Human–Wildlife Interactions 4(1):95–102, Spring 2010

Effects of waterfowl hunting on raccoon movements

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Abstract: Nontarget wildlife may react to hunters with avoidance, ambivalence, or attraction, depending upon the frequency of contact and the consequences of past contacts. We studied raccoons (*Procyon lotor*) located within the Bear River Migratory Bird Refuge, Utah, before and during waterfowl hunting seasons to assess changes in the size of their distributions, locations, and travel distances. Raccoon distribution size did not change with the onset of hunting. Once hunting began, raccoons were located more frequently in areas with lower densities of hunters and less frequently in areas with higher densities of hunters. Raccoons also responded to the presence of waterfowl hunters by traveling shorter distances at dawn, when hunters were active, and longer distances at dusk. This shift in movement to dusk may have allowed raccoons to exploit food resources provided by hunters, such as litter and wounded ducks, when few waterfowl hunters were in the marsh.

Key Words: distribution, human–wildlife interactions, hunting, *Procyon lotor*, raccoon, Utah, waterfowl

During the hunting season, game species may reduce their vulnerability to hunters by altering the periods when they are active to those periods when hunters are less likely to be present (Douglas 1971, Glueck et al. 1998, Hodges et al. 2000) or by increasing their wariness (Bender et al. 1999). They may also move to areas where there is better cover or where hunting is prohibited (Roy and Woolf 2001, Vieira et al. 2003). While these behavioral changes can reduce the probability of a game animal being shot by hunters, they can be detrimental to surviving animals by increasing their energy expenditures or reducing their ability to forage efficiently. These consequences can decrease the animals' ability to survive the following winter or reproduce in the spring (Short 1981, Knight and Cole 1995, Hodges et al. 2000).

The activities of hunters may also affect animals not targeted by hunters (nontarget species). Few studies have been published concerning the impacts of hunting disturbance to nontarget animals. Like target species, nontarget animals may respond to hunters by moving to safe areas or changing activity patterns. Conversely, hunter activity may attract wildlife. For example, grizzly bears (*Ursus arctos horribilis*) that were attracted to elk (*Cervus canadensis*) remains discarded by hunters outside the borders of Yellowstone National Park, USA, changed their activity and foraging patterns to utilize this food resource (Haroldson et al. 2004).

Waterfowl hunting is a popular recreational activity in the United States; 3 million people hunted migratory waterfowl during 2001 (U.S. Department of Interior 2003). Human activities during the waterfowl hunting season may be particularly disturbing to animals because most waterfowl refuges and marshes experience little human activity throughout the rest of the year.

This study was designed to determine if human activities during waterfowl hunting influenced raccoon (*Procyon lotor*) movements. We chose raccoons as a study subject because they are a common species found in wetland environments throughout North America (Whitaker 1996). While raccoons inhabiting waterfowl refuges may not be accustomed to human activity, the species is known for its ability to live among humans in suburban and urban environments (Randa and Younger 2006). We hypothesized that the presence of waterfowl hunters would reduce diurnal and crepuscular movements (when hunters are present) and increase nocturnal movements. Additionally, we hypothesized that human activities during

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the waterfowl hunting season would shift raccoon distribution patterns but not cause a change in their distribution location.

Methods

Study area

This study was conducted on the Bear River Migratory Bird Refuge west of Brigham City, Utah, USA (N41°28′43″ W112°16′01″). This study was conducted in the delta section of the refuge, which contained >26,000 ha of wetland habitat. This section of the refuge was created by a system of levees that control the flow of the Bear River into the Great Salt Lake (U.S. Fish and Wildlife Service 1997). The topography was relatively flat, falling approximately 0.1 m/km to the south, averaging 1,280 m above mean sea level. Daily high temperatures for the study period averaged 14° C, and average annual precipitation was 30 cm (U.S. Fish and Wildlife Service 1997).

