An automated system for detecting and reporting trespassing bears in Yosemite National Park

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Abstract: We developed and tested a system that alerts personnel when a radiocollared animal enters an area designated as off-limits. The remote alarm combines the monitoring capabilities of data loggers with a message transmitter that sends a voice message via 2-way radios when an animal enters a monitored area. We tested the remote alarm with food-conditioned American black bears (*Ursus americanus*) in Yosemite National Park by setting up 6 remote alarms in areas designated off-limits to bears (i.e., campgrounds and parking lots) and alternated nights when the message transmitters on the alarms were activated. We recorded the number of times a radiotagged bear entered an off-limits area, the number of times bear management detected a bear in areas off-limits, and the number of hazing events. Data loggers recorded 153 bear visits by 6 radiotagged bears, 59 with the alarm on and 94 with the alarm off. With the message transmitter activated, bear-managers found bears in areas off-limits 4 times more often than with the message transmitter off. Twelve hazing events occurred with the message transmitters active and 5 with them inactive. The number of bear visits/night to monitored areas was lower when message transmitters were active than when they were inactive, probably because bears entering areas off-limits were more likely to be detected and hazed with the message transmitter on. The remote alarm functioned well and aided park managers with their hazing program to reduce bear–human conflict.

Key words: American black bear, human–wildlife conflict, radiotelemetry, remote alarm, *Ursus americanus*, Yosemite National Park

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Effective non-lethal management of problem wildlife, particularly large carnivores, often requires knowledge of the presence of individuals in areas designated off-limits (e.g., campgrounds, calving pastures, residential areas). Once an animal is detected, appropriate actions can be used to resolve the conflict. Many animals that conflict with humans are difficult to detect or are active at night when people are less aware (e.g., American black bears [*Ursus arctos*]: Reimchen 1998, Beckmann and Berger 2003). An automated device that monitors delineated areas and alerts personnel when problem wildlife enter could enhance management effectiveness by facilitating a quick response to the approaching individual.

In Yosemite Valley, Yosemite National Park (Park, hereafter; Fig. 1) black bears have a long history of conflict with humans (National Park Service 1975, Graber 1981, Graber and White 1983, Matthews et al. 2006). Most conflict occurs with bears that have become conditioned to human foods and exhibit behaviors like breaking into cars and campgrounds in search of human food. In 1999 the park implemented a comprehensive program including education, law enforcement, and non-lethal management of bears with the goal of eliminating conflict. This program included patrolling campgrounds and parking lots throughout the night and hazing any bear found in these areas. Park personnel relied primarily on spotlights and radiotelemetry (i.e., many food-conditioned bears were radiocollared) to locate intruding bears. Once a bear was detected, negative conditioning techniques (e.g., yelling and chasing, cracker shells, rubber slugs) were applied depending on the situation (National Park Service 2003). A steady decline in problem bear

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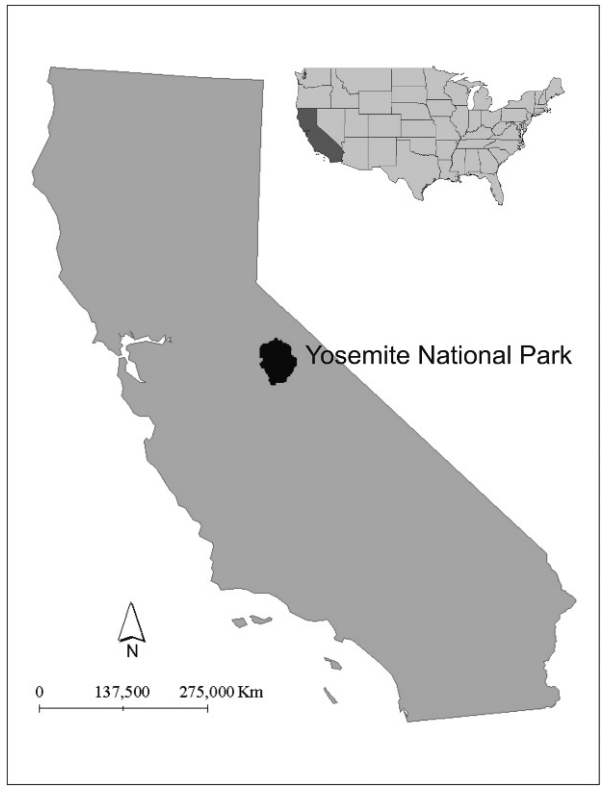

