyon walls (US Department of the Interior 1996). We surveyed nesting territories for occupancy in March and every 2 wk we followed up with surveys of occupied territories to determine nest location and record nesting attempts (Heath and Kochert 2016). We estimated the age of young eagles based on their plumage using aging guides (Hoechlin 1976, Driscoll 2010). We installed Bushnell 8MP Trophy Cam© HD motion-activated cameras with 32-gigabyte memory cards at Golden Eagle nests when we estimated nestlings to be at least old enough to thermoregulate, approximately 21 d old (Kochert et al. 2002). We selected nests for camera installation based on the physical characteristics of the nest cliff that allowed for a team to safely rappel into a nest and install a camera. We entered nests containing cameras every 4 d to collect prey and pellet remains. During these visits we checked the status of the batteries and downloaded memory cards. Images were stored on a hard drive until they could be reviewed.

Cameras were 30 × 19 × 7.5 cm and had a camouflage exterior. Initially, we installed unaltered cameras ($n = 2$), but found that the glossy plastic created a glare from the sun. Before we installed the subsequent 10 cameras, we painted the front and sides of cameras with a matte spray paint similar to the color of the rock where the camera was to be mounted. We covered the camera lens, motion sensor, flash, and light sensors with duct tape prior to painting. While the paint was still wet, we dusted the camera with dirt and dust to give the camera the appearance and texture of rock, and to reduce reflection from the sun. After the paint had dried we removed the tape from the lens, motion sensor, and light sensor, but left the flash covered to keep it from reflecting sunlight.

Camera Settings and Installation. We used a 1-min shutter delay between motion-activated photos to maximize the probability of recording each prey delivery while minimizing the likelihood that the 32-gigabyte memory card would fill with images of eagles moving on the nest. We used the maximum resolution of 8 megapixels to ensure that prey items were identifiable in image review. We left the sensor sensitivity on "normal" for 11 of 12 installations. At one nest we set the sensor level to "high" because the camera was farther (approximately 4 m; Table 1) away from the nest and to ensure that motion activated the camera.

We installed cameras during fair temperatures (10–21°C) and no precipitation to reduce the chances of negatively affecting the nestlings if adults did not return quickly. We avoided times when the nest would be exposed to the sun during or after installation, or if nighttime temperatures would be too cold. We checked the nest with a spotting scope before installation and delayed installation if we observed an adult shading or brooding a nestling.

Once at the nest, we selected locations for camera installation that would maximize concealment and optimize nest coverage and light angles (Fig. 1). We employed different installation methods, depending on the substrate and features at and around the nest. The most common method involved drilling a hole through the back of the camera housing, inserting a machine bolt through the hole, and sealing the hole with common household silicone sealer. We drilled into the cliff using an 18-volt battery powered drill and masonry bit, placed two-part epoxy putty and silicone into the hole to secure the mount, and screwed the bolt (with the camera) into the cliff. While the epoxy and silicon were hardening, the camera was shimmed to capture as much of the nest as possible, using small rocks or sticks found around the nest, and then held in place until the epoxy dried. We examined test photos from the trail camera memory card with a point-and-shoot digital camera while at the nest to ensure that the entire nest was being captured and made adjustments as necessary.

Post–installation Monitoring. We used one of two approaches for monitoring adult behavior in response to the camera after every installation. If a distant (approximately 800 m) observation site allowed a view of the nest, a trained observer watched the nest for up to 4–5 hr after installation. We considered an installation successful when an adult returned to the nest to tend and feed the young within the observation window. Alternatively, we left the nest after the camera installation and returned later in the day, or the next morning if overnight weather conditions were warm (>10°C), to review images from the camera to verify that adult eagles returned. Also, we examined the nest for new prey items and checked the nestling for an enlarged crop which would indicate that the adult had fed the nestling after the installation. In either case, if there

Table 1. Information on motion-activated camera installation at cliff-nests of Golden Eagles in the Morley Nelson Snake River Birds of Prey National Conservation Area, Idaho. Rows are ordered by installation date from first to last. Number of previous visits refers to the number of nest entries made prior to the installation of the camera at the nest. When two or more young were in the nest, Age of Young represents the median age of the nestlings. Distance is the estimated straight-line distance between the camera and the center of the nest. We show whether we added camouflage to the camera, the amount of time until adults returned and perched at the nest, the total number of nest entries we made to each nest during the breeding season that year, our method of post-installation monitoring for adult eagle avoidance behavior, and the number of young eagles that fledged from each nest.

