EFFECTIVENESS OF DETERRENTS ON BLACK BEAR (*URSUS AMERICANUS*) TO ANTHROPOGENIC ATTRACTANTS IN URBAN-WILDLAND INTERFACES

by

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ABSTRACT

Effectiveness of deterrents on black bear (*Ursus americanus*)
to anthropogenic attractants in urban-wildland interfaces

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The effectiveness of bear-resistant containers, electric fences, ammonia sprayed on food, and pepper sauce sprayed on food were tested as deterrents to black bears (*Ursus americanus*) anthropogenic food sources on the Hoopa Valley Indian Reservation, California. Deterrents were tested at multiple sites at different locations with presumably different bears and the results of the deterrents were compared to controls. The number of days that bait was removed by bears at ammonia and pepper sauce stations was not significantly different than the controls ($P = 0.31$). Bear-resistant containers deterred bears from eating the bait 100% of the time at sites that tested deterrents experimentally, and bears removed bait at the electric fences significantly less often than at control sites ($P < 0.001$). The mean number of return visits and time spent at bear-resistant containers and electric fence stations did not vary between bears that visited the deterrents first as a proactive deterrent (bait had not previously been obtained at a station by an individual bear) or first as a reactive deterrent (bait had been previously been obtained at a station by an individual bear). When proactive and reactive visits to bear-resistant containers were pooled, the mean number of return visits was less than at control sites ($P < 0.05$). Likewise, when proactive and reactive visits to electric fences were pooled, the mean number of return visits was less than at control sites ($P < 0.05$). Also, the amount of time spent per visit at bear-resistant containers and electric fences was greater during the time

bait was available and deterrents were not functional than when the bait was available and deterrents were functional ($P < 0.001$).

Amount of time spent at bear-resistant containers and electric fence stations did not vary between individual bears ($P = 0.99$), but amount of time bears spent varied between the two deterrents ($P < 0.001$). The amount of time spent at electric fences increased over time ($r^2 = 0.61$), and amount of time spent at the bear-resistant containers decreased over time ($r^2 = 0.69$).

Three of the 10 identified bears that had contact with the electric fence during the time the deterrent was functional returned once the fence was not energized. Bears that returned to the electric fence and bears that the electric fence failed to deter had significantly more visits to all stations than bears that did not return ($P = 0.001$, $P = 0.008$, respectively).

Levels of vigilance behavior were compared between three groups of bears based on frequency of visitation (1 visit, 2-10 visits, and 11-110 visits) to determine if vigilance behavior varied with the number of total visits to stations. Decreased vigilance behaviors (e.g. grooming and resting) were greater for groups with 2-10 visits and 11-110 visits than bears with one visit ($P = 0.01$).

Deterrents were placed at 14 residential sites based on complaints made by residents about black bears. One of nine bear-resistant containers at residential sites had bait removed from the container by a bear. However, bears did not remove attractants from any of the eight electric fences placed at residential sites.

Bear-resistant containers and electric fences were effective at reducing access by bears to anthropogenic foods and reduced the amount of time bears spent at a location.

Deterrents were not effective 100% of the time, but reductions in access by bears to anthropogenic food sources through the use of deterrents would potentially decrease the number human-bear conflicts over time. When addressing a community concerned with nuisance black bears, managers need to be aware that deterrents do not deter all bears, and bears that have received a food reward at a location are more likely to return.

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INTRODUCTION

Human-bear conflicts have commonly occurred in rural-wildland interfaces. Many rural areas adjacent to wildlands do not have ordinances or regulations prohibiting the intentional or unintentional feeding of wildlife, which may have had a direct influence on the number of human-bear conflicts (Beckmann and Berger 2003a,b). During the past two decades many communities have had an increase in the number of conflicts between American black bears (*Ursus americanus*, hereafter referred to as “bears”) and humans (Beckmann 2002, Beckmann and Berger 2003a). In Nevada there was an increase in the density of bears in the urban-wildland interface and a decrease in densities of black bears in wildlands, which may have accounted for an increase in the number of human-bear interactions from 1990 to 2000 throughout the state (Beckmann and Berger 2003a). Anthropogenic food sources in the urban-wildland interfaces may have provided a large enough food source to support greater densities of bears than natural food sources would provide (Beckmann and Berger 2003a).

For human safety and the maintenance of healthy bear populations, it has been important for rural communities adjacent to bear habitat, to develop comprehensive bear management plans that incorporate proper garbage storage and disposal, public education, and deterrents that serve as an alternative to lethal control of problem bears (Garshelis 1989, Peine 2001). Deterrents have included techniques that dissuade bears from accessing a particular area with food or trash, and have been considered effective if they prevented bears from accessing the attractant (Hunt 1984, Stenhouse and Cattet 1984, Garshelis 1989, Schirokauer and Boyd 1998). Deterrents that reduced access to anthropogenic food have been one part of some comprehensive bear management plans (Gunther 1994, Schirokauer and Boyd 1998, Peine 2001, National Park Service 2002). Deterrents have been based on operant conditioning, the use of a negative or positive reinforcement that strengthens, reduces, or terminates a particular behavior (Skinner 1974, Tarpy 1982). It has been important to know the effectiveness of deterrents in both experimental and real life settings before they are recommended in a comprehensive plan. In 2003, I investigated the effectiveness of deterrents to anthropogenic attractants on black bear.

Many previous studies on bear deterrents have described deterrents used on captive animals, in campgrounds, or in residential areas (Hunt 1984, Schirokauer and Boyd 1998, Huygens and Hayashi 1999, Peine 2001, National Park Service 2002). The use of captive animals has reduced sample sizes and influenced the level of habituation to human presence, which in turn may have affected the bear's reaction to deterrents (Hunt 1984, Jordan and Burghardt 1986). Also, deterrents described in captive or laboratory situations may not be implemented well in the field. For instance, a repellent spray tested in the laboratory and in the field repelled bears initially, but in the field bears returned quickly to the food source (Hunt 1984). Additionally, the success of deterrents in residential areas and campgrounds has varied due to different methods, policies, and public attitudes toward black bears (Kellert 1994, Peine 2001, National Park Service 2002). It is important to understand biological mechanisms of deterrents on black bears at food sources to provide public education and increase public support and approval

(Kellert 1994). One way to observe bears not in captivity and in a natural setting is to use the relatively new technology of portable video.

Deterrents have been classified as proactive and reactive (National Park Service 2002). Proactive deterrents reduce the source of anthropogenic attractants and prevent bears from learning behaviors that result in the bear obtaining the attractant (National Park Service 2002, Beckmann et al. 2004, Breck et al. 2006). Once a bear has learned about an attractant, reactive deterrents must be used. Reactive deterrents incorporate a negative stimulus associated with a particular site (such as a home or campground) or a particular anthropogenic food source (such as garbage) (Peine 2001, National Park Service 2002). Proactive deterrents have provided long-term preventive solutions for communities in close proximity to bear habitat. However, communities with widespread proactive black bear deterrents have still encountered bears that have already become accustomed to the reward of human food and have been more difficult to deter, thus making proactive techniques inappropriate to existing nuisance bear problems (McCullough 1982, Beckmann et al. 2004). Therefore, proactive deterrents combined with reactive deterrents in a comprehensive plan can provide a community with the tools needed to manage nuisance bears in both the long term and short term (Peine 2001).

Many variables have affected the success of a particular deterrent. Bear age, sex, presence of cubs, and time of activity have been correlated to the likelihood of bears returning to an area after being hazed by capture experience (Clark et al. 2002). How bears reacted to deterrents at a landfill was correlated with age and social rank

(Hunt 1984). I used video images of individual bear's characteristics and behavior to determine if bear traits such as size of bear, sex of bear, and number of visits were correlated to the effectiveness of deterrents. Knowledge of which bear traits affected success would enable managers to recommend the most appropriate and effective deterrents for a situation.

Jordan and Burghardt (1986) documented a consistent decrease in vigilance and alarm behaviors in bears with an increase in habituation to human presence. However, it was unknown how vigilance behavior of black bears would change over time at a location without the presence of humans. If vigilance behavior changed with habituation to a location, observed levels of vigilance behavior could be useful for managers to assess the level of habituation of bears to urban areas without captured and marked individual bears.

To determine the effectiveness of deterring black bears from attractants using proactive and reactive deterrents, I compared the success of deterrents at sites that experimentally tested deterrents and real-world application sites (residential sites). My objectives were to: 1) determine which deterrents were affective at keeping black bears away from attractants; 2) determine if proactive deterrents were more affective than reactive deterrents; 3) determine how deterrents altered black bear behavior at specific food sources; 4) determine how individual bear characteristics influenced the effectiveness of deterrents; 5) determine if the level of vigilance behavior was associated with the habituation to a specific location and, 6) determine if black bears had similar responses to deterrents in an experimental setting compared to a real life setting.

STUDY AREA

The study was conducted on the Hoopa Valley Indian Reservation (hereafter Reservation) in northeast Humboldt County, California (Figure 1). The area of the Reservation is approximately 360 km^2. Within the Reservation a 25 km^2 area along the Trinity River Valley (hereafter the valley), has been developed for residential and business purposes. The valley is surrounded by mountains ranging from 98 to 1170 m above sea level (Singer and Begg 1975).

Mean annual precipitation is 146 cm, and the mean low and high temperatures are 7°C and 21°C, respectively (National Oceanic and Atmospheric Administration 2002). The dominant vegetation found on the valley floor includes annual grasses, western redbud (*Cercis occidentalis*), gray pine (*Pinus sabiniana*), Himalayan blackberry (*Rubus ameriacus*), California wild grape (*Vitis californica*), Pacific madrone (*Arbutus menziesii*), and manzanita (*Arctostaphylos spp.*) (Singer and Begg 1975). The valley floor is also used for crops such as apples (*Malus spp.*), plums (*Prunus spp*.), peaches (*Prunus spp*.), cherries (*Prunus spp*.), melons (*Citrullus spp*.), pumpkins (*Cucurbita spp*.) red clover (*Trifolium pratense*), field corn (*Zea spp.*), tomatoes (*Solanum spp.*), and chicory (*Cichorium spp.*) (Singer and Begg 1975). Vegetation in the surrounding forests includes Douglas-fir (*Pseudotsuga menziesii*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), white fir (*Abies concolor*), big-leaf maple (*Acer macrophyllum*), incense-cedar (*Calocedrus decurrens*), Port Orford-cedar (*Chamaecyparis lawsoniana*), chinquapin (*Chysolepis chysophylla*),