Fig. 1. Map of California and Yosemite National Park, USA.

incidents from 1998 (1,674 incidents) to 2003 (416 incidents) was attributed partly to the efforts at managing bears (National Park Service 2003). However, bears continue to be a recurring problem in Yosemite Valley, and further reduction of incidents remains a high priority.

Anecdotal evidence suggests that some bears have adapted to bear management by becoming more elusive; thus, actually finding trespassing bears has become a limiting factor for further reducing problems. We developed a remote alarm to detect the presence of a radiotagged individual in an area designated off-limits and alert management personnel. This alarm was designed to help bear management locate trespassing bears by using radiotelemetry and combining the monitoring capabilities of data loggers with 2-way radios to send a voice message when an animal enters a monitored area (Fig. 2). Our objectives were to describe the alarm system and field test it on food-conditioned black bears in Yosemite National Park.

Methods

Materials

The remote alarm contained 5 major elements: message transmitter, data logger/receiver, attenuator, antenna, and container (Fig. 3). The message transmitter was a Quick Talk Voice Notification Radio Transmitter (Model RQT 155; cost $689 [2003]; RITRON, Carmel, Indiana, USA) that reported changes in the status of a switch by transmitting a user-recorded message broadcast to 2-way portable or base station radios. The Quick Talk was linked to a receiver (model R2100; cost $2,450 [2002]; Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA) and data logger (DCC Model D5041; cost $3,100 [2001]; Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA) by programming the data logger to send a signal to the Quick Talk when a transmitter was detected. For example, if the alarm was set up in a campground to detect the presence of food-conditioned black bears and a radiotagged bear entered the area, the Quick Talk sent a message stating a bear was in the campground (e.g., 'bear in campground 1').

The data logger sequentially scanned radiotelemetry frequencies of bears captured as part of an ongoing Park management program. We programmed the data logger to activate the message transmitter only when a signal was detected from the same frequency on 2 sequential passes through the frequency table to minimize messages sent due to spurious signals. We programmed the message transmitter so it would disarm (i.e., would not transmit another warning message from any bear detected) for 45 minutes following the transmission of an alarm. If any radiocollared bear entered the area during the disarmed period, the data logger would record its presence but the message transmitter would not broadcast an alarm. To our knowledge this scenario never occurred during the trials. Because Park service personnel were concerned that an individual bear could set off the system multiple times and that repeated alert messages would interfere with other radio traffic, we set the rearming schedule at 45 minutes as a conservative guess for the amount of time it would take personnel to find and haze a bear out of an area once an alarm message was transmitted. The system was adjustable, allowing us to set the time before rearming and the number of passes through a frequency table were needed to trigger the alarm.

