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A Study of the American Black Bear (Ursus americanus) in Utah: An Analysis of the Post-Denning Activities and Bear-Human Conflict

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ABSTRACT

A Study of the American Black Bear (*Ursus americanus*) in Utah: An Analysis of the Post-Denning Activities and Bear-Human Conflict

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This study examined two different aspects of black bear (*Ursus americanus*) ecology in Utah. First, we determined the post-denning behaviors of female black bears in order to help management agencies protect bears from human disturbances as well as set spring hunts that minimize the taking of females with dependent young. We looked at the timing of den emergence ($\bar{x}$ = 25 March), the number of days at the den site post emergence ($\bar{x}$ = 11 days), and departure ($\bar{x}$ = 8 April) for female black bears in Utah from 2011—2013. We also analyzed the effects of cohort (lone female, female with cubs, and female with yearlings), region of Utah, year, elevation, and weather on emergence, departure, and total number of days at den. Lastly, we describe behaviors observed at the den site. We found that first emergence was significantly correlated with cohort and spring temperature. Departure date was significantly correlated with geographic region, spring temperature during emergence and departure, and temperature the spring and summer before denning. Total number of days at den was significantly correlated with cohort and last frost date from the year before. Bears spent little of the post-denning period outside of the dens ($\bar{x}$ = 9.8% of total observation time). When outside of dens, bears were often observed walking, lying down, sitting and standing. We also observed unique behaviors, including gathering nest materials, nursing, and ingesting. Dens were frequently visited by other wildlife as well.

Second, we analyzed conflict between humans and black bears in Utah. The Utah Division of Wildlife Resources initiated a black bear sightings and encounters database in 2003. We upgraded this database by gathering available records and organizing them into a new database for analysis using Microsoft Access®. From 2003—2013 there were 943 records, with 499 bear-human encounters, 33 incidents, 10 attacks, 208 property damages, 187 sightings, and 6 vehicle collisions. Utah county had the highest number of events (*n* = 115). The majority of events took place at campsites (*n* = 363). Summer was the most common season for events (*n* = 715). Time of day was frequently not reported, but when it was, most events occurred at night (*n* = 173). We found no significant increase in the number of events over the last ten years. We also found no significant relationship between the number of events per year and drought data. The highest number of events involved single bears (*n* = 843), and over half of events had food or garbage available for the bear (*n* = 475).

Key Words: American black bear, bear attacks, bear-human conflict, behaviors, camera traps, database, denning, departure, emergence, hibernation, *Ursus americanus*, Utah

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CHAPTER 1

THE POST-DENNING ACTIVITIES OF THE AMERICAN BLACK BEAR IN UTAH

ABSTRACT

Understanding the timing of den emergence and departure allows management agencies to establish hunting seasons that minimize the take of females with dependent young as well as protect denned bears from human disturbances. We determined the timing of den emergence date ($\bar{x}$ = 25 March), the number of days at the den site post emergence ($\bar{x}$ = 11 d), and departure date ($\bar{x}$ = 8 April) for female black bears in Utah from 2011 to 2013. We analyzed the effects of cohort (lone females, females with cubs, and females with yearlings), region of Utah, year, elevation, and weather on emergence, departure, and total number of days at den site post-emergence using model selection and model averaging. First emergence date (n = 37) was significantly correlated with cohort (estimate = 12.27, P = 0.01) and spring temperature (estimate = -2.54, P = ≤0.01). Final departure date (n = 21) was significantly correlated with geographic region (Wasatch and Uinta Mountains: Colorado Plateau, estimate = -19.23, P = 0.01), spring temperature during emergence (estimate = -2.97, P = 0.01), and temperature the spring and summer before denning (estimate = -3.38, P = 0.01). Total number of days at den (n = 21) was significantly correlated with cohort (lone females: females with cubs, estimate = -21.81, P = ≤0.01; females with yearling: females with cubs, estimate = -16.68, P = 0.01) and last frost date from year before (estimate = - 0.31, P = 0.04). We also described behaviors observed at the den site. Bears spent little of the post-denning period outside of the den ($\bar{x}$ = 9.8% of total observation time). When outside of the den, bears spent 4.1%–31.5% of the time walking, 3.6%–26.9% lying down, 8.0%–23.3% sitting, and 35.9%–62.8% standing, depending on the cohort.

We also observed several unique behaviors including gathering nest materials, nursing, ingesting, and visitation of den sites by other wildlife.