Territory	Year	Date Installed	Number of Previous Visits	Age of Young (d)	Distance (m)	Added Camouflage	Adult Return Time (min) After Camera Installation	Total Number of Visits	Post-installation Monitoring[a]	Number of Young Produced[b]
Pole 369[c]	2014	18 Apr	0	18	<1	No		10	CC	2[d]
Rapids[c]	2014	2 May	2	25	2.5	No		12	DO	2[d]
Cabin	2014	17 May	3	35	1.5	Yes	130	9	CC	1
Crater Rings	2014	12 May	0	23	1.5	Yes	69	6	DO	0[e]
Narrows	2014	25 May	8	40	3	Yes	134	11	CC	2
Waterfall	2015	13 Apr	1	19	3	Yes	256	12	CC	2
Cabin	2015	19 Apr	1	18	2	Yes	80	13	CC	1
Pump station	2015	21 Apr	1	22	3	Yes	29	13	CC	1[f]
Commeford	2015	3 May	3	20	2	Yes	82	13	DO	2
A-58	2015	13 May	3	21	4	Yes	205	11	CC	1
Crater rings	2015	17 May	2	35	1.5	Yes	70	12	DO	2
Chalk Gulch	2015	19 May	0	42	1	Yes	127	4	DO	2

[a] CC = camera check, DO = direct observation.
[b] Number of young reaching age of 51 d, considered acceptable fledging age (Steenhof et al. 2017).
[c] Camera removed.
[d] Determined through observation and nest visits.
[e] Died from premature fledge from nest at 42 d old.
[f] Died from fall from nest at 56 d old (post-fledging-age mortality).

Figure 1. Image of a motion-activated camera installed to monitor Golden Eagle diet and productivity. The camera is concealed in a rocky crevice (left) and is flush against the cliff at a distance of >2 m from the nest (right, camera is highlighted by white box).

was no evidence of adults returning to the nest, we removed the cameras.

Eagle Dietary Assessments. We reviewed all camera images to identify delivered prey items and recorded the date, time, species, size class, and if possible, sex of the prey. In addition, we recorded prey remains and collected pellets at the nest every 4 d (see Heath and Kochert 2016 for details). We examined inedible prey remains and pellets in the laboratory. Species, size, and sex of prey items were ascertained by comparison with study skins and taxonomic keys. We tallied the frequency of all unique prey items collected from each nest visit. The number of individual prey was calculated from a maximum count of body parts (e.g., two right femurs represented two individuals; see Mollhagen et al. 1972, Steenhof and Kochert 1985). We assigned weights to individual prey according to their species, size, and sex based on average weights reported by Steenhof (1983).

Data Analysis. We treated each method (camera images, and inspection of prey remains and pellets) as an observer and followed a double-observer method of data analysis to assess whether detection probability differed between methods and to estimate total number of prey (Moore et al. 2004). For the eight most commonly detected prey species, we created detection histories where the two methods were treated as distinct sampling occasions. A detection via an inspected prey item was considered a capture during the first occasion and detection via a camera image was a capture during the second occasion. Sampling occasions for prey were linked through matching of time, date, and nest identity in both the image data and prey and pellet data. From these detection histories we used the Huggins Closed Capture (Huggins 1989, 1991) model in program MARK (version 8.0; White and Burnham 1999) to model detection and abundance. We fixed the probability of recapture to be equal to the probability of capture in occasion 2 to ensure independence of detection probability estimates. We ran candidate models of observation method, species, interaction between method and species, and an intercept-only model. We modeled all data for the eight most common prey species simultaneously to estimate the detection probability of each species for each method and the total estimated number of each prey item brought back to all nests. We did not account for year or territory effects in the model. We used the abundance estimates from the Huggins Closed Capture model to estimate percentage of prey items by species to compare corrected to naïve diet estimates. We assessed productivity through follow-up visits and review of camera images that showed nest departure of young eagles.