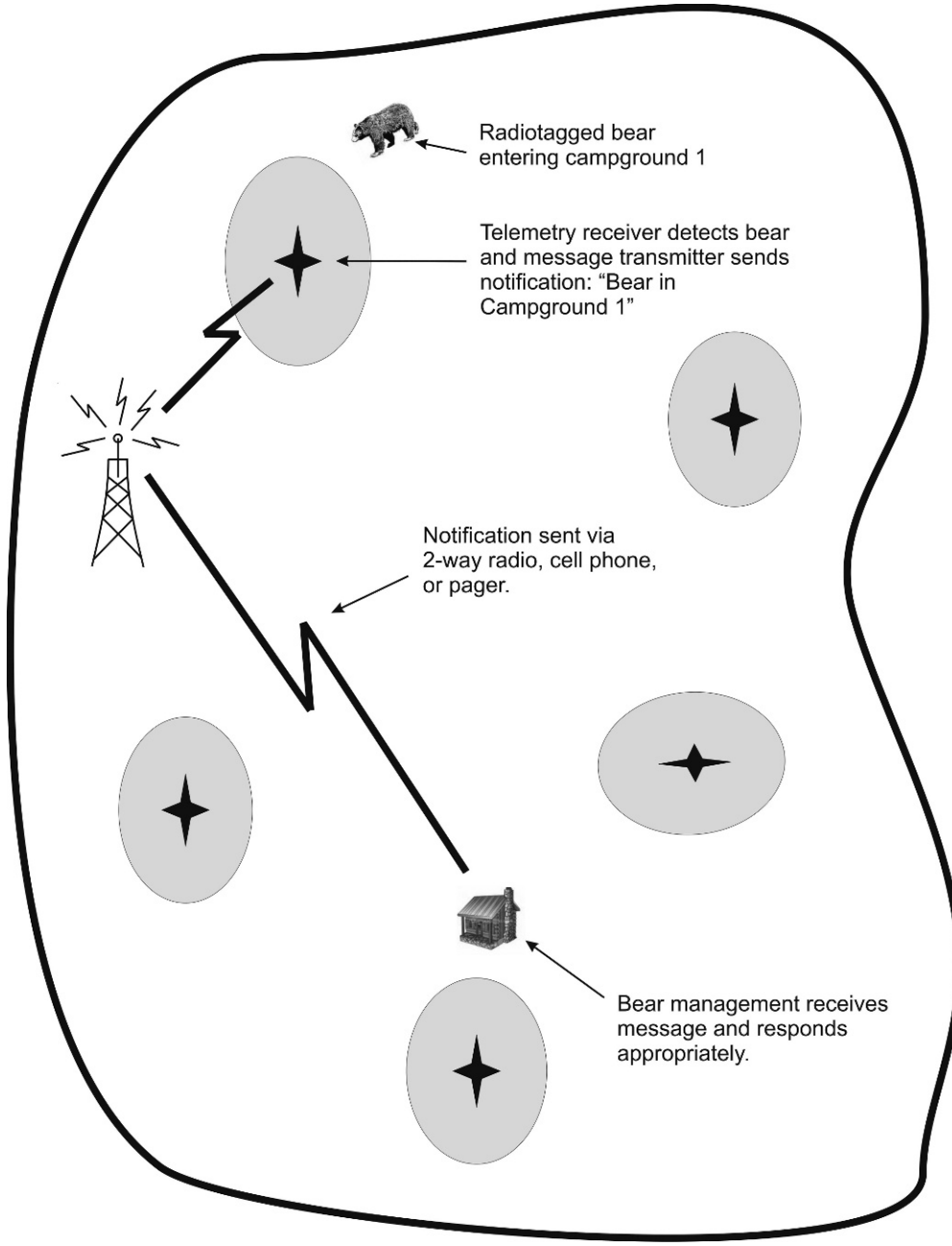

Fig. 2. Schematic of Yosemite Valley, Yosemite National Park, and the remote alarm system. As a radiocollared bear approaches a monitored area (i.e., gray ovals representing campgrounds or parking lots), the remote alarm is triggered and sends a voice message via 2-way radio to park personnel.