INTRODUCTION

Hibernation in bears is an adaptation that allows them to survive during winter months when food is limited (Johnson and Pelton 1980, Gaines 2003). This is especially important for black bears (*Ursus americanus*), as their diet relies on seasonal foods, including fruits, nuts, and plants (Jonkel and Cowan 1971, Bates 1991). Black bears enter dens in early winter, then depart the following spring. In addition to hibernation, dens are used by female black bears as birth chambers and nurseries. Females give birth to altricial young from January to February, and then nurse them at dens until den departure in spring (Hamilton and Marchinton 1980, Clark et al. 1998).

Black bear hibernation has been studied across a variety of biogeographic regions in North America. However, the length of denning varies among geographic regions and habitat condition. In addition, the majority of these studies used radio-telemetry to estimate the timing of den emergence (Lindzey and Meslow 1976, LeCount 1983, Hamilton and Marchinton 1980, Johnson and Pelton 1980, Tietje and Ruff 1980, Hellgren and Vaughan 1989, Smith et al. 1992, Weaver and Pelton 1994, Gaines 2003). More recently, Bridges et al. (2004) suggested using camera traps to determine den emergence dates and behaviors performed at the den site, while minimizing disturbances. At the time, they had to visit den sites every 7 to 21 d to inspect cameras and insure adequate film supply (Bridges et al. 2004). In recent years, advances in digital camera technology have allowed the capture of thousands of images without the need to frequently service cameras.

While reproduction of bears is essential to species survival, hunting is used to control bear numbers (Utah Division of Wildlife Resources 2000, Oregon Department of Fish and Wildlife 2012). Management agencies can use denning chronology to establish hunting seasons. For example, knowing when mothers and dependent young emerge in spring allows agencies to establish hunting seasons that minimize the take of this cohort. The timing of den emergence varies by cohort, generally with males being the first to depart and females with dependent cubs being the last (Jonkel and Cowan 1971, Tietje and Ruff 1980, O'Pezio et al. 1983, Hellgren and Vaughan 1989, Smith et al. 1992, Gaines 2003). In Utah, understanding the denning behaviors of black bears will aid managers in protecting bears from human disturbances, as well as help set spring hunts that minimize the take of females with dependent young.

Our objectives were to determine the date of den emergence and den departure for females, as well as the amount of time spent at the den site post-emergence. Additionally, we analyzed the effects of year, cohort (lone females, females with cubs, or females with yearlings), geographic location, and environmental variables on the emergence date, departure date, and number of days spent at the den after emergence. We also described and compared behaviors performed at dens by lone females, females with yearlings, females with cubs, yearlings, and cubs. Lastly, we described unique behaviors observed at den sites. Our objectives aim to help managers better understand black bear denning, as well as set better hunting seasons.

METHODS

Study Area

We conducted research throughout the mountainous regions of Utah where black bears exist. As of 2013, the Utah Division of Wildlife Resources (UDWR) had 27 radio-tagged bears denning in the Northeastern, Central, Southeastern, and Southern regions of Utah (Figure 1-1).

We positioned remote cameras (Reconyx® PC 900 model) outside dens of radio-tagged bears during annual den visits which occurred from December to April, 2011, 2012, and 2013. We either accompanied UDWR biologists to the dens and deployed cameras ourselves or had the UDWR biologists deploy them.

Camera Settings and Placement

We programmed cameras to take two images per trigger (i.e., motion-activated firing), with a one second delay between trigger events, resulting in nearly continuous video-like footage of bear activity outside the den. Each photographic image has a unique date/time/temperature stamp. For on-board data storage we mostly used 32 GB memory cards, although in 2011, two cameras had only a 4 GB card, and one camera had a 16 GB card. A 32 GB card can store up to 60,000 3.1 megapixel color images. Remote cameras were also capable of taking nighttime images by using an infrared illuminator with a flash range of up to 15 m.

Approximate den locations were first determined by aerial VHF telemetry. Den entrances were subsequently located on foot using VHF radio-tracking gear. Adult female bears were immobilized in the den with standard drugs administered using a jabstick. While biologists handled bears (e.g., fitted and replaced radio-collars, sexed and weighed cubs/yearlings, etc.), cameras were positioned <8 m from den entrances, to position them within the motion sensors' limit of sensitivity. In 2011, we anchored cameras to trees with an elastic cord (Figure 1-2). In

2012 and 2013, we mounted cameras with either an elastic cord or tree mount kit that provided more precise aiming of the camera's lens toward the den entrance. All cameras were secured with a cable lock to protect them from theft and removal by curious bears. Camera placement was often determined by the nearest available tree that was stout enough to withstand shaking by wind, which would trigger useless images. After mounting and initializing the camera, we secured the case with a zip tie strip to thwart bears from opening them. To discourage theft, we labeled cameras to inform people that they were for research and were protected by a lockout code. We also recorded den elevations and locations using GPS so that cameras could be recovered in May and June.