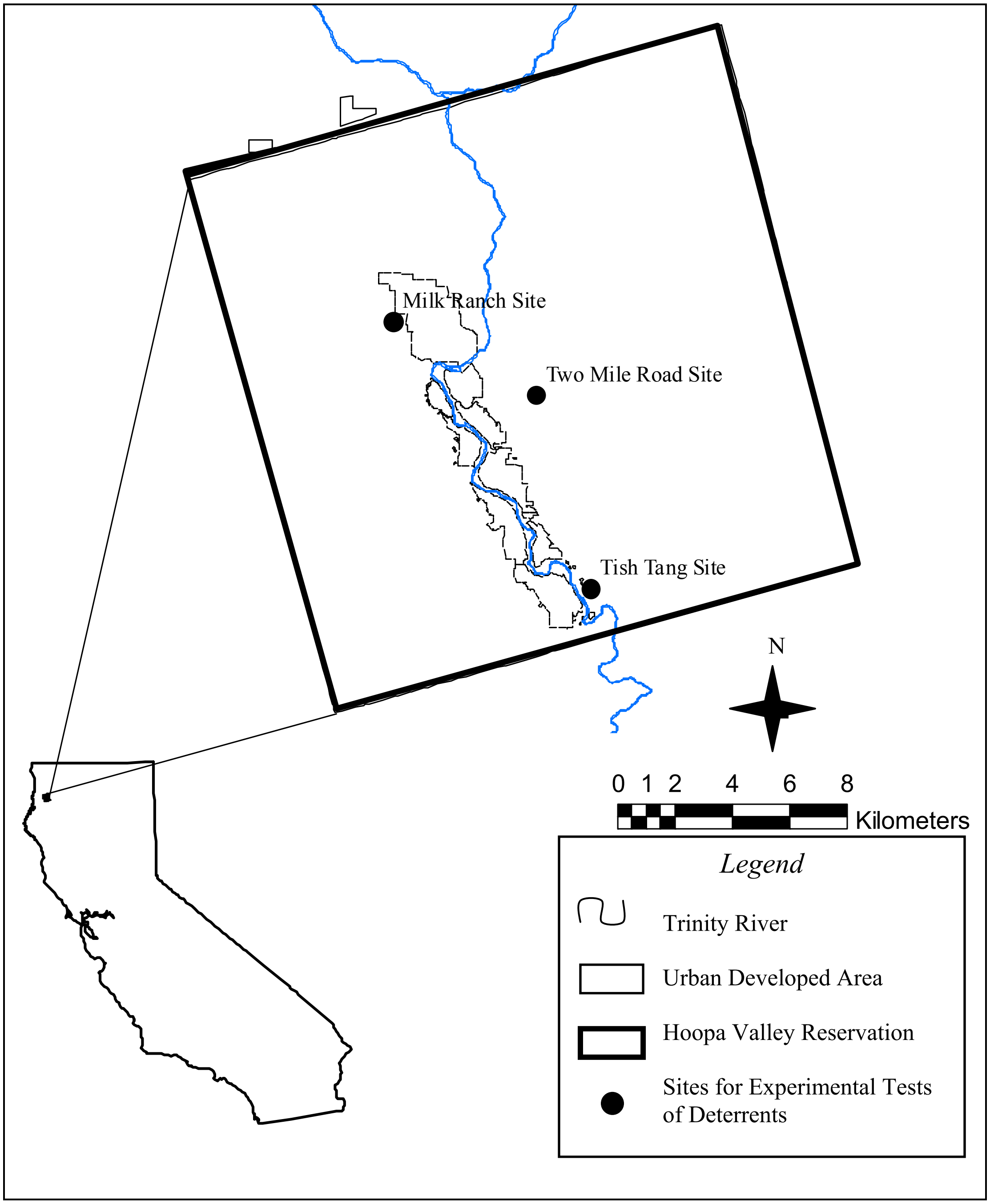


Figure 1. Hoopa Valley Reservation, Humboldt County, California, and locations of three areas used to evaluate the effectiveness of deterrents on black bear to anthropogenic attractants that were outside the urbanized valley.

silver pine (*P. monticolia*), knobcone pine (*P. attenuata*), ponderosa pine (*P. ponderosa*), Pacific yew (*Taxus brevifolia*), mountain dogwood (*Cornus nuttallii*), and willow (*Salix spp.*), manzanita (*Arctostaphylos spp.*), huckleberry (*Gaylussacia spp.*), poison oak (*Toxicodendron diversilobum*), salal (*Gaultheria shallon*), elderberry (*Sambucus spp.*), ceanothus (*Ceanothus spp.*), and wild rose (*Rosa californica*) (Singer and Begg 1975, Matthews 2002).

In 2000, the Reservation was home to approximately 2,600 human residents (United States Census Bureau 2000). The Reservation also had the greatest reported density of black bears in the western United States (Matthews 2002). Bears have been considered a culturally important species for the Hupa people, and have not been harvested on the Reservation for food or sport.

Human-bear conflicts have occurred on the Reservation when bears have accessed human food and trash at salmon nets along the river, at smoke houses with fish inside, at campgrounds, and at residential trash. The Reservation's only landfill closed in September 1998, resulting in higher costs to residents to properly dispose of their garbage (Masters et al. 2005). The higher costs of garbage removal, combined with low incomes on the Reservation resulted in some residents allowing garbage to accumulate around their homes or the illegal dumping of trash throughout the Reservation (Masters et al. 2005). In 2003 and 2004, approximately 50 residents complained about nuisance bears to the Hoopa Tribal Forestry Department (J.M. Higley, Hoopa Tribal Forestry, personal communication). However, this underestimates the number of conflicts because many residents do not report human-bear conflict and instead kill bears that cause property damage or were perceived as a threat to humans, pets, livestock, or property. As of 2006, there were no laws, regulations, or ordinances that restricted the killing of black bears that were considered a threat or nuisance by the public.

METHODS

In order to recommend the most effective deterrents for a comprehensive bear management plan for the Reservation, I tested the effectiveness of a bear-resistant garbage container, electric fence, ammonia sprayed on food, and pepper sauce (Habanera Pepper Sauce, Tabasco, McIlhenny Co., Avery Island, Louisiana) sprayed on food. Bear-resistant garbage containers have been one of the most widely used and effective proactive deterrents used by communities and campground managers (Schirokauer and Boyd 1998, Peine 2001, National Park Service 2002, Beckmann et al. 2004). Ammonia mixed with an attractant has been shown to deter bears both by taste and scent (Hunt 1984). Furthermore, residents of the Reservation have anecdotally claimed to use pepper sauce sprayed on garbage to successfully deter bears (J.M. Higley, Hoopa Tribal Forestry, personal communication). Electric fences have been successfully used to protect livestock, agriculture, beehives, and homes (Storer et al. 1938, Davies and Rockwell 1986, Huygens and Hayashi 1999, Clark et al. 2002).

Tests of Deterrents

To maximize the number of different bears observed at each deterrent, deterrents were experimentally tested at three different locations on the Reservation. Sites that experimentally tested deterrents were placed a minimum of 300 m from the urban-rural interface on the Reservation, to minimize the influence of multiple anthropogenic food sources on bear behavior at a specific site and to avoid attracting bears to human occupied areas (Figure 1). To decrease the chance of re-sampling individual bear, sites were separated by at least 5 km. This separation of sites was calculated using the average male black bear home ranges on the Reservation (Matthews 2002). Each of the 3 sites for experimental tests of deterrents consisted of 4 stations: control, bear-resistant container, electric fence, and bait covered with ammonia or pepper sauce. Stations were placed a minimum of 100 m apart (to reduce the association of one deterrent to another), and a maximum of 400 m apart (to maximize the chance of a single bear visiting multiple stations).

Bait was provided at all stations as an anthropogenic food source. Bait used at each station was 946 ml of molasses covered oats (Omolene #100, Purina Mills, St. Louis, Missouri) mixed with one 355 ml can of dog food (Kirkland Signature Premium Lamb and Rice, Costco Wholesale Corporation, Seattle, Washington). A 5 m^2 area around the bait was sprayed with concentrated raspberry flavoring (Raspberry Flavor, Mother Murphy's, Greensboro, North Carolina) mixed with water as an olfactory attractant. Bait and attractant were replaced or refreshed daily between 07:00 and 11:00. Bait was placed in a metal #10 can, and hung between two trees with metal cable approximately 1.5 m off of the ground to ensure availability of bait only to bears.

Control stations had bait, but no deterrents. The bear-resistant containers were 242 l steel drums with locking tops (Environmental Technology Inc., Fields Landing, CA). The locking tops had lever lock rings that enclosed the lid and locked it in place. At stations with bear-resistant containers, bait was placed in #10 cans inside the container. Pure ammonia (Longs Drug Stores, Walnut Creek, California) was mixed in a

3:1 ratio with vegetable oil. The mixture was placed in a spray bottle and 89 ml were sprayed on top of the exposed bait. Pepper sauce was placed in a spray bottle and 89 ml were sprayed on top of the exposed bait. Ammonia or pepper sauce as a deterrent was tested at the same station. Ammonia was used the first 3 or 4 d each period and pepper sauce was used the remaining 3 or 4 d.

The electric-fence station used a weatherproof, portable electric fence energizer with a maximum output of 9,500 V (Model MAG. 12 U.O. Parmak, Parker McCrory Manufacturing Company, Kansas City, Missouri). The minimum distance from the fence to the bait was the maximum shoulder length (91 cm) of male black bears captured on the Reservation. This reduced the chance of bears reaching through the fence and accessing the bait. The electric fence surrounded a 4 m^2 area. The area surrounding the perimeter of the fence was hand-raked and any vegetation or debris that could interfere with the electrical charge was removed. To penetrate bear hair, electric fences were set at a minimum guard voltage of 5000 V. The electric fence was tested each day with a voltage tester (Model RSVT8, Zareba Systems, Ellendale, Minnesota) to ensure the fence produced a guard voltage between 5000 to 8000 V. The electric fence was constructed using four strands of wire attached to four 1.2 m plastic poles (Figure 2).

To record observations of bear behavior and bear identification, each station was equipped with a black and white, weatherproof night-capable digital video camera (Model EX26NX , Extreme CCTV, Burnaby, British Columbia).