Measuring hunter activity

This study was conducted from 3 weeks prior to and 3 weeks after the October opening day of the waterfowl hunting seasons of 2001 and 2002. During the study years, approximately 8,000 waterfowl hunters visited the refuge from mid-October to January 15 each year (B. Olsen, U.S. Fish and Wildlife Service, personal communication, 2004). Most, but not all, of the study area was open to waterfowl hunters during this time. Hunters accessed the interior of the refuge by either walking on dikes or using boats. While hunter use of the refuge's delta was extensive, hunter activity was concentrated during dawn, as is common with waterfowl hunting. Hunter numbers declined as the day progressed, and no hunters were allowed to remain on the refuge at night (B. Olsen, U.S. Fish and Wildlife Service, personal communication, 2004).

Monitoring raccoons

We trapped raccoons as part of an ongoing study (IACUC #975R ; Frey and Conover 2006). Raccoons chosen for this study were a subset of the total study population. We chose raccoons that had been radio-tracked consistently for >2 months prior to the start of this study. Thus, there was a high probability that we would continue to gather data from these animals for another 6 weeks.

We trapped raccoons using box traps baited with commercial cat food. Box traps were wire-woven, single-door live traps (Tomahawk Livetrap Co., Tomahawk, Wis., USA). We placed each trap under a bush or structure that would provide shelter from natural elements. We immobilized trapped animals using <0.1 mg per kg body weight of an acepromazine-ketamine mixture (0.01 mg acepromazine and 0.09 mg ketamine; Bigler and Hoff 1974). Raccoons weighing >5 kg were sexed, ear-tagged, and fitted with a radio collar (160 g; Advanced Telemetry Systems, Isanti, Minn.; similar to model M2220). To minimize collaring juveniles, animals weighing <5kg were ear-tagged, but not fitted with collars (Major and Sherbourne 1987, Gehrt and Fritzell 1998). Upon recovery from the immobilization, raccoons were released at the trap site.

Kamler and Gipson (2003) reported that raccoon activity was correlated with temperature and there was less activity in autumn as individuals began to enter into a partial-hibernation. Additionally, the water level in the management ponds at the refuge may have affected the availability of food in an area, which may in turn have affected raccoon movements. Thus, to minimize the effect of both changing temperatures and water levels on the study animals' behavior, we limited monitoring to 3 weeks prior (pre-season) to the start of the waterfowl-hunting season and for the 3 weeks after the opening day of the waterfowl hunting season in 2001 and 2002. While this was a short time frame, these raccoons were located 3 to 4 times a week for several months prior to and after the study, as part of a larger project that provided a frame of reference for the study raccoons' locations and movement patterns within this study.

During 2001, we radio-tracked raccoons in 2 monitoring sessions, each 8 hours in duration, 1600 to 2400 hours and 2400 to 0800 hours, to account for their crepuscular activity (Ough 1979). These times represented periods of the highest raccoon movement. During 2002, we created 4, 6-hour monitoring sessions (i.e., 0400 to 1000 hours, 1000 to 1600 hours, 1600 to 2200 hours, and 2200 to 0400 hours) to analyze daytime movements in addition to crepuscular periods. Diurnal movements are not typical of this species; however, during the first year of our study, we found that this population of raccoons moved among rest areas and foraged during the day. Data collected from the monitoring sessions were then reclassified as dusk, night, dawn, and day, based on seasonal photoperiods prior to analysis. Dawn and dusk represented the 2 crepuscular movement periods. Dusk began 1 hour before sunset and continued for 2 hours after sunset. Dawn began 1 hour before sunrise and ended 2 hours after sunrise. We used meteorological data to determine sunrise and sunset times during the study. For each monitoring session, we tracked each raccoon ≥3 times pre-season and ≥3 times during the hunting season.

Prior to the start of each monitoring session, we initially located the target study animal. Once the monitoring session began, the study animal was located every 30 minutes using a 3-element yagi antenna (Advanced Telemetry Systems, Isanti, Minn.) and corresponding receiver (R-1000, Communication Specialists, Orange, Calif.). We obtained 2 to 3 bearings for each location; 3 bearings were preferred so that we could calculate an error estimate. We chose radio-tracking locations so that bearing estimates would be >20° and <160° apart from each other to minimize estimation errors during triangulation (Kitchen et al. 2000). Because traveling animals may cause large telemetry estimation errors, we obtained subsequent bearings within 10 minutes. Although passing vehicles usually did not disturb foraging raccoons, we did not stop vehicles close to study animals to avoid disturbing raccoon movements (Ellis 1964).

