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# A Video Surveillance System for Monitoring Raptor Nests in a Temperate Rainforest Environment

## Introduction

Remote photography has been used increasingly to record behavior of birds at their nests (McQuillen and Brewer 2000). Recent advances with time-lapse video recording systems have made remote videography an ideal technique for recording avian behavior (Booms and Fuller 2003c). If the species of interest is sensitive to disturbance, cameras can be placed so that recording equipment and the power source are well away from the nest (Kristan et al. 1996, Delaney et al. 1998, Booms and Fuller 2003b). By using remote videography to record nesting behavior, some of the same information available by direct observation is obtained without considerable observer time spent at each nest (Poole and Boag 1988, Rosenberg and Cooper 1990). Videotape is analyzed later to extract desired information, and the researcher can view the permanent video record of nest behavior as many times as necessary to quantify the behavior.

There are disadvantages to remote videography. A system (i.e., camera, lens, recorder, and power source) can cost thousands of dollars, which multiplied over a large sample of nests, could be prohibitive to some research budgets. Systems usually include a bulky recorder and power source, and often there can be mechanical or electrical problems (McQuillen and Brewer 2000). Providing and sustaining DC electrical power to each system is critical for successful operation, yet requires heavy lead-cell batteries or solar panels that can be burdensome to transport to remote location. Despite these disadvantages, advances in video system technology continue to improve the utility of these systems as a tool for remote monitoring of wildlife (Cutler and Swann 1999, Booms and Fuller 2003a).

Ecologists and managers needed information about the diet of northern goshawks (*Accipiter gentilis*) in southeast Alaska. Although a year-round description of goshawk diet was desirable, observations of young being fed at the nest was the most efficient way to collect large amounts of information during a critical period of goshawk natural history. We used a video surveillance system to monitor goshawk nests in the coastal temperate rainforest of southeast Alaska to document and quantify the breeding season diet of this raptor, and to record behavior associated with feeding at goshawk nests. Here we describe the system we developed and used in the temperate rainforest environment, the results of this effort, and the problems encountered.

## Methods

### Study Area

We monitored northern goshawk nests on islands of the Alexander Archipelago and the narrow strip of mainland coastal mountains in southeast Alaska. The forests of southeast Alaska are dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), occurring at low elevations as a mosaic with muskeg and other wetlands

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(Harris et al. 1974). A cool and wet maritime climate characterizes the region. Precipitation throughout the year varies within the region but can be as high as 600 cm (Farr and Hard 1987). During the summer when goshawks nest, air temperature ranges from 8 to 18°C, but can drop to 6°C or lower. Relative humidity averages 88% in the forest interior (Concannon 1995), which can present significant problems with electronic equipment kept in the field for prolonged periods.

### Video Surveillance Systems

We designed a video surveillance system that cost $ 2100 per unit (not including batteries and charger) in 1998. Each system consisted of a miniature, color video camera (ToteVision model MX-40), a time-lapse video recorder (VCR; GYYR model TLC2100), and a portable 13 cm black-and-white television (TV). We equipped the camera with a manual focus, auto-aperture, 3.7 mm *f* 2.0 lens, and wired it into a waterproof plastic housing (15× 8×8 cm). We placed a small silica gel desiccant inside this housing to absorb moisture. Power to, and video images from, the camera were conveyed via a 30.5 m modified S-video cable between the camera and the VCR located at the base of the nest tree. We housed each VCR and TV in a water- and bear-proof aluminum case and placed silica gel desiccant inside the housing. We used silicone sealant on all connections exposed to weather to minimize corrosion. We powered each system with a single, deep-cycle marine battery (12-V DC, 105 amp-hr, Group 27, 25 kg). While a single 12-volt battery powered each system, rotation of two batteries was required for continual operation; one battery was used to power the system while the second battery was being charged.

Before camera installation, we confirmed that nestlings had hatched by observing the behavior of the adult female goshawk and from evidence beneath the nest (e.g., nestling excreta). We installed cameras only on warm, sunny days to minimize thermal stress to young goshawks. We climbed each nest tree to a height from which we could install the camera. We wore a hardhat with leather neck-guard and a heavy jacket for protection against aggressive adult goshawks. We connected the camera to the video cable and aimed it down at the nest while an assistant on the ground directed placement by watching the image on the TV. Once the best location for the camera on the nest tree was determined, we affixed the camera's base to the tree using screws and then refined the aim before locking it into place with the ball-joint adjuster. We aimed the camera so that no part of the interior bowl of the nest was out of view as seen on the TV monitor and in the video image.