We analyzed cost expenditures for different diet study methods by summing the costs associated with each method over the course of the investigation at one representative territory located 96.5 km from the field station (a round trip of 193 km). We assumed a mileage rate of $0.48 (USD), crews working in pairs with each person earning $14 per hr, one nest visit to install and remove the camera, one "in-progress" visit to check batteries or memory cards, and a total of 10 nest visits for the prey-and-pellet collection approach. We summed the costs associated with transportation, personnel (including post-installation monitoring and image review), and camera equipment.

We used terms and definitions described in Steenhof et al. (2017). Fledging occurred when young left the nest voluntarily for the first time. A fledgling was a fully feathered young that had voluntarily left the nest but had not dispersed from the nesting territory. A nesting territory was a confined locality where nests were found, usually in successive years, and where no more than one pair was known to have bred at one time. An occupied nest was a nest that contained eggs, young, or an incubating bird, or had a pair of birds on or near it, or had been recently repaired or decorated. An occupied nesting territory was a nesting territory inhabited by a pair of birds, as evidenced by an occupied nest (see above) or a pair of birds copulating, displaying, or defending a nest. Our evaluation included only those nesting pairs that hatched at least one egg and thereby initiated a brood-rearing attempt. Productivity was defined as the number of young that reached 51 d, which we report as the number of young per brood-rearing attempt. Research was authorized by the Bird Banding Laboratory (20537 and 23307), State of Idaho (071119), and Boise State University's Animal Care and Use Committee (006-AC14-007).

Results

We installed cameras at five Golden Eagle nests in 2014 and seven in 2015 (Table 1); two territories contained a camera in both years. Young ranged from 18–42 d old when cameras were installed. Installation time, recorded as the duration between arrival at and departure from the nest, ranged from 19–46 min ($\bar{x}$ = 34 min). For comparison, prey remains and pellet collection ranged from 5–15 min with a frequency of 4–13 visits per nest. We removed two cameras in 2014 because the adults did not return to the nest after installation. At one nest, an adult did not return to the nest within the observation period and at another nest adults did not return overnight. These cameras were unpainted, close (<1.0 and 2.5 m from the nest), poorly concealed, and highly visible because of mounts that held the camera away from the cliff to improve the view of the nest. At the 10 nests where adult eagles returned, cameras were painted, farther away (1–4 m), concealed, and mounted close to the cliff. On average, adults returned to these nests in 118 min (range = 29–256 min) after the climber left the nest.

We did not need to replace AA lithium batteries during the course of the study for the 10 cameras installed at nests, but we did replace AA alkaline batteries every 12–24 d depending on the number of images collected per day. We replaced memory cards during our prey and pellet nest visits so cards did not fill with images. Although the flash was covered with one layer of tape to reduce reflection, the covered flash and camera recorded images in low-light conditions and at night because the light of the flash showed through the tape. Adult eagles did not bring prey to the nest at night, but the camera captured movement of eagles in the nest.

We identified 622 individual prey items representing 33 species of prey from the camera images compared to 316 individual prey items representing 31 species of prey using prey remains and pellets. We categorized 40 (6%) prey items as unidentified from the camera images and 34 (11%) prey items as unidentified from prey remains and pellets. Unidentified avian prey was the most common (32%) unidentified category based on inspection of prey remains and pellets, and unidentified mammal was the most common (17%) unidentified category for camera images. The most supported candidate model to explain detection probability was an

Table 2. Candidate models, AIC_C, ΔAIC_C, model weights, likelihood, and number of parameters (K) in models to explain detection of prey species observed in Golden Eagle nests. The variable "observation method" allowed for differences in detection probability between prey data collected via review of camera images versus inspection of prey remains and pellets.

MODEL	AIC_C	ΔAIC_C	AIC_C WEIGHTS	MODEL LIKELIHOOD	K
Observation method × Species	946.4	0.0	1	1	16
Observation method	1125.0	178.7	0	0	2
Species	1291.9	345.5	0	0	8
Intercept-only	1327.8	381.5	0	0	1

interaction between method and species (Table 2). Detection probability for the eight most common prey species ranged from 0.33–0.91 for camera images and 0.10–0.78 for prey remains and pellets (Fig. 2). The two smallest and one largest prey species were detected more often via review of camera images than by inspection of prey remains and pellets (Fig. 2). Mid-sized items were detected at similar rates, and inspected prey remains and pellets detected Mallards (*Anas platyrhynchos*) more often than camera images. The eight most common species represented 35% of the items identified from cameras and 31% of the items identified from prey and pellet remains. Differences in detection probabilities between the two methods resulted in different estimates of diet composition (Fig. 3).