Camera Retrieval

Cameras were recovered in May and June. At each den site we measured the distance from the camera to the den entrance. We also opportunistically documented notable observations, such as dead cubs or the presence of scat and hair. After camera retrieval, we downloaded images to a computer where we viewed and encoded them. We determined emergence and departure dates, as well as den site activity budgets through image analysis. We assigned denned bears to the following cohorts: lone females, females with yearlings, and females with cubs. For behavior analyses, we added two more cohorts, yearlings and cubs, to compare activity patterns of adults to those of young.

Emergence, Departure, and Number of Days at Den Analysis

We defined den emergence as the first time bears exited their dens after winter hibernation. Den departure was defined as when bears left the den site permanently. Some bears do not immediately leave the denning area upon waking from hibernation, but emerge, stay for a period of time, then depart (Lindzey and Meslow 1976, Tietje and Ruff 1980, O'Pezio et al.

1983). We refer to this period of time between den emergence and departure as the post-denning period. For most dens, we did not know whether the bear was active or not (i.e., moving in and out of the den) before remote cameras were positioned. However, as snow was on the ground and little food was available, we concluded that time of camera placement was likely prior to den emergence. Supporting this conclusion, Utah Division of Wildlife Resources (UDWR) biologists who also visited dens reported no sign of activity, such as footprints, around them (UDWR, personal communication).

For consistency, we further defined den emergence as a full body exit followed by subsequent exits with no more than 6 d between exits. If the bear emerged on the same day as being visited by biologists, we excluded that bear from analysis. Additionally, we did not include dens that were visited after 31 March because the likelihood of the occupant having already been active was high. Upon departure from the den site, bears would rarely be seen again. Occasionally, however, bears would return for short periods of time weeks after having departed the den. They would not, however, re-enter the den so we did not consider this activity part of the post-denning period.

We determined emergence date, departure date, and number of days at den for bears in 2011, 2012, and 2013. In order to test the relationship between these three events and possible explanatory variables, we tested each one using candidate models and Akaike's Information Criterion adjusted for small sample size using Program R v2.15.2 (AIC_c; Akaike 1973, Burnham and Anderson 2002). Due to our small sample size, we limited candidate models to $\leq$ two explanatory variables (Concato et al. 1995, Peduzzi et al. 1996). Dates were converted to ordinal dates for analysis. The following potential explanatory variables were tested: year (2011, 2012, or 2013), cohort (lone female, female with cubs, or female with yearlings), ecoregion of Utah

(Woods et al. 2001), latitude, elevation, and weather variables from the spring/summer before denning as well, as the spring following denning (Table 1-1). We included weather variables from the spring and summer before denning as indicators of the mast and berry production in the previous season. Mast and berry production during the summer and fall determine the physical condition of bears as they enter dens, which in turn may influence the length of denning (Grinnell et al. 1937, Spencer 1955, Erickson and Youatt 1961, Rausch 1961). We also included weather variables from the spring during the time when bears emerged from dens. Weather at this time likely influences emergence and departure dates (Northcott and Elsey 1971, Rogers 1974, O'Pezio et al. 1983).

We tested explanatory variables for correlation, and those that had a correlation coefficient ≥ 0.6 were not included in the same model because they were considered too highly correlated (Graham 2003). We ranked models based on smallest AIC_c value. We selected models that had an AIC_c weight > 0.05 and used model-averaging in the face of model uncertainty (Burnham and Anderson 2002, Johnson and Omland 2004, Richards et al. 2011, Symonds and Moussalli 2011). To evaluate individual variables, we looked at whether or not 95% confidence intervals around estimates overlapped zero. MuMIn package (Barton 2013) in Program R v2.15.2 was used for model averaging.

Behavior Analysis

We calculated the total time at den from first emergence to final departure. We also calculated total time outside of den. In order to determine how much time was spent out of den, we found the percent time spent out of den for each cohort by adding the time spent out of den for each bear, dividing by the total time at den, and averaging this number for bears within a cohort.

We documented the different behaviors (Table 1-2) performed by bears at den sites while outside the den. We coded behaviors for each bear by recording date, time behavior started, and time behavior stopped. By documenting all den exits and entries, we were able to calculate total time bears were out of den. We also coded the activities of cubs and yearlings. However, multiple cubs at the same den made individual identification difficult. Consequently, all cub or yearling behaviors were encoded and combined to create an average for cubs or yearlings.