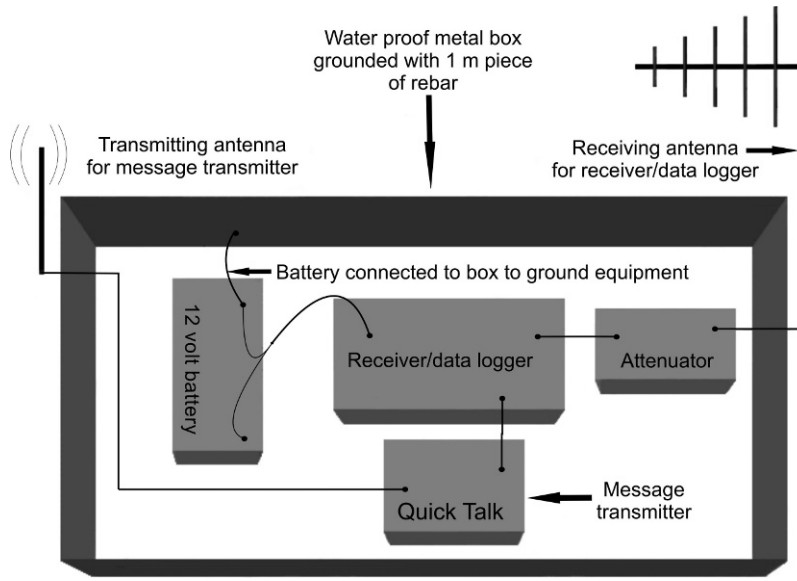

Fig. 3. Components of the remote alarm, including a receiver/data logger with receiving antenna, adjustable attenuator, Quick Talk message transmitter with transmitting antenna, and battery, housed in a metal box and grounded with a rebar stake.

We used a Manual Step RF Attenuator (Model 839; cost $350 [2003]; Kay Elemetrics Corp., Lincoln Park, New Jersey, USA) to control the size of area monitored (Breck et al. 2006). We used two 5-element directional antennas mounted in opposite directions for Park field trials because this configuration covered the oblong areas well. Coaxial cables from each antenna were joined to allow the pair to work as one.

We used a waterproof enclosure to house the system, including two 12-volt deep cycle batteries wired in parallel that powered the system for up to 2 weeks. The system was grounded by driving a 1-m piece of 3/8″ steel rebar into the ground and running copper grounding wire from the box to the rebar. Antennas were grounded by attaching them to the box with copper wire. Grounding the system prevented signals transmitting through the ground and being detected by the receiving system (Breck et al. 2006).

Alarm system effectiveness

In summer 2003 we installed 6 remote alarms in campgrounds and parking lots throughout Yosemite Valley, Yosemite National Park. The valley encompasses approximately 1,800 ha and has 12 campgrounds and parking lots (Mathews et al. 2006). The selection of areas to monitor was based on conflict histories. Each alarm system was centrally positioned in a campground or parking lot, and we established monitoring boundaries approximately 50 m beyond the perimeter of each campground or parking lot using methodology in Breck et al. (2006).

Park biologists routinely attached radiocollars (Mod-500, Telonics, Inc., Mesa, Arizona, USA) to bears perceived as causing problems in campgrounds and parking lots as part of bear management policy. From 29 July through 2 September 2003, we evaluated the alarm system by alternating nights when message transmitters were on or off and comparing the number of bear visits detected by data loggers with the number of bear visits detected by park personnel in monitored areas. Because our sampling unit was the number of bear visits, some bears were recorded multiple times the same night. During test nights all units were activated by 2200 Pacific Daylight Time (PDT) and deactivated by 0400 PDT. We tested for differences between expected and observed frequencies of bear visits detected by data loggers and found by park personnel with the message transmitter turned on versus off using a χ^2 test of independence, and for differences in mean nightly bear visits with message transmitters activated versus deactivated using a Stu-

dent's *t*-test. All work was approved by the National Wildlife Research Center's Institutional Animal Care and Use Committee.

Results

Message transmitters on the remote alarms were active 25 of 53 operational nights. Data loggers recorded 153 bear visits from 6 radiotagged bears, 59 with the alarm active and 94 with the alarm inactive. Management personnel found 19 bears with the message transmitters active (20.2% of bears detected by data loggers were found by management personnel) and 5 bears with them inactive (5.3% of bears detected by data loggers were found; $\chi^2 = 8.279$, 1 df, $P = 0.004$). The higher detection rate resulted in more hazing incidents with the message transmitters active (12) than inactive (5). Higher detection rate and more hazing events likely explained the lower number of bear visits/night to monitored areas with the message transmitter active ($\bar{x} = 2.4$, SE = 0.29) than inactive ($\bar{x} = 3.6$, SE = 0.38; $t = 2.045$, 51 df, $P = 0.046$).