A coaxial cable connecting the camera to the VCR was stapled to the tree after the camera was secured in place. We reviewed the first videotape in the lab to ensure the camera was not disturbing the birds and that the system was focused and functioning correctly. We operated cameras until the young goshawks no longer used the nest after fledging, the nest failed, or the system failed. We removed the entire system after the young had left the nest stand.

The time-lapse VCR accommodates 13 options for capturing a frame from real-time (30 frames/sec) to a 960-hour time-lapse (0.25 frames/sec) on a standard 2-hour VHS videotape. Each setting involves a trade off between the number of frames that could be recorded of a certain event and the total number of frames that would fit on the videotape. For this study, we wanted many frames of each prey delivery while maximizing the length between visits to change the videotape. Therefore, each system was programmed to record from ~15–30 min before sunrise to ~15–30 min after sunset. We recorded frames at the 48-hr setting (0.7 frames/sec) at all nests except one where we used the 72-hr setting (0.4 frames/sec) because visits here could be made only at this longer interval due to site logistics. The VCR registered time and date on each frame.

Routine maintenance required approaching the nest tree to change the videotape and battery. The period for which a charged battery operated depended on its initial charge and the ambient temperature at the base of the nest tree. We did not climb to the camera once installed unless repairs were needed.

We copied videotapes after retrieval from the nest site, and then stored them for viewing after the nesting season. We viewed tapes using the GYYR VCR and a 69-cm color TV. This VCR allowed the frames to be replayed at 13 different speeds and could freeze each frame so that they could be inspected one at a time. We viewed each tape to document the total amount of nest time recorded, to identify each delivery, and to documented specific behaviors. We calculated the percent of the season recorded by dividing the total hours recorded on tape by the total daylight hours available from hatch until the nest failed or the young no longer used the nest.

## Results

We operated five video surveillance systems in southeast Alaska during each of the 1998 and 1999 nesting seasons. We installed cameras between 26 May to 20 June 1998 and 29 May to 15 June 1999, an average of 10 days (range = 1–19 days) post-hatching (Figure 1). It took 75 min (range = 30–155 min) installing each camera in nests that were 14.9 m (range = 9.1–26.6 m) in height. The total time we spent in the nest stand during set-up averaged 110 min (range = 65–200 min). When we began to climb the nest tree, each adult female goshawk left the nest and showed aggression, which varied from perching in a nearby tree and calling to repeated flights close to the climber. Females returned to the nest in the camera field of view an average of 66 min (range = 14–195 min) after cameras started recording and all persons left the nest site. No nest failures were attributed to the installation or maintenance of these systems.

We recorded 5834 hrs on 153 tapes during an average of 33 days (range = 12–47 days) that the systems were operated. Once the nesting seasons were complete, it took ~ 430 hr to review all videotapes. We recorded an average of 69.3% (range = 44.2–83.1%) of the available daylight hours from the day young hatched until nests were no longer used (i.e., first full day with no visits by goshawks to nests). We documented an average of 154 deliveries (range = 42–231 deliveries) over the nestling season at these nests, and we identified 93.1% (range = 81.0–98.9 %) of deliveries to class and 79.1% (range = 45.2–91.5 %) of deliveries to genus. Unidentified deliveries resulted from poor light (22%), bright sun (7%), blocked camera