Data analysis

Distribution. We used the software package LOCATE® (Pacer, Truro, Nova Scotia) to calculate estimated telemetry locations for each study animal from the collected radio-telemetry bearings. LOCATE established an error estimate for locations determined by 3 points. We deleted all estimated locations with an associated error ≥100 m in any cardinal direction, regardless of the associated error polygon.

Using ArcView 3.x (ArcView GIS, ESRI, Redlands, Calif.), we combined triangulated estimations with visual locations for each individual raccoon to determine distribution and movement. For each season (pre-hunting or hunting), we used the Minimum Convex Polygon (MCP) method to establish a distribution location for each study raccoon. Additionally, we estimated distribution sizes for each movement period. We considered the area an animal occupied during a season or movement period the distribution for that season or movement period. By the nature of our study design, which was built to detect small movements over the course of 24 hours, we could not ensure that all of our locations were temporally independent. Therefore, our estimates of distribution should be considered only a term of reference used for comparisons within this study and should not be compared to other research on actual home-range sizes.

Using SAS (SAS Institute Inc., Cary, N.C.), we conducted a *t*-test to determine if distribution sizes differed between seasons (α = 0.05). Because of the nature of the movement period estimates, with possible location dependence and a limited number of telemetry locations per raccoon, we conducted basic statistic analyses (mean, standard error) only on these data sets.

Raccoons and hunter activity. We classified each section of the refuge by its relative hunter density for each year of the study to determine the trends in spatial avoidance of raccoons to waterfowl hunters. This categorization was created by the U.S. Fish and Wildlife Service based on its monitoring of hunter activity during the course of the waterfowl season. This classification represented the proportion of total hunters that visited each of the sections during the entire study period.

The location of waterfowl habitat during the fall differed each year due to management of the refuge. For example, 1 section may be a shallow pond the first year and a dry playa the next. The number of hunters using a section fluctuated each year in relation to the amount of wetland habitat available and, thus, presumably, the density of waterfowl in the section. Therefore, hunters' use of a given section could differ from 1 year to the next. Classifying the sections as to their relative density over the entire study period enabled us to compare results between years as well as study periods. We classified sections according to the total number of hunters who used the study area each season as having relatively high (>40%), medium (10 to 40%), low (<10%), or no hunter activity during the waterfowl-hunting season each year of the study. Thus, 1 section may have had low hunter density the first year of the study and high hunter density the next year.

We calculated the percentage of the total number of times each individual raccoon was located within each classified section of the refuge (% frequency) for each season. Using analysis of variance (ANOVA) of our normalized data, we analyzed the effect of both season and movement period on the percent frequency of locations within each level of hunter density.

Raccoon movements. To analyze the movement patterns of raccoons during the seasons, we utilized the Home Range Analysis extension within ArcView 3.x (Rodgers and Carr 1998) to calculate the straight-line distance traveled by a radio-collared raccoon from 1 radio-telemetry location to the next (30-minute periods). Data were labeled by 4 movement periods. Using ANOVA, we determined the influence of hunter activity on the distance that a raccoon traveled in 30 minutes for each movement period.

Results

Distribution area

We obtained 1,799 locations on 11 unique individual raccoons (5 raccoons in 2001, and 6 raccoons in 2002). The average standard error associated with each triangulated location was 45 m. Previous data analyses determined that there were no sexual differences among animals in distribution size or distribution use (Frey and Conover 2006). Therefore, we pooled all data for our analyses. No study raccoons were lost during the waterfowl hunting seasons in which they were being radio-tracked.