In 2014, the three pairs with cameras produced an average of 1.0 young per brood-rearing attempt (range = 0–2; Table 1). The unsuccessful 2014 camera nest was heavily infested with ectoparasites,

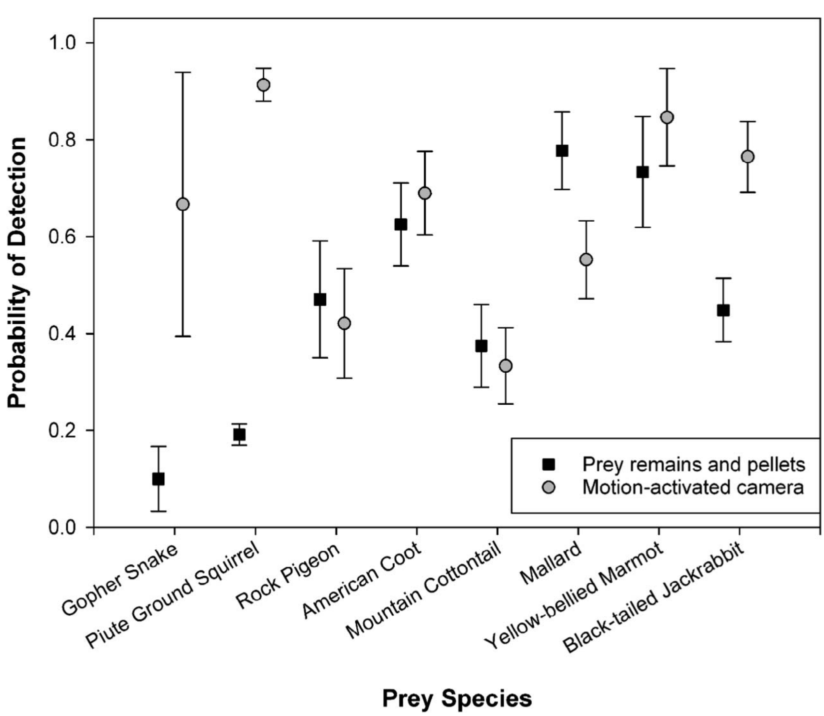

Figure 2. Probability of detecting the eight most common prey species identified in 10 Golden Eagle nests in the Morley Nelson Snake River Birds of Prey National Conservation Area, Idaho, USA, via inspection of prey remains and pellets or motion-activated cameras, 2014–2015. Detection probabilities were calculated from Huggins Closed Capture models. Symbols represent mean detection probabilities from nests and bars are 95% confidence intervals. Prey are ordered from smallest to largest size.