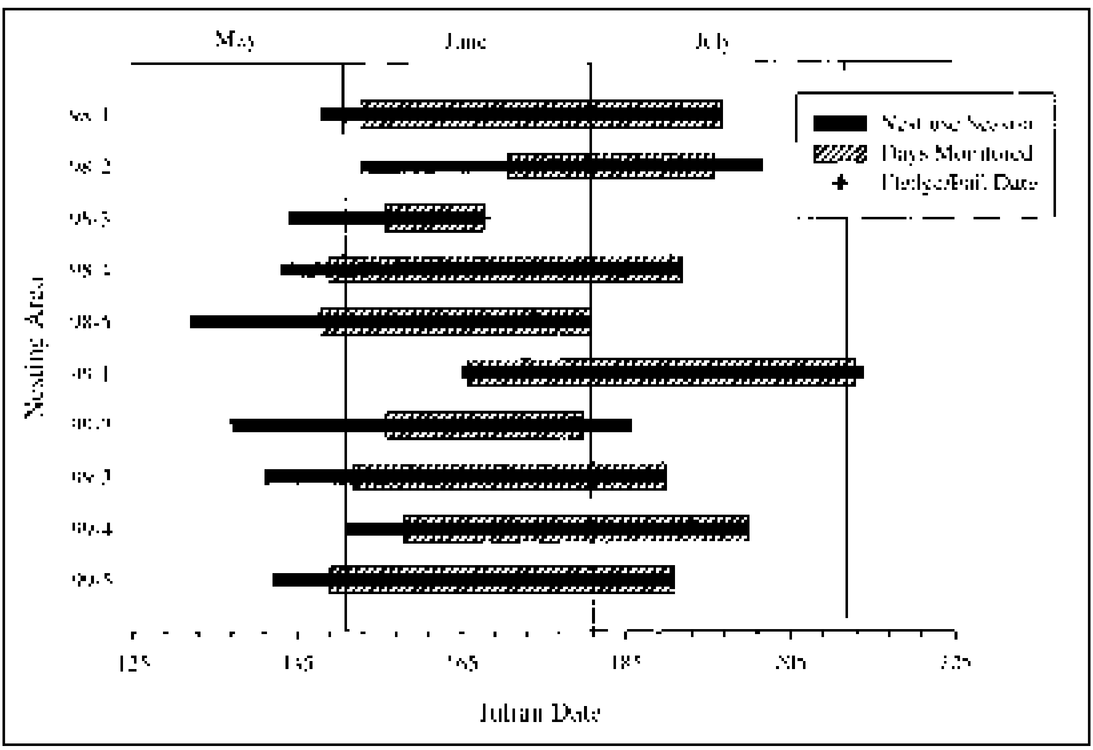


Figure 1. Nest use season from hatch date to seven days after fledging and days monitored with video surveillance systems at northern goshawk nests in southeast Alaska during 1998 and 1999.

(30%), fog (2%), or because it was unidentifiable (39%).

## Discussion

The video surveillance systems we deployed effectively monitored northern goshawk nests, and we believe such systems can be adapted for many applications in rainforest environments. For raptors that nest on open platforms, these systems can be especially useful for quantifying the food brought to the nest, and behaviors of adult and nestling birds at the nest. While the cost of high quality time-lapse VCRs remains about $600, other components are less expensive now. Therefore, a system similar to ours could be assembled for about $800–$1200.

We found it was difficult to supply a constant source of power to the systems. Under-charged batteries, combined with low ambient temperatures at the base of the nest tree, can cause recurrent poor battery performance. To alleviate this problem, we used a high-quality charger, confirmed a full charge with a voltmeter before use, and performed regular maintenance of the water level in battery cells. Insulation of batteries in a cooler also helped prolong recording. Using these methods, we were able to improve performance of batteries and, therefore, of the recording systems. Between study years, the number of hours recorded at each nest increased (mean = 519 hr in 1998; mean = 648 hr in 1999), as did percent of season recorded (mean = 63.5% in 1998; mean = 75.2% in 1999).

We had other recording system problems related to the recorded image. We improved video images by focusing all cameras prior to installation and by placing cameras closer to the nests in 1999 (mean = 41 cm; range = 22–59 cm) than in 1998 (mean = 81 cm; range 69–96 cm). This increased our ability to identify deliveries to class (mean = 90.5% in 1998; mean = 95.7% in 1999) and to genus (mean = 70.6% in 1998; mean = 81.6% in 1999).

At times, the position of the adult blocked prey deliveries and feedings of young from the camera. Regardless of the position of the camera at a nest, it was not possible to eliminate all instances where visibility of a prey item was partly or completely blocked by the body of an adult. However, by considering the physical attributes of the nest and nest stand, and their influence on where on the nest an adult could land with prey or feed the young, we were able to select a camera position that minimized obstruction of the view by an adult.

The amount and quality of sunlight reaching the nest were the primary factors influencing image quality, and consequently, our ability to identify deliveries. Ambient light at nests varied considerably with time of day, weather, and density of the forest canopy. Extreme contrast in lighting greatly affected image quality. Cameras achieved the best image on overcast days when the diffuse light was evenly distributed across the nest.