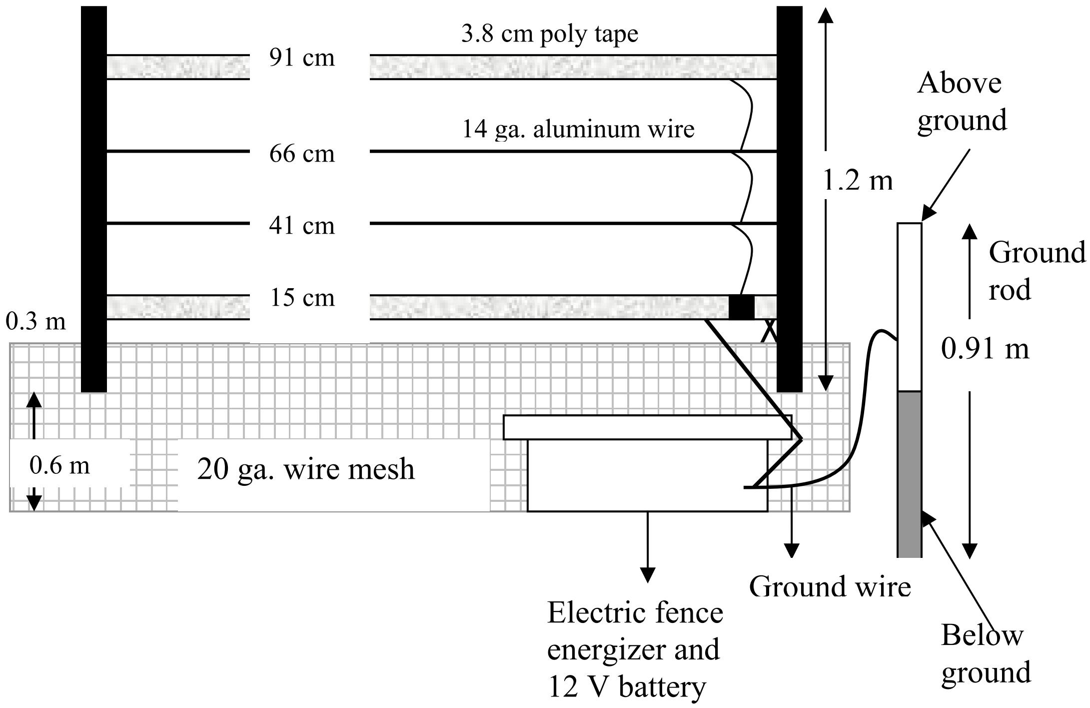


Figure 2. The front view of the electric fence constructed at all sites, Hoopa Valley Indian Reservation, California, 2004 through 2005. To improve grounding around the electric fence, wire mesh with 2.5 cm mesh spacing (Style #412-1-20, Red Brand, Peoria, Illinois) and a 0.91 m steel ground rod were placed along the perimeter. The electric fence had two strands of white 3.8 cm poly tape with 15 stainless steel strands (G624544, Gallagher, North Kansas City, Missouri) and two strands of aluminum wire (XL17250, Gallagher, North Kansas City, Missouri). The strands were attached to four plastic posts and all strands of wire were attached and connected to the electric fence energizer (Model MAG. 12 U.O. Parmak, Parker McCrory Manufacturing Company, Kansas City, Missouri). The electric fence energizer was powered by a deep cycle Absorptive Glass Mat 12 volt battery (MU-1 SLD M, MK Batteries, China), and both were placed in a plastic container outside of the fence.

The camera was connected to a motion sensitive digital video recorder (DVR; Seabird Technologies, Arcata, California) using Siamese RG-59U 18/2 coaxial cable (Arrow Wire and Cable, City of Industry, California). Cameras were powered using deep cycle Absorptive Glass Mat 12-volt batteries (MU-1 SLD M, MK Batteries, China). DVR's were powered using an inverter with 150 W AC output (Model Xpower Inverter 175 Plus, Xantrex, Burnaby, British Columbia) connected to two additional batteries. Power consumption of the camera and DVR required the batteries be changed every 24 h. Batteries and DVR were housed in a second 242 l retro-fitted steel drum. A 1.8 m vertical measuring stick with white and black alternating marks at 0.30 m intervals was placed in view of the camera and was used to measure individuals.

Infrared illuminators allowed approximately 15 m of visibility from the camera at night. The camera was secured to a tree approximately 2 m above the ground and 3 m from the bait. All video was archived on removable 80 GB hard drives (Western Digital Corporation, Lake Forest, California) within the DVR. Hard drives were replaced every 24 h when batteries were changed. All video that contained bears was saved to the computer for later analysis.

Each site had stations functional for approximately four weeks (Figure 3). Cameras recorded 24 h per d and 7 d a week. Proactive techniques were tested first at all sites to ensure a number of bears encountered the bear-resistant containers prior to receiving a reward at the station. During the second week of the study, bait was available at all stations, thus conditioning the bears to know there was a potential food reward

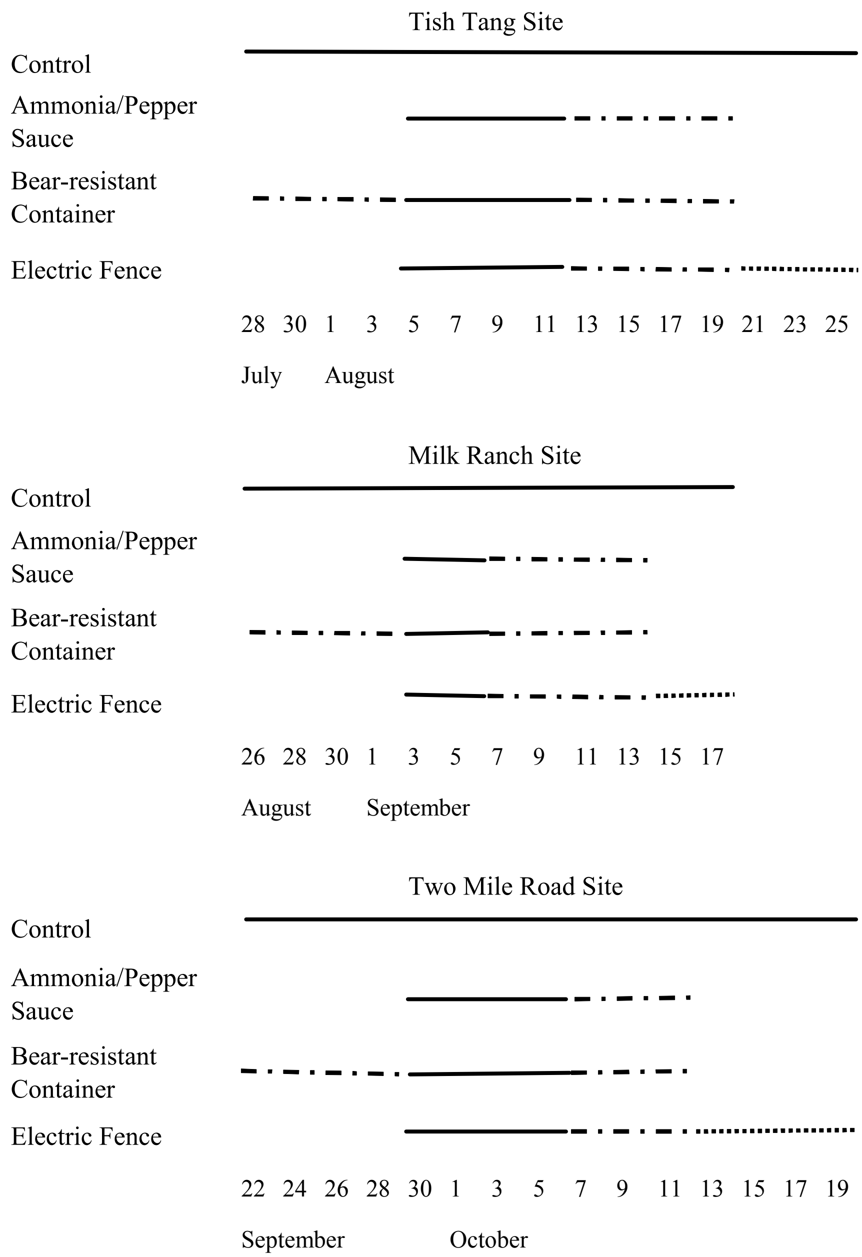


Figure 3. Timeline of deterrent schedule at three sites for experimental testing of deterrents on black bear to anthropogenic attractants on the Hoopa Valley Reservation, Humboldt County, California in 2004. The solid line (-) represents the time bait was available and deterrent, if present, not functional, the dashed line with dot (- ˙-) represents the time deterrents were functional, and the small dashed line (⋯ ¨) represents the time the electric fence was not energized.

which prepared the bears for analyses of reactive deterrent methods. Reactive deterrents were placed at the stations when a minimum of five individual bears had been observed eating bait at the stations. During the third week, all deterrents and the control were functional. In the last week, I tested the rate at which bears returned to an electric fence once it had been turned off. The non-energized electric fence and control remained at the site until at least one bear that had previously contacted the electric fence returned and sought the bait.

Analysis of Video Observations

To avoid pseudo-replication at deterrents, bears were individually identified based on several physical traits. The Reservation had approximately 360 black bears that had been captured and ear-tagged prior to this study (J.M. Higley, Hoopa Tribal Forestry, personal communication). In addition, twenty-five black bears were radio-collared within the valley at the time of my investigation. Ear-tags and collars were visible with cameras, however the color and unique numbers on ear-tags could not be identified. Each site was functional for a short enough duration (1 month) to allow the use of size and molt pattern to distinguish between different individuals. Sex was determined when possible. To uniquely identify an individual, three of the following identification features were observed: presence or absence of ear-tag or collar, molt pattern, blaze, shoulder height (referenced against the meter-stick placed in the camera’s field of view), sex, and a consistent behavior. Not all bears were individually identified.

A 1.8 m vertical pole with alternating marks at 0.30 m was used to categorize bears into three size classes based on height at shoulder, small (30 – 53 cm), medium (54 – 76 cm), and large (> 77 cm). Size classes were chosen based on capture data collected in other studies on the Reservation (e.g. Matthews 2002). When this size classification was compared to 148 bears (a sub-sample of the 360 bears previously captured on the Reservation), 88% of bears in the small category were less than two years of age, 62% of bears in the medium category were three to nine years of age, and 71% of bears in the large category were male bears that were older than five years of age.

Date and time were recorded by the DVR and were visible on each video. Observations of bears on video were classified into visits. A visit began when a bear first became visible in the camera and ended when the bear departed the view of the camera and did not return for at least 30 min. In each visit, I identified each bear (if possible), noted any other bears present, size class, time of arrival, time of departure, total time at station, and if the deterrent was successful. When a bear did not access the bait I classified that deterrent as successful for that visit. I determined how bears behaviorally responded to a deterrent. Responses included; running away, walking away, charging, remaining motionless, and no noticeable change in behavior prior to contact with the deterrent.

Effectiveness of Deterrents During Experimental Tests

All statistical analyses were completed using Number Cruncher Statistical Systems (Hintze 2004). All visits by bears (identified and unidentified) were used to determine the overall effectiveness of deterrents. However, to avoid pseudo-replication only identified bears were used in additional analyses.

Effectiveness of deterrents was determined by calculating the total number of days (24 h periods) identified black bears were present at the deterrent, but did not eat bait available at functional deterrents. A chi-square test was used to identify statistical differences between the observed numbers of days bears removed bait at deterrents compared to expected (calculated using the number of days bears removed bait at control sites during the same period of time).

Bear-resistant containers and electric fences were considered proactive if an individual bear had not eaten bait at the station prior to the deterrent being functional, and reactive if the bear had eaten bait at the station prior to the deterrent being functional. To determine if bears that encountered a proactive deterrent behaved differently than bears that encountered the same deterrent as a reactive deterrent, the mean number of repeat visits and the mean time (s) spent at each station type were compared with two sample t-tests (Zar 1999). Chi-square test was an alternative that I considered for analysis of repeat visits, but cells had values less than five which made this test unavailable (Zar 1999).