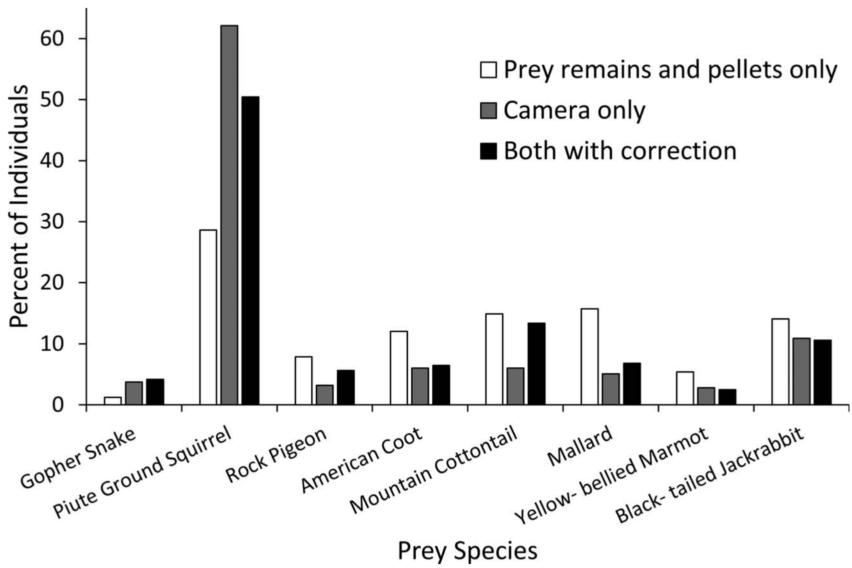

Figure 3. Percent of prey items for the eight most common species in Golden Eagle diets based on: naïve counts of prey items from prey remains and pellets, naïve counts of prey items from motion-activated cameras, and the combination of both data sources and after we accounted for imperfect detection. Prey are ordered from smallest to largest size.

and the nestling died during a premature fledging. In 2015, the seven pairs produced 11 fledglings (1.6 young per brood-rearing attempt; range = 1–2). Camera images at one nest in 2015 revealed a fatal fall of a single 56-d-old eaglet from its nest (Table 1). Adults successfully reared two young per brood-rearing attempt at the two nests where cameras were installed and removed in 2014 (Table 1). Over the two breeding seasons, young eagles fledged at 42–73 d old ($\bar{x} = 62$ d), with the youngest eaglet dying during fledging (Table 1).

We collected 143,349 images from 10 cameras during the two breeding seasons. Review of these images for prey identification took 86 hr or 8.6 hr per nest. Inspection of prey remains and pellets took an average of 8.0 hr per nest. For our representative territory, the use of a camera for monitoring diet and productivity summed to $935 USD in total costs, and the use of repeated prey and pellet collection at the nest summed to $1880 USD. Pellet and prey inspection was almost twice the cost compared to using cameras mounted at the nest, largely because of increased staff time associated with more visits to the nests.

Discussion

We developed a protocol for using motion-activated cameras at Golden Eagle cliff nests for recording diet information and fate of nesting attempts. Our adapted protocol included camera camouflage, camera placement to maximize concealment, and immediate post-installation monitoring. Motion-activated cameras require fewer visits to the nest, allow a higher rate of detection of prey items, and are a less-expensive method for monitoring diet than inspection of prey remains and pellets.

The time it took for the adult eagles to return to the nest varied among pairs. At the two nests where we removed cameras, prior to removal the adults returned to the nest site after installation but made several aborted landing attempts and did not attend young. Once cameras were removed, adults returned to the nest and cared for young. After these events, we adapted our approach by painting cameras and mounting cameras flush to the cliff, and we did not observe similar nest avoidance again. Although this is a small sample, these observations suggest that Golden Eagles may be sensitive to novel objects placed near nests and support the need to conceal cameras and reduce camera profiles. Installing cameras before the nesting season, so they are not a novel object at the nest, may work in areas where nesting substrate is limited with a low number of nest structures in the territory. Concurrent with our study, Longshore et al. (2015) installed cameras at 18 Golden Eagle nests in California and Nevada to record diet and productivity. Their cameras were mounted on brackets and more exposed relative to the cameras that we installed; however the distance they mounted the cameras from nests (2–4 m) and their method of installing cameras near nests before the breeding season may have decreased the perceived risk of the novel object at the nest. Installing cameras before the breeding season would not be as feasible in areas like the NCA where the number of alternative nests averages 6 and ranges up to 19 (Kochert and Steenhof 2012). Results from other studies suggest motion-activated and video camera installation and presence does not disturb nesting eagles or influence nest success (Dykstra et al. 2002, López-López and Urios 2010). Our results support this lack of disturbance and influence on nest success when cameras are installed and camouflaged appropriately. Disturbance to nesting Golden Eagles, and raptors in general, may vary by species, location, or the stage of the breeding season when the climbs and camera installations occur (Cutler and Swann 1999, McQuillen and Brewer 2000, Reif and Tornberg 2006, López-López and Urios 2010). Camera concealment in our study area seemed to decrease the likelihood of adult avoidance for Golden Eagle nests with nestlings, and post-installation monitoring was critical to ensure positive outcomes.