This system provided more extensive coverage than we could have gained by direct observations. For example, observation of 20 northern goshawk nests from blinds during 3 yr resulted in 1539 hr of nest monitoring, an average of 77.0 hr per nest (Boal 1993). Therefore, assuming that setup and maintenance of cameras was roughly equivalent to that of blinds, and using Boal's (1993) results as a reference, we were able to collect 7.5 times more data with less than half the effort using remote videography. While some information (e.g., vocalizations, behavior away from the nest) was not recorded with the video that could have been collected from a blind, data most important for a diet study (i.e., images of delivered prey) was readily available on the video recording.

Since we assembled this system, wireless connectors, inexpensive motion sensors, and audio capabilities have been developed that will increase efficacy in the field. Additional advances in technology, such as digital cameras, will continue to improve remote videography.

This study provides an example of results that can be expected in a temperate rainforest environment, and technical considerations that must be addressed. Despite continued technological advances, power management and the number of systems that can be deployed to obtain adequate sample sizes will remain important considerations when using remote camera systems. There likely will be technical difficulties and other problems as systems are applied in different environmental conditions, but we were able to minimize the problems we encountered. Therefore, we recommend testing the systems under the field conditions in which they are to be used.

## Acknowledgements

The Alaska Department of Fish and Game, the U.S. Forest Service, and the U.S. Fish and Wildlife Service funded this research. We thank C. J. Flatten and R. E. Lowell for their assistance throughout this project. We thank R. Chandos for his electronics expertise and assistance with design of these systems. We offer our sincere gratitude to the many individuals that hauled batteries and changed videotapes.


## Literature Cited


Boal, C. W. 1993. Northern goshawk diets in ponderosa pine forests in northern Arizona. M.S. Thesis, University of Arizona, Tucson, Arizona.

Booms, T.L., and M.R. Fuller. 2003a. Gyrfalcon diet in central West Greenland during the nesting period. Condor 105:528-537.

Booms, T.L., and M.R. Fuller. 2003b. Time-lapse video system used to study nesting gyrfalcons. Journal of Field Ornithology 74:416-422.

Booms, T.L., and M.R. Fuller. 2003c. Gyrfalcon feeding behavior during the nestling period in central West Greenland. Arctic 56:341-348.

Concannon, J. A. 1995. Characterizing structure, microclimate and decomposition of peatland, beachfront, and newly logged forest edges in southeastern Alaska. Ph.D Dissertation, University of Washington, Seattle, Washington.

Cutler, T. L., and D. E. Swann. 1999. Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin 27:571-581.

Delaney, D. K., T. G. Grubb, and D. K. Garcelon. 1998. An infrared video camera system for monitoring diurnal and nocturnal raptors. Journal of Raptor Research 32:290-296.

Farr, W. A., and J. S. Hard. 1987. Multivariate analysis of climate along the southern coast of Alaska – some forestry implications. USDA Forest Service Research Paper PNW-372, Pacific Northwest Research Station, Portland, Oregon.

Harris, A. S., O. K. Hutchinson, W. R. Meehan, D. N. Swanston, A. E. Helmers, J. C. Hendee, and T. M. Collins. 1974. The forest ecosystem of southeast Alaska. 1. The setting. USDA Forest Service Research Paper PNW-12, Pacific Northwest Research Station, Portland, Oregon.

Kristan, D. M., R. T. Golightly, and S. M. Tomkiewicz, Jr. 1996. A solar-powered transmitting video camera for monitoring raptor nests. Wildlife Society Bulletin 24:284-290.

McQuillen, H. L., and L. W. Brewer. 2000. Methodological considerations for monitoring wild bird nests using video technology. Journal of Field Ornithology 71:167-172.

Poole, K. G., and D. A. Boag. 1988. Ecology of gyrfalcons, *Falco rusticolus*, in the central Canadian Arctic: diet and feeding behavior. Canadian Journal of Zoology 66:334-344.

Rosenberg, K. V., and R. J. Cooper. 1990. Approaches to avian diet analysis. Studies in Avian Biology 13:80-90.



*Received 16 May 2003*
*Accepted for publication 21 August 2003*