Alterations in Bear Behavior at Deterrent Stations

Proactive and reactive visits to each deterrent station were combined to further analyze how different deterrents altered bear behavior at a specific food source. Two sample t-tests were used to identify differences in the mean number of return visits between the controls and bear-resistant containers, the controls and the electric fences, and between both deterrents (Zar 1999). Two sample t-tests were also used to compare the mean times bears spent at each deterrent station when bait was available (and deterrents were not functional) versus the mean time spent at deterrent stations when deterrents were functional.

Repeated Measures ANOVA was used to determine if the decrease in time spent at deterrents was associated with 1) a difference in individual bears, 2) the type of deterrent, or 3) the number of subsequent visits to the stations (Hintze 2004). To be included in this analysis, identified bears were detected at both the bear-resistant container and electric fence stations a minimum of one visit while the deterrent was functional, and had at least four subsequent visits to any station after the initial visit (in order to meet the assumption that the bear was still in the area even if it did not return to the deterrent station). Bears that failed to return to the deterrent station after initial contact, but visited another station, were given a value of zero for that day (they were still in the area, but spent no time at the deterrent station). To further analyze decreases in time spent at deterrents over time, a simple Linear Regression was used to compare the mean time bears spent at electric fences and bear-resistant containers for each subsequent visit (Hintze 2004).

To determine if bears that had contact with an electric fence would return, electric fences were not energized during the last week of sampling at a site. The proportion of bears that contacted electric fences and returned after the fences were not energized was compared to an expected value using chi-square analysis (Zar 1999). The expected value was calculated using the proportion of return visits to the control station during the same periods of time electric fences were functional and when they were not energized. Two sample t-test was used to compare the mean number of visits to all stations between the bears that failed to return and bears that returned to the electric fence during the time the fence was not energized (Zar 1999).

For deterrents that were not 100% successful at deterring bears, sex of bears, size category, and number of visits to all stations were compared, to evaluate similarities among bears that the electric fence failed to deter. Two sample t-tests were used to compare differences in mean numbers of visits to all stations for bears that the deterrent successfully deterred and failed to deter (Zar 1999).

Variations in Vigilance Behavior

Jordan and Burghardt (1986) reported a decrease in vigilance and alarm behaviors in black bears when habituated to human presence. Behaviors of bears at sites that experimentally tested deterrents were analyzed to determine if the same decrease in vigilance behavior occurred with an increase in habituation to the sites. Habituation to these sites was based on the number of visits to the stations.

Video was used to categorize behavior at stations into five categories; vigilance behavior directed at station, vigilance behavior directed at environment, alarm responses, grooming, and resting (Table 1). The proportion of time individual bears exhibited these behavior categories for visits to the control, ammonia, and pepper sauce stations was

Table 1. Description of behaviors collected for all visits where bears were visible, Hoopa Valley Indian Reservation, California from July to October, 2004, and May to August, 2005.

Behavior	Description
Resting	Included lying stretched, lying curled, sitting (Stenhouse and Cattet 1984, Jordan and Burghardt 1986)
Grooming	Included roll, scratch, lick, shake, defecate, urinate, and play (Stenhouse and Cattet 1984, Jordan and Burghardt 1986)
Vigilance Behavior Directed at Station	Attention directed at the equipment: included lateral head shift, stand on hind legs, sniff air, sniff substrate, and head-up down (Stenhouse and Cattet 1984, Jordan and Burghardt 1986, Jones 1998, Childress and Lung 2003, Switalski 2003).
Vigilance Behavior Directed at Environment	Attention directed at the environment surrounding the site and included: lateral head shift, stand on hind legs, sniff air, sniff substrate, and head-up down (Stenhouse and Cattet 1984, Jordan and Burghardt 1986, Jones 1998, Childress and Lung 2003, Switalski 2003).
Alarm Behavior	Included ears upright, little body movement, and run (McLean et al. 2000, De Palma et al. 2005).

calculated by dividing the total duration of the behavior by the total time at the station. Behaviors may have been influenced by successful deterrents. Therefore visits to bear-resistant container and electric fence stations were not used in the analysis.

Behavior categories hypothesized *a priori* as increased levels of vigilant behavior included vigilance behavior directed at station, vigilance behavior directed at the environment, and alarm responses (Hunt 1984, Jordan and Burghardt 1986, Jones 1998, Childress and Lung 2003, Switalski 2003). Behavior categories hypothesized *a priori* as decreased vigilant behavior included grooming and resting (Jordan and Burghardt 1986, McLean et al. 2000). Principal Components Analysis was used to identify groups of behavior categories, and to determine if the behavioral groupings supported the hypothesized *a priori* behavior categories of either increased or decreased vigilance behaviors (Zar 1999).

To determine if the principal component values were related to an increased familiarity to stations, bears were placed into three groups based on the total number of visits to all stations at a site. The groups were 1 visit, 2-10 visits, and 11-110 visits. Mean values of principal components one and two were compared between bears in each group using ANOVA. Mean principal component values that were significantly different between groups were further analyzed using a Tukey-Kramer multiple comparison test (Zar 1999).

Effectiveness of Deterrents at Residential Sites

I placed deterrents at residential sites in 2005, to examine whether information learned at sites that experimentally tested deterrents was applicable to real-world situations. A telephone line was dedicated to in-coming calls from residents regarding nuisance bears near their homes or fish nets. Residential sites were selected based on calls by residents that requested assistance with nuisance bears.

Each residential site was assessed for signs of bears (trails, scat, visual, or audio), type of attractant, and the time of day residents observed the bear in the area. Bear-resistant containers were placed at sites that had garbage or pet food as an attractant. Attractants other than garbage or pet food had an electric fence placed around the perimeter of the attractant. Electric fences were constructed using the same methods as described for non-residential sites.

Video cameras were placed at residential sites when permission was granted by property owners. Cameras were the same as described for non-residential sites. Bears were identified if possible. When residents declined the use of cameras on their property, I assessed whether the protected attractant was disturbed after placement of the deterrent. Due to small sample sizes, vast differences in conflict types, and deterrents, statistical analyses were not performed on deterrents placed at residents' homes. The deterrent was considered successful if a bear did not remove the attractant.

RESULTS

Effectiveness of Deterrents During Experimental Tests

Cameras recorded 581 visits to sites that experimentally tested deterrents, and some visits included more than one bear present. Fifty-seven bears were uniquely identified. Among the 57 identified bears, gender was identified for 14 (4 females and 10 males). Ninety-one visits included bears that could not be uniquely identified, while 490 visits were made by bears that were uniquely identified. The mean time until the first detection of a bear at a site following the addition of bait was 13 ± 9 h ($\bar{x}$ ± SE, n = 3).

The number of days that bait was removed by bears when ammonia and pepper sauce were applied at stations was not significantly different than expected (χ^2 =1.03, P = 0.31; χ^2 =1.05, P = 0.31, respectively) (Figure 4). Thus, ammonia and pepper sauce were not included in any further analysis as deterrents. The bear-resistant container deterred bears from eating the bait 100% of the time. Bears removed bait significantly less often than expected when the bait was surrounded by an electric fence (χ^2 =29.7, P <0.001, Figure 4). However, the electric fence failed to deter three bears. One bear pulled the ground wire before touching the electric fence, causing the electric fence to have insufficient voltage transfer. Two other bears were able to get under the wire without receiving stimulus from the fence (the electric wire touched the bears but the electric pulse apparently did not penetrate the hair and there was no visible response to the wire when the bear was in contact). However, these bears did receive stimulus once they were inside the fence, and one bear collapsed the fence immediately after the encounter.

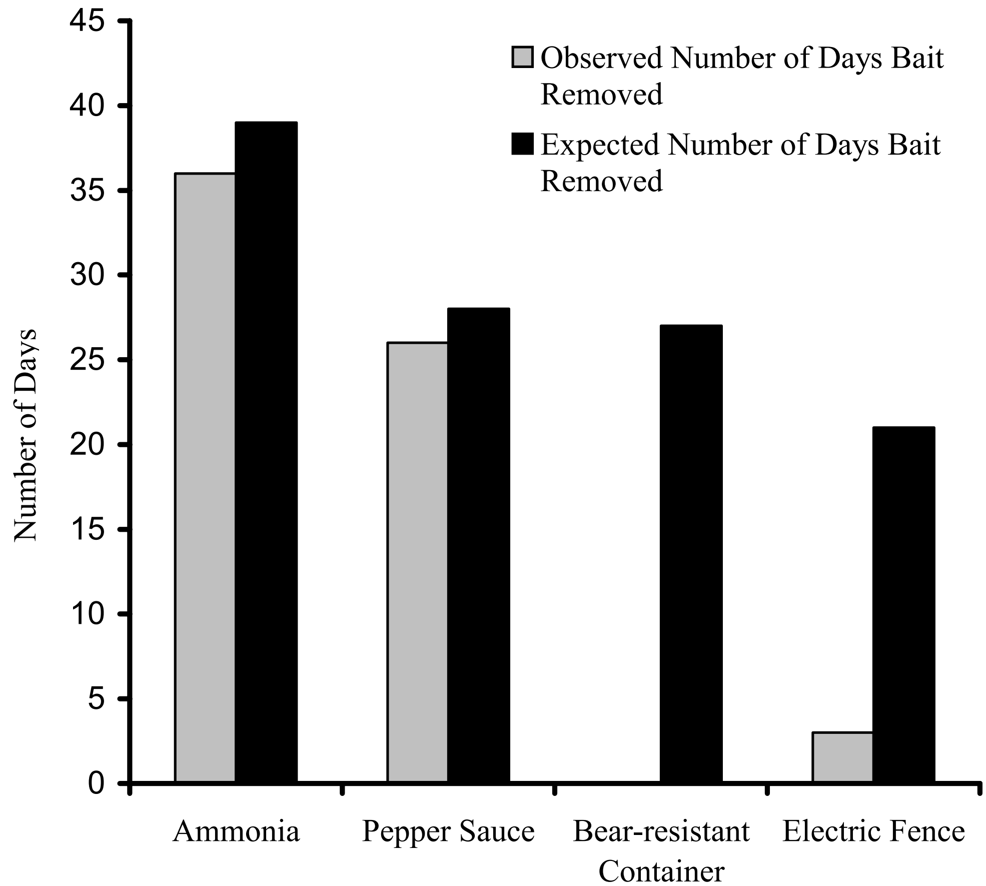


Figure 4. Number of days (24 h periods) that bait was removed by bears at stations compared to an expected value during the time deterrents were functional on the Hoopa Valley Indian Reservation, California from July to October, 2004.

Two of these three bears returned to the station after accessing the bait, but were deterred on the latter visits.