Discussion

An important weakness in the park's hazing program was finding bears in areas designated as off-limits, as indicated by the low percent of bears detected by personnel while the message transmitter was inactive (5% of bear visits to monitored areas). Bear-managers found 4 times more bears that had entered areas off-limits when the message transmitter was active than inactive. Remote alarms likely increased detections in 2 ways. First, because the area patrolled was extensive (approximately 12 campgrounds and parking lots in 1,800 ha), alarms helped personnel focus search efforts in areas known to contain bears. Second, the alarm system indicating that a bear was in an area caused personnel to be more alert and search more thoroughly for bears, thus increasing their likelihood of finding the unwelcome bear.

During the trials, bears detected in off-limits areas were usually hazed. The increased likelihood of locating problem bears resulted in more hazing events while message transmitters were activated (12) than inactivated (5). This increased incidence of hazing likely explains the lower visitation rate of bears to monitored campgrounds and parking lots when the message transmitters were active.

All radiotagged bears during this study were food-conditioned and experienced at evading and overcoming management strategies. Stopping these bears from using campgrounds and parking lots was probably more difficult than stopping bears that were not food-conditioned. The alarms helped decrease the activity of trespassing bears, as indicated by the lower mean nightly visits with the message transmitters activated, but did not stop these bears from continuing to use off-limits areas. To stop these highly motivated bears using nonlethal means will probably require greater efficiency at finding and hazing them combined with more efforts to make human food less available (e.g., law enforcement and education). For bears that are not food-conditioned, remote alarms would be an effective tool for preventing them from becoming so, but this would also require proactive management efforts focused on capturing and radiotagging bears before they become food-conditioned.

An important technical aspect to consider when using remote alarm systems is the inability to set distinct boundaries for detecting approaching animals due to inherent variation in radiotransmitter signal strength. This results in a zone of uncertainty around each monitoring system in which an animal may not be detected (Breck et al. 2006). We attempted to ensure that a bear was detected when it entered a closed area by setting the radius of detection of the monitoring systems to a worst-case scenario (defined in Breck et al. 2006), which resulted in a zone of uncertainty of approximately 50 m around each delineated area. Setting the systems in this way meant that bears could have triggered alarms while outside delineated areas. However, this did not seem to be a critical factor (i.e., did not create situations where personnel were falsely alerted) because bear sightings increased when the alarms were activated and personnel did not report the systems sending false alarms.

We linked the message transmitter to an expensive receiver/data logger system, but this message transmitter could be linked to other less expensive monitoring units for greater cost effectiveness. However, a less expensive monitoring unit must have the capability to program a logic switch that will activate when a radiotransmitter signal is detected. Additionally, we transmitted a voice message via 2-way radio, but it is possible to link the message transmitter to a phone or pager. Finally, any receiving antenna tuned to the frequency of the

radiotransmitters can be used with the system and the choice of antenna should be based upon the shape of the area being monitored.

The primary disadvantage of our system is that it requires radiotagged animals. Where non-lethal management is a priority, radiotagging is often used to aid management and provides ideal conditions for deployment of our system. Our system has advantages over automated hazing systems because personnel alerted by the alarm can employ a variety of techniques to negatively condition the intruder, thereby avoiding habituation. The remote alarm has become a valuable tool at Yosemite National Park because it allows personnel to be proactive in education, food storage compliance, and other measures, instead of acting as campground guards waiting for bears to arrive. Personnel can focus on other tasks knowing that if a bear enters a campground or parking lot, they will get an alarm. We encourage areas that are willing to invest more resources into non-lethal management of bears to consider implementation of this system.

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