All raccoon distributions calculated in this study included areas used by waterfowl hunters with varying hunter use and some areas with no use. During the pre-hunting season, the average raccoon distribution size was 1.90 ± 0.17 (SE) km^2 in 2001 and 2.28 ± 0.62 km^2 in 2002. Once hunting began, the average distribution size was 1.60 ± 0.67 km^2 in 2001 and 2.52 ± 0.50 km^2 in 2002. Raccoon distribution size did not differ before and during the waterfowl-hunting season during 2001(n = 5, t_8 = 0.44, P = 0.68) or during 2002 (n = 6, t_{10}= -0.30, P = 0.77).

Time of day was not related to raccoon distribution area. Distribution sizes during both day and night were similar before (day: 1.25 ± 0.36 km^2; night: 1.54 ± 0.32 km^2) and after the hunting season began (day= 1.19 ± 0.27 km^2; night = 1.95 ± 0.42 km^2; Figure 1). While there was a pattern of change during the crepuscular times of the day, this trend was not statistically different. Pre-hunting raccoons had a larger distribution during dawn (1.26 ± 0.24 km^2) than dusk (0.25 ± 0.1 km^2). After waterfowl hunting began, there was a trend for distributions to be smaller during dawn (0.76 ± 0.27 km^2) when hunters were most active, but larger during dusk (0.68 ± 0.32 km^2) when the last hunters were leaving for the day (Figure 2).

Effects of hunter density on raccoon location

Hunter density within different areas of the refuge impacted raccoon locations ($F_{3,\ 240}$ = 14.01, P < 0.001). There also was an interaction between seasons (pre-hunting and hunting) and hunter density ($F_{3,\ 240}$ = 3.34, P = 0.02). Specifically, raccoons decreased their time in areas with medium densities of hunters and increased their time in areas with low densities of hunters (Figure 2). Time of day did not affect the percentage of frequency of locations within differing levels of hunter density before or after waterfowl hunting began ($F_{6,\ 240}$= 0.03, P = 0.99).

Raccoon movements

The distance individual raccoons moved within 30-minute periods differed among time periods, regardless of hunting season ($F_{3,\ 1405}$ = 25.92, P < 0.001; Figure 3). There was a significant interaction between time periods and seasons ($F_{3,\ 1405}$ = 4.30, P = 0.005). After the hunting season began, movement distances were shorter during the dawn period (P = 0.008, post-priori least square means t-test) and longer during the dusk (P = 0.02, post-priori least square means t-test). In contrast, movement distances at night and day were similar before and during the hunting season (P = 0.90 and P = 0.77, respectively; Figure 3).

Discussion

Raccoons did not respond to the sudden influx of waterfowl hunters on the refuge by completely changing their distribution locations (i.e., moving to a different part of the

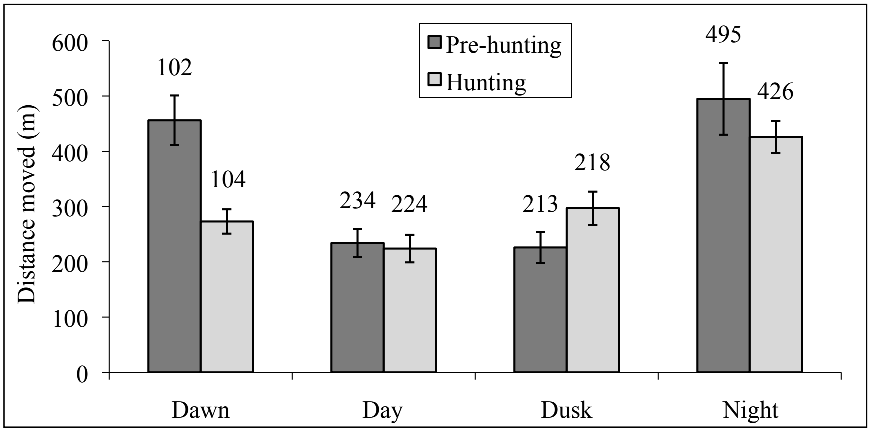

Figure 1. Distribution area of raccoons (km²) before and after waterfowl hunting began, Bear River Migratory Bird Refuge, Utah, USA, 2001–2002. Numbers represent sample size; bars represent SE.