The mean number of return visits for identified bears that encountered a bear-resistant container as a proactive deterrent (0.25 ± 0.11, n = 16) was not statistically different from the mean number of return visits by bears that encountered a bear-resistant container as a reactive deterrent (2.8 ± 1.39, n = 5) (t = -1.82, P = 0.14). The mean number of return visits for identified bears that first encountered electric fence as a proactive deterrent (1.00 ± 0.58, n = 3) was not different from the mean number of return visits by bears that encountered electric fence as a reactive deterrent (1.14 ± 0.99, n = 7) (t = -0.09, P = 0.93). The mean time spent during visits for identified bears that encountered bear-resistant container as a proactive deterrent was not statistically different from the time spent by bears that had encountered it as a reactive deterrent (Figure 5). Likewise, the mean time spent during visits for identified bears that first encountered an electric fence as a proactive deterrent was not different from time spent by bears that encountered an electric fence as a reactive deterrent (Figure 5). For perspective, the mean time identified bears spent during a visit to the control was 677 ± 84 sec (n = 125). Due to lack of statistical difference and small sample size, proactive and reactive visits were pooled within each deterrent type for all further analyses.

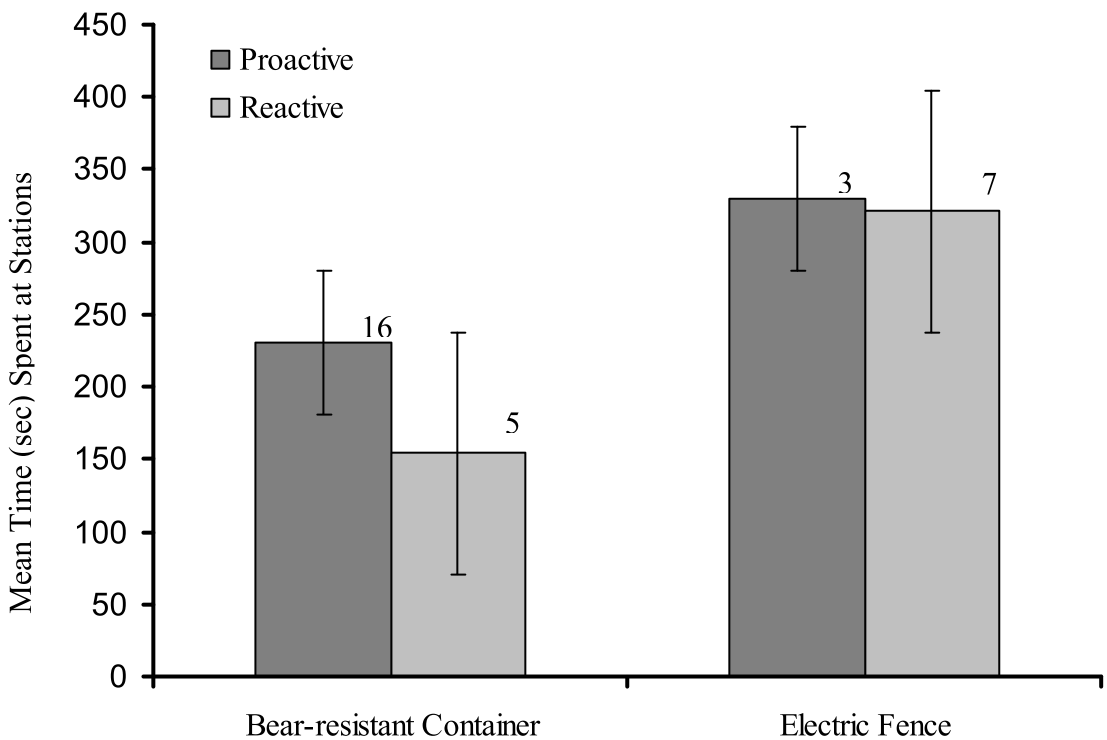


Figure 5. Bars represent mean times (s) spent for all identified bears at bear-resistant container stations and electric fence stations, Hoopa Valley Indian Reservation, California, July to October, 2004. Vertical lines represent error bars (± 1 SE), and numbers to the right of error bars represent sample size. The time spent during each visit for identified bears that encountered bear-resistant containers as a proactive deterrent was not statistically different from the time spent by bears that encountered them as reactive deterrents ($t = 1.44$, $P = 0.16$). The time spent during each visit for identified bears that first encountered electric fences as a proactive deterrent was not different from time spent by bears that encountered electric fences as a reactive deterrent ($t = 0.03$, $P = 0.98$).

Alterations in Bear Behavior at Deterrent Stations

After proactive and reactive visits were combined, behaviors at bear-resistant containers and electric fences were compared to behaviors at control sites to determine if deterrents affected the number of return visits or amount of time bears spent per visit to stations. The mean number of return visits after the initial visit was less at bear-resistant containers and electric fences than at control sites during the period of time deterrents were functional ($P < 0.05$, Figure 6). However, the mean number of return visits after initial contact with deterrents did not differ between the two deterrents ($P = 0.41$, Figure 6).

The mean time spent per visit at the bear-resistant container and electric fence stations was greater during the time bait was available and deterrents were not functional, than the period of time bait was available and deterrents were functional ($P < 0.001$, Figure 7). The mean time spent per visit at the control did not vary during the time bait was available and deterrents were not functional at other stations, than the period of time bait was available and deterrents were functional at other stations ($P = 0.72$, Figure 7).

Five identified bears were detected at both bear-resistant containers and electric fences for minimum of one visit while the deterrent was functional, and four subsequent visits to stations during the time that deterrents were functional. The amount of time spent at the stations did not vary for individual bears (ANOVA, $F = 0.01$, $P = 0.99$). The amount of time spent at the stations was less at electric fences than at bear-resistant containers (ANOVA, $F = 1016$, $P < 0.001$, Figure 8).

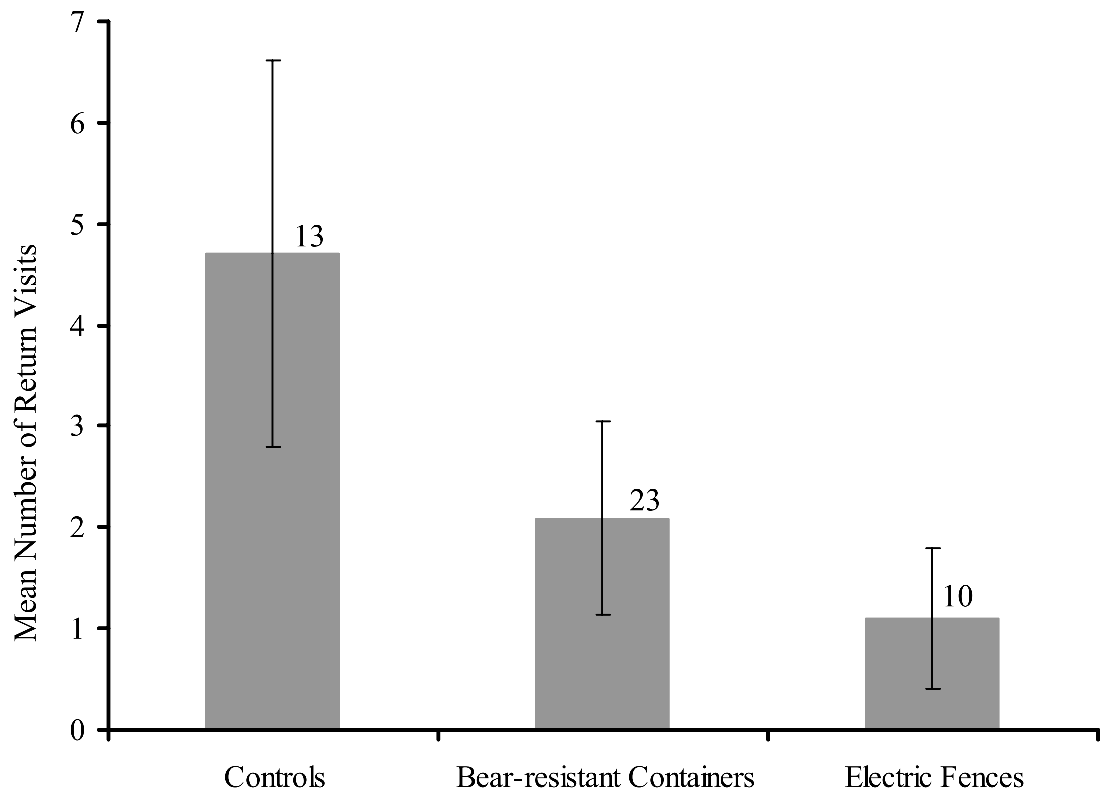


Figure 6. Bars represent the mean number of return visits for identified bears after initial visits during the time deterrents were functional, Hoopa Valley Indian Reservation, California, July to October, 2004. Vertical lines represent error bars (± 1 SE), and numbers to the right of error bars represent sample size. The number of return visits at the bear-resistant containers differed significantly from the controls ($t = -2.34$, $P = 0.018$). The number of return visits at electric fences differed significantly from the controls ($t = 2.64$, $P = 0.01$). The number of return visits did not significantly differ between electric fences and bear-resistant containers ($t = 0.83$, $P = 0.41$).