The combinations of settings and memory card capacity worked well for our research, in part because we removed memory cards every 4–8 d when we were collecting prey and pellet remains from the nest. In subsequent work, during the 2017 and 2018 breeding seasons, when cameras were installed and not checked again until the young eagles left the nest, some memory cards filled to capacity in nests with a high frequency of prey deliveries, or when vegetation in or near the nest triggered the motion sensor repeatedly (C. Davis pers. comm.). Therefore, when calculating the costs and effort for a camera-only study we included one in-progress nest visit to check the status of the memory cards. Lithium batteries did not need to be replaced in cameras.

Cameras had higher detection probabilities for many types of prey compared to inspection of prey remains and pellets. Detection biases associated with prey size were consistent with other studies that have compared direct observation with prey remains and pellet analyses (Collopy 1983, Simmons et al. 1991, Booms and Fuller 2003). Smaller prey items such as Piute ground squirrels (*Urocitellus mollis*) and gopher snakes (*Pituophis catenifer*) had lower detection rates in prey remains and pellets compared to camera images, which was consistent with the results of Collopy (1983), who observed Golden Eagle prey deliveries with a spotting scope. Lower detection of small prey via inspection of prey remains and pellets may occur because smaller prey are more likely to be consumed whole than larger prey. Although remains of smaller prey occur in regurgitated pellets, pellets in Falconiformes, such as Golden Eagles, do not always contain a significant portion of the prey eaten; thus, there is less observable evidence of prey in pellets of Falconiformes than in those of Strigiformes (Marti et al. 2007). In addition, black-tailed jackrabbits (*Lepus californicus*), which formed the majority of the biomass of eagles' diets in the Morley Nelson Snake River NCA (Heath and Kochert 2016), were more likely to be detected using cameras compared to prey remains and pellets. This result was surprising, given that large prey would be consumed in pieces, increasing the potential for remains to be found in the nests. However, there are several possible explanations for this result. Jackrabbits that were brought to the nests were of different size classes ranging from approximately 500–2400 g. Cameras may have detected a higher number of small jackrabbits missed by the inspection of prey remains and pellets. Another possible reason is that jackrabbits could have been overestimated with cameras because of misidentification of skinned leporids as jackrabbits instead of cottontail rabbits (*Sylvilagus* spp.). However, if this were true, then the detection of cottontails by cameras would be significantly less than prey and pellet remains, but this was not the case. Finally, some adult eagles regularly removed old prey remains, but other adults left prey remains in the nest throughout the season. Nest cleaning would result in lower detection of prey via inspection of prey remains and pellets compared to cameras. Interestingly, Mallards were more likely to be detected through inspection of prey remains and pellets than in camera images. Most Mallards were plucked before being delivered to the nest, so they may have been misidentified and underestimated during image review. Alternatively, we may have overestimated the number of Mallards in tallies of prey remains and pellets. We used a novel approach to estimate diet given imperfect detection by both camera images and inspection of prey remains and pellets. One reason that neither method is perfect is the uncertainty in prey identification. Estimates of uncertainty (Robinson et al. 2015) and the use of double-observer approaches to estimate prey-specific detection should result in less-biased diet studies.

Motion-activated cameras were helpful for assessing brood size at fledging and the exact date and age when young left the nest. Other information, such as food-provisioning rate, delivery of green nesting material, and activity budgets could be assessed through review of camera images (e.g., Warnke et al. 2002). In one case, we were able to determine cause of death based on camera images. The early departure of this young eagle was likely the result of a heavy infestation of Mexican chicken bugs (*Haematosiphon inodorus*) in the nest (Dudek 2016). The combination of camera and nest visit was particularly helpful in understanding the death of this nestling, because we would not have been able to assess the parasite load from just the cameras, nor could we assess nestling health or growth rates. Given the quality of data captured by cameras and the relative reduction in resources for installing cameras, the use of motion-activated cameras on their own or in combination with other approaches may improve the accuracy of diet and behavior studies compared to estimates from direct or distant observation. However, cameras should be used judiciously because camera installation creates a persistent manipulation at the nest, when eagles are sensitive to disturbance. Cameras should only be used as part of a well-planned study, and investigators should follow protocols that minimize disturbance to eagles during installation and should camouflage camera appearance. These best practices are important to reduce investigator effects and improve our ability to study cliff-nesting eagles and other raptors.

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