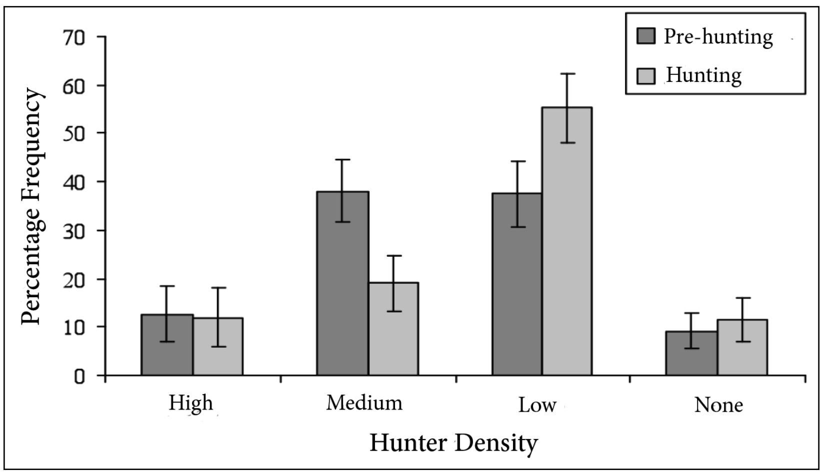

Figure 2. Average percentage frequency of raccoon locations found within each of 4 levels of waterfowl–hunter density before and during the waterfowl-hunting season, Bear River Migratory Bird Refuge, Utah, USA, 2001–2002. Bars represent SE.

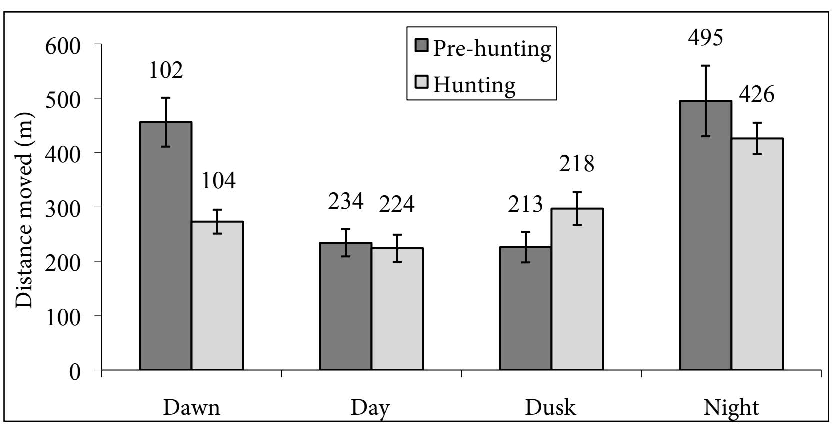

Figure 3. Average distance moved (m) within 30 minutes by a raccoon before and during the waterfowl hunting season, by time of day, Bear River Migratory Bird Refuge, Utah, USA, 2001–2002. Numbers represent the sample size of movements. Bars represent SE.

refuge). Instead, raccoons responded to the presence of waterfowl hunters by spending less time in those parts of their distributions where there were medium densities of hunters (i.e., 10 to 40% of all hunters) and more time in areas with few hunters (i.e., <10% of all hunters) even though raccoons were not the target of waterfowl hunters. We expected raccoons to spend less time in areas with high hunter densities (i.e., >40% of all hunters) and more time in areas with no hunters. We did not record this behavior because of a low sample size. Not all of the raccoons we studied had distributions that incorporated areas without hunters or with high hunter densities. Thus, movement into such areas was not possible for some raccoons without completely changing their distribution locations. Also, the short time period of the study may have influenced this result. As the hunting season progressed, raccoons might have moved their distribution locations away from hunted areas, in reaction to repeated disturbances by waterfowl hunters. However, our continued monitoring of the raccoons in conjunction with the larger on-going study did not record any changes in distribution location during the winter.