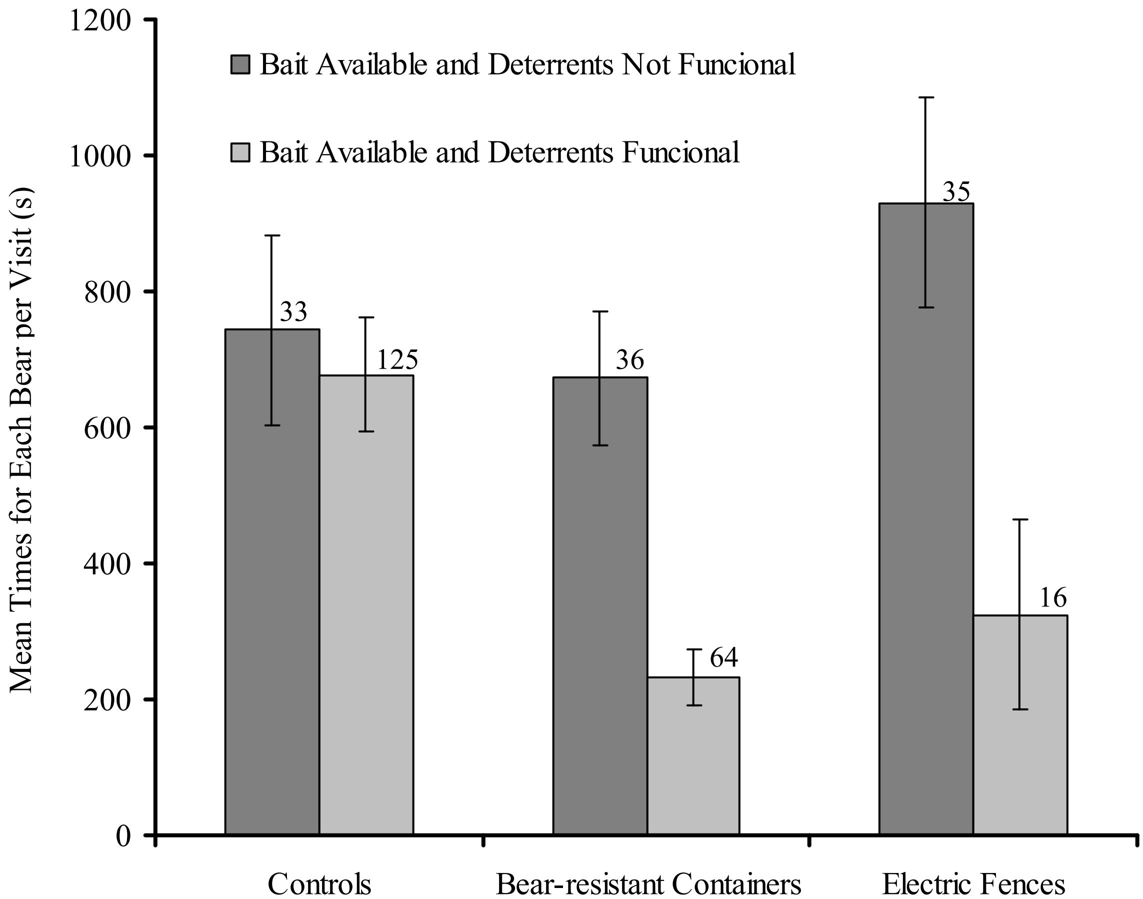
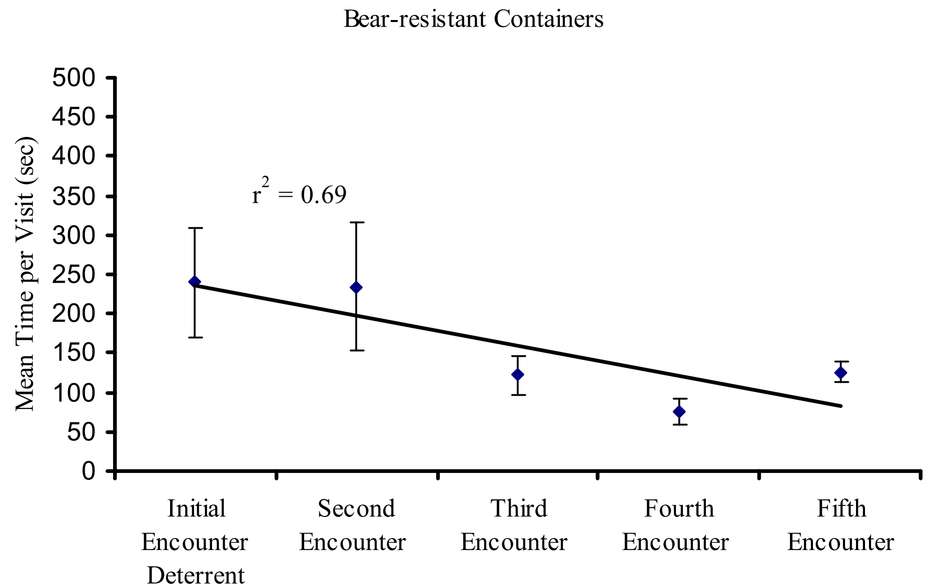


Figure 7. Bars represent mean times per visit that identified bears spent at stations when bait was available and deterrents were not functional and when bait was available and deterrents were functional, Hoopa Valley Indian Reservation, California, July to October, 2004. Vertical lines represent error bars (± 1 SE), and numbers to the right of error bars represent sample size. The time spent per visit did not differ between when bait was available and when deterrents were functional at the controls (t = -0.36, P = 0.72). The mean time spent per visit was greater during the time bait was available than during the time deterrents were functional at bear-resistant containers (t = -4.83, P < 0.001), and electric fences (t = -4.83, P < 0.001).



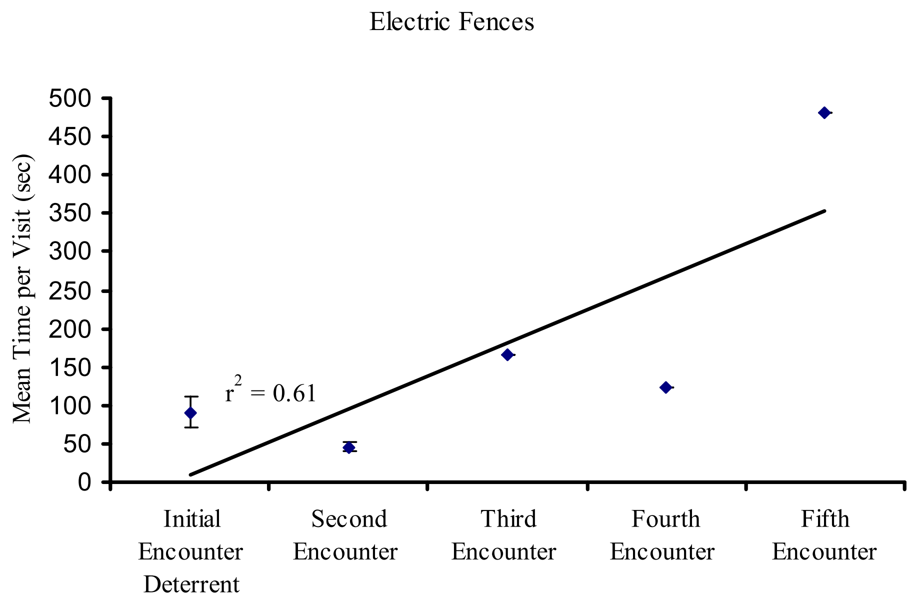


Figure 8. The mean time per visit of all bears that visited bear-resistant containers and electric fences during the time that deterrents were functional, Hoopa Valley Indian Reservation, California, July to October, 2004. Vertical lines represent error bars (± 1 SE). Bear-resistant containers decreased the amount of time spent at the sites, but time spent at the electric fences increased over time.

Also, the amount of time significantly changed over repeat visits for all bears at both deterrents (ANOVA, $F = 3.94$, $P = 0.03$). Mean time bears spent at bear-resistant container decreased with sequential visits ($r^2 = 0.69$, Figure 8). The mean time bears spent at the electric fence increased with sequential visits ($r^2 = 0.61$, Figure 8). However, only one of five bears visited the electric fence station more than twice after contact; this bear collapsed the fence on the second visit and was able to access the bait on the fifth visit.

The electric fence was functional for a total of 21 d and was not energized for 14 d. Three of the 10 identified bears that had contact with the electric fence during the time the deterrent was functional returned once the fence was not energized, which was not statistically different from expected ($\chi^2 = 0.24$, $P = 0.62$). Bears that returned to electric fences once they were not energized had significantly more visits to all stations (79 ± 24) than bears that did not return (11 ± 4) ($t = -4.30$, $P = 0.001$). The mean time it took bears to return to the electric fence once it was not energized was 14 ± 5 h (n = 3).

The electric fence was ineffective at keeping identified bears from the bait 30% of the time (n = 10). Sex and size category did not appear to be related to the failure or success of the electric fence, but the sample size was too small for statistical interpretation (Table 2). Identified bears that accessed food at the electric fence when it was functional had significantly more visits to all stations than bears that failed to get the bait in their encounter with the electric fence ($t = -3.03$, $P = 0.008$).

Table 2. Characteristics of identified black bears that had contact with the electric fence during the time the electric fence was functional, Hoopa Valley Indian Reservation, California, July to October, 2004.

			Size Category			Mean Number of Total Visits to All Stations	
	Total (n)	Sex	Small (1 – 1.75 ft)	Medium (1.76 – 2.5 ft)	Large (>2.5 ft)	$\bar{x} \pm$ SE	Range
Electric Fence Successful	7	1 Male 2 Females 4 Unknown	3	3	1	13 ± 5	1 - 35
Electric Fence Failed to Deter	3	1 Male 1 Female 1 Unknown	2	1	0	73 ± 130	14 - 110

Of the 10 identified bears and 8 visits by unidentified bears that had contact with electric fences none of them charged the fences, and all of them initially fled on contact.

Variations in Vigilance Behavior

Principal Components Analysis (PCA) compiled the behavior categories into three principal components (Table 3). The three principal components represented 72% of the variation in behavior categories. Because PCA repeated the use of variables, the two principal components that accounted for the most variation were used in further analyses. Principal components one and two accounted for 51% of the variation and were used in further analyses. Principal component one included the behaviors hypothesized *a priori* as an indication of decreased vigilance behavior. Principal component two included behaviors hypothesized *a priori* as an indication of increased levels of vigilance behavior.

Bears were grouped into three categories based on frequency of visitation (1 visit, 2-10 visits, and 11-110 visits), to determine if principal components one and two varied with the number of total visits to stations. Principal component one was significantly different between the three categories of visitation frequency (ANOVA, $F = 3.46$, $P = 0.04$), but principal component two did not differ between the three categories (ANOVA, $F = 0.62$, $P = 0.54$). The mean value of principal component one was less for bears with only one visit than for bears that visited the stations 11-110 visits (Tukey-Kramer, $T = 2.43$, $P = 0.02$, Figure 9).

Table 3. Behavior categories that were highly correlated with principal components. Proportion of time identified bears exhibited behavior categories (Table 1) was collected at control, ammonia, and pepper sauce stations. Behavior category data are from 131 visits to stations by 19 identified bears, Hoopa Valley Indian Reservation, California, July to October, 2004.

Principal Component No.	Correlated Behavior Categories	+/- Correlation [a]
One	Grooming	-
	Resting	-
Two	Alarm Responses	+
	Vigilance Directed at Station	+
Three	Vigilance Directed at Station	+
	Vigilance Directed at Environment	-

[a] Note that because factor loadings are correlations, relationships between factors and variables can be positive or negative.