Other nontarget predators are known to change their behavior during hunting seasons. For instance, Florida panthers (*Puma concolor coryi*) avoided areas near off-road vehicle trails used by hunters during the deer hunting season (Janis and Clark 2002). We found that raccoons also changed the timing of their daily behaviors in response to waterfowl hunters. After the hunting season began, raccoons reduced their movement around dawn, which was the period when most hunters arrived to launch their boats and set their decoys.

These changes in raccoon behaviors raised the question: what was it about waterfowl hunters that caused raccoons to alter their behavior? Raccoons may have exhibited a neophobic response to hunter activity (e.g., walking, boating, vehicles, gunfire, and dogs). Outside of the hunting season, most raccoons on the refuge did not encounter humans because the public was limited to a single 19-km road. Alternatively, raccoons may quickly learn that contact with waterfowl hunters is hazardous. This seems plausible because some hunters in the refuge were reported to have shot at raccoons they encountered (S. Hicks, U.S. Fish and Wildlife Service, personal communication, 2004). However, none of our marked raccoons died during the waterfowl season; hence, the direct hazard that hunters actually posed to raccoons seemed minimal.

We found that raccoons respond to waterfowl hunters by moving more at dusk, perhaps in an attempt to compensate for their decreased movements at dawn. Also, raccoons may have increased dusk movements to search for food (e.g., litter and crippled ducks) that hunters made available that day. The U.S. Fish and Wildlife Service estimated that 4 to 5 million waterfowl nationwide are wounded but not retrieved by hunters (Van Dyke 1980, 1981). Yeager and Elder (1945) noted an increased raccoon consumption of waterfowl in the fall. Hence, raccoons that investigated areas of human activity and found crippled birds received a positive reinforcement that encouraged them to continue foraging in these areas used by waterfowl hunters (Dorney 1954, Esler and Grand 1993). During spotlight surveys conducted during the course of a concurrent study, we recorded several instances of raccoons running away from our lights with birds such as white-faced ibis (*Plegadis chihi*; 46-56 cm; 0.450 - 0.525 kg) in their mouths. Certainly, it is possible for raccoons to use wounded ducks similar in size (e.g., green-winged teal, *Anas crecca*, 31-39 cm, 0.14 - 0.50 kg).

In response to a sudden increase in human activity on the refuge at the onset of the hunting season, we predicted that raccoons might change their distribution size in an attempt to avoid human disturbance, but would not change their overall distribution location by moving to an entirely different part of the refuge. While our study was limited in scope by raccoon sample size, we were able to make general conclusions and support our hypothesis that raccoons would not move their overall distribution location. However, distribution size was not influenced; instead, raccoon movements within that distribution differed after hunting began. The results of the study suggest that waterfowl hunting does influence raccoon movement. We encourage future studies to replicate these methods with a larger sample size and longer time frame to investigate the general conclusions of this study.

Management implications

Our results suggest that there are nontarget effects of waterfowl hunting. Encounters with humans and their dogs during the hunting season may have resulted in negative consequences (e. g., harassment, becoming a target) that taught raccoons located in the hunting areas to reduce movements to avoid hunting activity, especially during dawn when human traffic was heavy. The negative impacts of hunting confrontations were not great enough to displace raccoon distributions or eliminate foraging at any time period. During dusk, raccoons increased their movements, possibly in association with an increased food opportunity. While potentially hazardous to raccoons on the refuge, waterfowl hunting may also be beneficial, providing raccoons with access to new food.

While we did not study the effect of an increased food source, we suggest future research in this subject. If our hypothesis that raccoons are supplementing their winter diet with wounded waterfowl is correct, it is a concern for wildlife managers of waterfowl refuges. An increase in winter food sources, such as wounded waterfowl, might lead to an increase in raccoon survival, and, thus, an increase in depredation pressure on nesting waterfowl the following spring.

Acknowledgments

Funding for this research was provided by the Jack H. Berryman Institute, Utah Agricultural Experiment Station, and U.S. Bear River Migratory Bird Refuge. M. Bodenchuk and G. Cook, from USDA/APHIS/WS provided guidance and instruction during the initial trapping of the study animals.

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