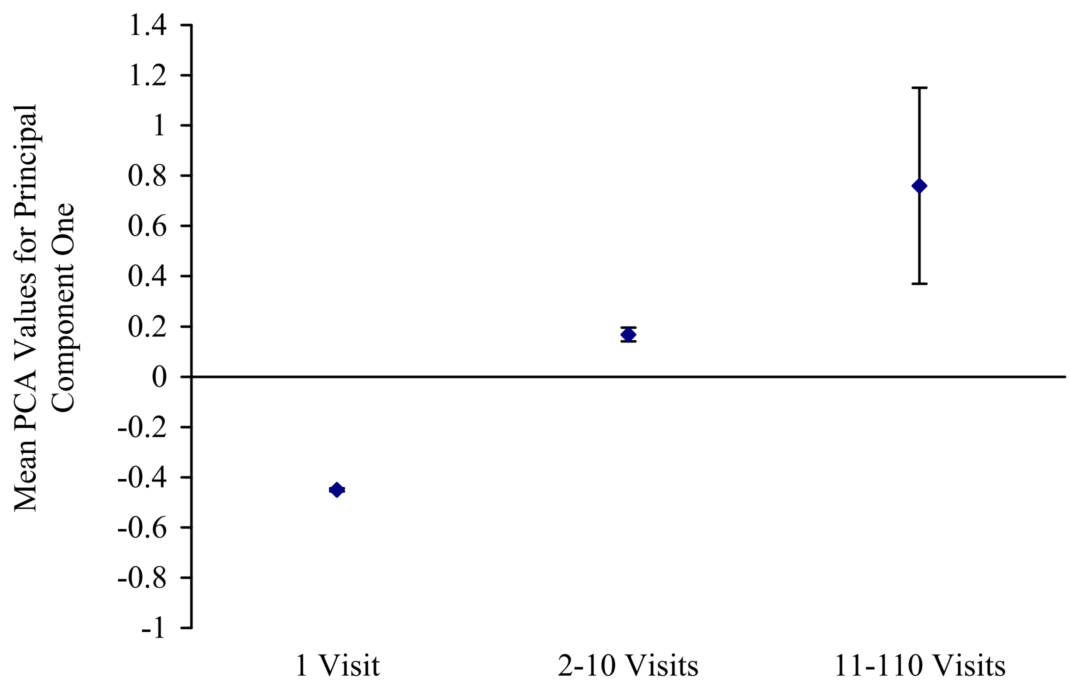


Figure 9. Mean principal component one values for identified black bears at the control, ammonia, and pepper sauce stations, Hoopa Valley Indian Reservation, California, July to October 2004. Vertical lines represent error bars (± 1 SE). The mean value of principal component one was less for bears with only one visit than bears that visited the stations 11-110 visits (Tukey-Kramer, $T = 2.43$, $P = 0.02$). The mean value of principal component one was not significantly different between bears that visited once and 2-10 times, or between 2-10 visits and 11-110 visits (Tukey-Kramer, $T = 1.45$, $P = 0.15$).

However, the mean value of principal component one was not significantly different between bears that had one visit and 2-10 visits or 2-10 visits and 11-110 visits (Tukey-Kramer, $T = 1.45$, $P = 0.15$, Figure 9).

Effectiveness of Deterrents at Residential Sites

Deterrents were placed at fourteen homes from 2 May 2005 through 31 August 2005 in response to complaints made by residents of the Reservation (Appendix A). Deterrents placed at residents' homes included six bear-resistant containers, five electric fences, and three homes had both a bear-resistant container and an electric fence (Table 4). One of nine bear-resistant containers at residential sites had bait removed from the container by a bear. Bears did not remove attractants from any of the eight electric fences placed at residential sites.

Table 4. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the residential testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005.

Type of Deterrent	Number of Residences	Description of Attractants Causing Conflict	Time of conflict	Number of Sites with Cameras	Number of Sites Bears Returned after Initial Contact with Deterrent	Number of Sites Attractant was Removed by Bears
Bear-resistant Containers	6	6 Garbage	4 Night 1 Day 1 Day and Night	3	2	0
Electric Fences	5	1 Freezer 1 Garden 1 Bee Hive 1 Fish Net 1 Entered Home	2 Night 1 Day and Night 2 Unknown	2	3	0
Bear-resistant Containers and Electric Fences	3	1 Dog Food 1 Garbage and Pool 1 Garbage and Garden	1 Night 1 Day and Night 1 Unknown	1	2	1

DISCUSSION

All sites at which deterrents were tested experimentally had multiple bears visit the stations during each period (bait available, deterrent functional, and post deterrent functional). The mean latency of detection at these sites was less than 24 h, which indicated that residents should expect bears to find anthropogenic food sources around their homes in a short amount of time.

Ammonia and pepper sauce sprayed on food were not affective at deterring bears from eating the bait. Hunt (1984) had success deterring bears by mixing molasses with equal parts ammonia. However, the technique I used in this study sprayed a small amount of ammonia relative to the bait and was used on top of the bait (not mixed together in equal parts), which may have decreased the effectiveness of ammonia as a deterrent. Equal parts of garbage and ammonia mixed together would not have been a realistic application for homeowners trying to dissuade bears from garbage containers, because of the amount of ammonia needed. Pepper sauce had not been tested previously, and was tested because residents had anecdotally claimed that it worked as a deterrent. During the experimental tests of pepper sauce as a deterrent, there were no observations indicating that bears paused or hesitated at the bait.

Bear-resistant containers were successful at deterring bears from bait 100% of the time at sites that experimentally tested deterrents. Other types of bear-resistant containers have also been successful in deterring bears (Shirokauer and Boyd 1998, National Park Service 2002). Other studies have found that most instances of human-bear conflicts involved food conditioned bears (Gunther 1994, Shirokauer and Boyd 1998). The use of bear-resistant containers not only decreased the opportunity for bears to become habituated to anthropogenic foods, it also altered human behavior, which may have contributed to the overwhelming success of bear-resistant containers in a variety of situations (McCullough 1982, Gunther 1994, Shirokauer and Boyd 1998, National Park Service 2002).

Electric fences were successful at deterring bears from a food source 70% of the time at sites that experimentally tested deterrents. The electric fences tested in this study reduced bear access a little less effectively or the same as what had been reported in other studies. Storer et al. (1938) found that electric fences were 100% effective at preventing black bears from entering two test enclosures. Bee hives that were not protected by electric fences had a 70% greater likelihood of damage by black bears in Florida (Brady and Maehr 1982). Huygens and Hayashi (1999) had 100% success at keeping Asiatic black bears (*Ursus thibetanus*) from entering protected areas surrounding crops. The greater density of bears in Hoopa, California could be a potential explanation for the lower success rate of electric fences tested in this study. Previous studies were not able to determine how many bears visited the electric fence (Storer et al. 1938, Brady and Maehr 1982, Huygens and Hayashi 1999), and in areas with lesser densities of bears sample sizes may have been small. Beckmann et al. (2004) was able to test deterrents on 62 bears, and found that there was individual variation in how bears reacted to deterrents.

My study tested responses to electric fences on at least 10 individual bears, and variation in individuals may have influenced the failures of electric fences.

The failure of the electric fence in the case of the bear removing the ground wire could have been prevented by moving the wires and electric fence energizer inside the electric fence. In the other two cases in which bears accessed the bait at the electric fence, one bear had 110 visits to all stations and the other had 96 visits; the two greatest total number of visits for all identified bears. For perspective, the third greatest number of visits for an individual bear was only 35 visits. These two bears were able to get through the fence without touching sensitive areas such as their nose, pads of their feet, or under their legs. There was no evidence that suggested age, sex, or size of bears was related to the likelihood of the electric fence failing; however sample size was only 10 bears. Results suggested that bears that were more habituated (greater number of visits) to the stations were more likely to exploit these design flaws and find a way to get around an electric fence.

Bear-resistant containers and electric fences encountered as proactive deterrents did not significantly reduce the number of return visits to stations or amount of time spent at stations, when compared to bears that encountered these deterrents as reactive deterrents. However, only a small number of bears revisited electric fences during the time they were functional whether or not they encountered fences as a proactive or reactive deterrent. Eighty-six percent of bears that visited bear-resistant containers as a reactive deterrent returned after their first encounter with the deterrent, but only 25 % of bears that visited bear-resistant containers as a proactive deterrent returned. Due to small sample sizes and variation among bears, the mean number of return visits was not statistically different between proactive and reactive visits. However, this reduction in "returned visits" may be significant for communities attempting to reduce the number of human-bear encounters, because each homeowner that is proactive in removing anthropogenic food sources may actually deter bears from "returned visits" to the area.

When proactive and reactive visits were combined for each type of deterrent, bear-resistant containers and electric fences successfully reduced the mean number of return visits and the mean time spent at stations. Manley and Williams (1998) also noted that once solid waste containers were bear-proofed, bear visitation decreased. However, bear-resistant containers and electric fences did not differ when compared to each other in decreasing the number of return visits. The lack of variation in how bears reacted to two very different deterrents suggests bears that do not receive a food reward regardless of what method is used will not return as often or stay as long during future visits. Evolutionary theory predicted that animals should maximize net energy intake (MacArthur and Pianka 1966). To calculate net energy intake, the cost of obtaining and digestion of food was subtracted from the amount and quality of food (Goldsmith et al. 1981). Once a food source has been removed or made harder to obtain by a deterrent, the cost of obtaining that food source may be elevated and no longer provide optimal foraging for bears.

For those bears that visited both the bear-resistant container and electric fence during the time deterrents were functional, there was no variation between individual bears in the amount of time they spent at each station. In order for bears to be included in the analysis, bears had to visit both a bear-resistant container station and an electric fence station when deterrents were functional and also had four subsequent visits to any of the stations at the site. By design this requirement included bears that were frequent visitors to the stations, and may have decreased variation between bears. However, the amount of time spent at bear-resistant containers and electric fences varied between deterrents and over time. Bears at bear-resistant containers spent less time at the stations on subsequent visits, but bears at electric fences spent more time at the stations on subsequent visits. The reason for an increase in time spent at the electric fences was that only one bear returned to an electric fence more than twice after contact. The one bear that visited the electric fence station all five times accessed the bait on the fifth visit. Small sample size combined with including a bear that the electric fence failed to deter may have accounted for the variation between deterrents. Once again, the decrease in time at the bear-resistant container suggested that bears responded to the lack of food instead of a negative stimulus provided by the electric fence.

Thirty percent of bears that were shocked at an electric fence returned once the fence was inactive. The mean time it took bears to return was less than 24 h. Bears may avoid or reduce their time spent at a particular location, but bears probably did not leave the area. Clark et al. (2005) observed that bears damaged beehives protected by electric fences within a few days of the expiration of the batteries that charged the electric fence energizer. Huygens and Hayashi (1999) noted that after the placement of electric fences around ripe cornfields bears damaged unripe cornfields in close proximity. Bears that remained in the area continued to test their ability to access a food source or traveled to the nearest available anthropogenic food source that was not protected by a deterrent (i.e. a neighbors house) (Huygens and Hayashi 1999, Clark et al. 2005). Residents must be diligent in removing anthropogenic attractants and maintaining deterrents, because bears that remain in the area will likely exploit any lapse in maintenance.

Behaviors such as grooming and resting indicated lower levels of vigilance, and were correlated to a bear's habituation to a location. Hunt (1984) also reported that bears that consistently visited deterrent stations were less vigilant approaching them than bears that visited stations for the first time or occasionally. In addition, when electric fences failed, bears had an increased number of visits to those stations (indicating habituation). Bears that exhibited decreased levels of vigilance may be harder to deter, because they were more habituated to an area or food source. In addition to decreased vigilance behavior, time of day bears were present in developed areas, and bears reactions to human disturbance may give managers evidence to the level of habituation of an individual bear (Clark et al. 2002, Beckman and Berger 2003b).

During the second year of the study, bear-resistant containers and electric fences were tested at residential sites. The bear-resistant containers failed as a deterrent at one home while electric fences worked 100% of the time keeping bears away from anthropogenic food sources. The variation in the success of the bear-resistant container may have been attributed to the type of attractant, amount of attractant, and level of habituation of the bear. Sites that tested deterrents experimentally had a small amount of food at each station that would not be considered a major food source for an individual bear. Some of the residential sites had consistent, predictable quantities of fruit, pet food, and garbage that bears could use as a primary food source. Bears may be more persistent in attempting to open a bear-resistant container once a primary food source has been removed. The lack of regulations against killing bears or reporting bears that were killed on the Reservation makes conclusions on the success of deterrents difficult to interpret due to the unknown fate of the bears after they left the residents' homes.

One important factor for the reduction of human-bear conflicts is refuse management (Herrero and Fleck 1990, McCarthy and Seavoy 1994, National Park Service 2002). The use of bear-resistant containers coupled with an enforceable refuse management policy, has led to a reduction in the number of nuisance bear complaints in many communities and parks (Gunther 1994, Schirokauer and Boyd 1998, Peine 2001, National Park Service 2002). Most bears that were killed in Denali National Park, Alaska prior to 1975, were attracted to the area by improperly stored food and garbage (Dalle-Molle and Van Horn 1989). Also, a study conducted in 1981 through 1987 throughout Minnesota, found most bear complaints involved disturbance of garbage and perceived threat of human injury (Garshelis 1989). However, Yellowstone National Park was able to reduce the number of people injured by bears from 48/yr to 1/yr, after enforcement of a policy that kept all human food secured from bears (Gunther 1994).

Not only were bear-resistant containers and electric fences effective at reducing access to anthropogenic foods, they also reduced the amount of time bears spent at a location. Homeowners and managers that can successfully reduce the time bears spend in an area inhabited by humans will reduce the potential for human-bear interactions. However, bears that have become habituated to a site may be more difficult to deter; thus widespread use of proactive deterrents would reduce the number of bears that interact with humans in the first place, and not become habituated.

If deterrents can reduce the number of human-bear interactions and increase public awareness, fewer bears might need to be removed lethally. Lethal control of nuisance black bears has not been successful in reducing the number of complaints in Minnesota or Japan (Garshelis 1989, Huygens and Hayashi 1999), and unregulated removal of nuisance black bears may have a detrimental effect on black bear populations (Beckmann and Berger 2003a). Public awareness and tolerance of black bears have been important factors in the success of black bear management plans (Peine 2001).

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APPENDICES

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005.

Residence #1

Resident #1 called the bear hotline 15 August 2005 and reported a bear getting into garbage at night. The garbage was contained in rubber cans with lids. Two bear-resistant containers were given to the resident and a camera was placed to view the containers from 15 through 30 August 2005. The camera was active 24 h per d for 16 d. One visit recorded a bear at the residence. The bear was visible for 2 min at which point he approached and attempted to open the bear-resistant container. As of 30 August 2005 the bear had not returned to the residence, and the homeowner felt that the deterrent was successful.

Residence #2

Resident #2 called the bear hotline 29 June 2005 and reported a bear on the porch looking through the screened door. The bear was present during the day and was not scared off by loud noises. Garbage contained in rubber cans with lids was located on the porch next to the door. Bear-resistant containers were provided and placed at the edge of the property. A camera was not placed at the home. As of 8 July 2005 the bear had not returned to the residence, and the homeowner felt that the deterrent was successful.

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

Residence #3

Resident #3 called the bear hotline 28 July 2005 and reported multiple bears in the yard at night. The garbage was uncontained next to the home, and the compost was just outside the back door. There was no garbage container because a bear had destroyed it previously. Two bear-resistant garbage containers were placed at the edge of the property, and the compost pile was also moved to the opposite end of the property. A camera was placed in view of the bear-resistant containers from 28 through 1 August 2005. The camera was active 24 h per d for 4 d, and then the camera was removed due to vandalism. The camera did not detect bears. As of 30 August 2005 bears had not gotten into the garbage, and the homeowner felt that the deterrent was successful.

Residence #4

Resident #4 called the bear hotline 16 June 2005 and reported a bear taking a garbage container into the forested area behind the house. The bear was coming at night and rolling the rubber garbage container with lid to an area with cover and eating the garbage. A camera was placed where the garbage was prior to the bear taking the container from 16 through 22 June 2005; the camera was active 24 h per d for 6 d. Two bear-resistant containers were placed at this site on 20 June 2005. The camera was taken

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

down by the request of the homeowner. As of 22 June 2005 bears were not visible at the bear-resistant containers, and the homeowner felt that the deterrent was successful.

<u>Residence #5</u>

Resident #5 called the bear hotline 10 June 2005 and reported a bear eating their garbage, pet food, and coming on the porch during the day while people were outside. There was a large amount of uncontained garbage and the pet food was stored outside. The garbage was cleaned up and disposed of by a crew on 20 June 2005 and two bear-resistant containers were provided. The pet food was also moved indoors on 20 June 2005. A camera was not placed at the home. As of 1 July 2005 the yard had remained clean and the garbage was being kept in the bear-resistant containers. According to the homeowner the bear had not returned, and they felt that the deterrent was successful.

<u>Residence #6</u>

Resident #6 called the bear hotline 5 May 2005 and reported a bear getting into the garbage at night. The garbage was in a rubber container with lid and the bear destroyed the container and ate the garbage. One bear-resistant container was provided on 5 May 2005. A camera was not placed at the home. As of 2 June 2005 the resident reported the bear still in the area, but had not accessed the garbage and they felt the deterrent was successful.

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

Residence #7

Resident #7 called the bear hotline 15 July 2005 and reported a bear opening an outside freezer and eating food stored inside. Multiple bears were visiting the home day and night. One bear was in an apple tree less than 10 m from the house when we first arrived. The resident did not have garbage or pet food outside and the area under the fruit tree was clean. The freezer was moved away from the front door of the house and an electric fence was placed around the perimeter. The family removed the electric fence on 18 July 2005 and placed a locking device on the door of the freezer. A camera was placed at the residence from 15 through 21 July 2005.

On 15 July 2005 at 21:44 the bear that was suspected of getting into the freezer prior to the placement of the deterrent visited the site. The bear did not attempt to access the freezer or touch the electric fence. On 16 July 2005 at 2:40 the same individual returned and was shocked by the electric fence, and had not returned as of 21 July 2005. A second bear walked through the yard on 20 July 2005 at 15:23, but did not investigate the freezer. The camera was taken down by the request of the family on 21 July 2005. Bears did not disturb the freezer during the time the camera was active however, the residents were unhappy that bears were still around the home.

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

Residence #8

Resident #8 called the bear hotline 30 June 2005 and reported a bear walking through their garden. The resident was concerned the bear would eat the fruit and vegetables in the garden when they became ripe. An electric fence was placed around the perimeter of the garden on 30 June 2005. A camera was not placed at the home. As of 26 July 2005 bear scat and tracks were present in the yard, but the garden had not been disturbed. The homeowner felt that the deterrent was successful.

Residence #9

Resident #9 called the bear hotline 20 June 2005 and reported a bear had destroyed beehives during the night of 19 June 2005. The remaining hives were consolidated and an electric fence and a camera was placed within view of the hives on 21 June 2005. The camera was active from 21 June 2005 through 1 July 2005, 24 h per d for 11 d. Bears were not visible at the beehive during this time, and the homeowner felt that the deterrent was successful. The electric fence remained active until November 2005.

Residence #10

Resident #10 called the bear hotline 9 June 2005 and reported bears eating fish out of two gill nets, which ultimately destroyed the nets. The nets were placed in a

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

remote area along the Trinity River, which were only accessible by boat. Two electric fences were placed along the shore of the river surrounding the perimeter of the nets on 9 June 2005. The electric fences were active until the gill nets were removed in July 2005. Cameras were not present at the nets. On 17 June 2005 the electric fence around the first net had been disturbed by a bear, tracks were visible, and the chicken wire surrounding the fence shorted out the electric fence charger. However, the fishing net was not disturbed. On 17 June 2005 tracks of bear were found around the second net, but the electric fence and net were not disturbed. There was no loss of fish or damage to the nets after placement of the electric fences, and the owner felt the deterrent was successful.

Residence #11

Resident #11 called the bear hotline 2 May 2005 and reported a bear entering a screened porch. There were no obvious attractants on the porch and an electric fence was placed around the perimeter of the porch on 2 May. The electric fence was active until 2 June 2005. A camera was not placed at the home. As of 2 June, bears had not entered the porch, and the homeowner felt the deterrent was successful.

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

Residence #12

Resident # 12 called the bear hotline on 23 June 2005 and reported a bear coming on the porch and eating pet food during the day and night. Garbage was not kept outdoors, but approximately 91 kg of dog and cat food were stored in bags on the porch. On 23 June 2005 the remaining pet food was placed in a bear-resistant garbage container and the resident agreed to remove any uneaten pet food from the porch at night. A camera was placed in view of the bear-resistant container from 23 June through 6 July 2005, and operated 24 h per d for 13 d. The camera recorded 17 visits of one identified bear at the bear-resistant container.

The bear unlatched the bear-resistant container by rolling the container on 23 June, but did not open the container. However on 26 June 2005 the bear unlatched and opened the container and ate the remaining dog food. A lock was placed on the bear-resistant container on 27 June 2005, which kept the bear from opening the container again. The homeowners were concerned with the amount of time the bear was spending in their yard. In order to try and deter the bear from returning to the residence, an electric fence was placed around the bear-resistant container on 30 June 2005. The bear returned once after the electric fence was active on 1 July 2005 and was shocked. The electric fence and camera were taken down on 6 July 2005 by which time the bear had not

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

returned. As of 1 August 2005 the homeowner reported that the bear had not returned. The homeowner did not feel that the bear-resistant container was successful, and no longer placed pet food in the container or outside. The homeowner did feel that the electric fence was successful.

Residence #13

Resident #13 called the bear hotline on 7 July 2005 and reported a bear had bitten an inflatable swimming pool damaging a portion of the pool. The pool was next to the garbage, which was in rubber containers with lids. The resident was given 2 bear-resistant containers, and an electric fence was placed around the perimeter of the pool and bear-resistant containers on 7 July 2005. Bear scat was seen around the perimeter of the property, but as of 1 August 2005 bears had not bothered the garbage or swimming pool. The electric fence was removed on 1 August 2005, and the homeowner felt that the electric fence was successful.

Residence #14

Resident #14 called the bear hotline on 28 July 2005 and reported a bear in their yard close to the home during the night. Attractants around the home included pet food stored outdoors, garbage in rubber containers, unripe fruit tree, and a garden with unripe pumpkins and melons. The bear had not eaten any of the attractants as far as the

Appendix A. Description of human-bear conflicts that were addressed by giving residents bear-resistant containers, electric fences, or both during the field application testing of deterrents, Hoopa Valley Indian Reservation, California, May to August, 2005. (continued)

homeowner knew. On 28 July 2005 two bear-resistant containers were provided for pet food and garbage and an electric fence was placed around the garden and fruit tree. The electric fence was active until October 2005. As of 30 August 2005 the resident had not seen a bear in the yard, and felt that the deterrents were successful.