Once behaviors were encoded, we calculated totals for each bear, including the average time and proportion of time spent in each behavior by cohort. We also compared the proportion of time spent per behavior by cohort. We analyzed differences between behaviors using one-way analysis of variance followed by a Tukey-Kramer test to determine significance (Zar 1984). If data were not normally distributed, or did not have equal variances, we transformed them using the arcsine transformation for proportions. We set statistical significance at the $\alpha = 0.05$ level. We determined the frequency of behavior bouts for all cohorts by dividing the total number of bouts of any given behavior by the total number of bouts for all behaviors observed for each cohort then multiplied by 100. We determined the duration of time spent out of den per exit by cohort. We recorded total time spent out for each individual exit for all adults, cubs, and yearlings, then compared cohorts using linear mixed effect models in Program R, with individual bears as the random effect, cohort as the fixed effect, and time spent out per exit as the response variable. In order to meet the assumption of normality, we transformed data using the natural logarithm.

We analyzed den exits by time of day to determine when bears were most active. We divided days into three hour blocks (00:01–03:00, 03:01–06:00, 06:01–09:00, 09:01–12:00, 12:01–15:00, 15:01–18:00, 18:01–21:00, and 21:01–24:00). We counted the number of exits for each bear within each time section. Analyses included data from all bears combined as well as by cohort.

RESULTS

We analyzed 37 dens and determined a mean emergence date of 25 March ± 13 d. Mean emergence for females with cubs was 23 March ± 12 d (*n* = 21). Mean emergence for females with yearlings was 26 March ± 19 d (*n* = 8). Mean emergence for lone females was 30 March ± 10 d (*n* = 8; Figure 1-3). Five models describing the timing of emergence received enough support to be included (AIC_c weight > 0.05; Table 1-3). Each of these models included spring temperature during emergence. Emergence dates were negatively correlated with the mean temperature for March and April following emergence, meaning that colder springs had later emergence dates (estimate = –2.54, 95% CI = –3.92 to –1.17; $P = < 0.01$; Table 1-4). The most parsimonious model also included cohort (AIC_c weight = 0.45). Lone females emerged from dens significantly later than females with cubs, while females with yearlings were not significantly different from either group (lone: cub, estimate = 12.27, 95% CI = 2.77 to 21.77, $P = 0.01$; yearling: cub, estimate = 3.19, 95 % CI = –6.01 to 12.40, $P = 0.50$; lone: yearling, estimate = –9.08, 95% CI = –20.43 to 2.28, $P = 0.11$; Table 1-4). The variables elevation, ecoregion, and precipitation of the prior year had 95% confidence intervals that overlapped zero and were not significant (Table 1-4).

Mean departure date for all bears was 8 April ± 16 d (*n* = 21). Mean departure date for females with cubs was 19 April ± 14 d (*n* = 7). For females with yearlings, it was 4 April ± 18 d (*n* = 6). Mean departure date for lone females was 2 April ± 13 d (*n* = 8; Figure 1-4). Three models describing the timing of departure dates received enough support to be included (AIC_c

weight > 0.05; Table 1-5). These models included ecoregion of Utah, mean spring temperature during departure, and mean temperature of the spring and summer before denning. Departure dates for the Wasatch and Uinta Mountains ecoregion were significantly earlier than departure dates for the Colorado Plateaus ecoregion (estimate = –19.23, 95% CI = –35.61 to –2.84, P = 0.02; Table 1-6). Dens located on the Wasatch and Uinta Mountains ecoregion were not significantly different in elevation than those located on the Colorado Plateau ecoregion (Wilcoxon Rank Sum Test, $P = 0.08$). Departure dates were also negatively correlated with mean temperature for March and April during emergence and departure, meaning that colder springs had later departure dates (estimate = –2.97, 95% CI = –5.30 to –0.63, $P = 0.01$; Table 1-6). Mean temperature of the spring and summer the year before denning was also negatively correlated with departure dates, meaning that lower temperatures the year before correlated with later departure dates (estimate = –3.38, 95% CI = –6.11 to –0.66, $P = 0.01$; Table 1-6).

Twenty-one denned bears were analyzed to determine total number of days spent at the den. Mean number of days spent at the den post-emergence for all bears was 11 ± 14 d ($n = 21$). Females with cubs spent on average 24 ± 15 d ($n = 7$) at the den. Mean number of days at the den for females with yearlings was 6 ± 11 d ($n = 6$). For lone females, mean number of days at the den was 3 ± 4 d ($n = 8$; Figure 1-5). Six models describing effects of independent variables on total number of days at den received enough support (AIC_c weight > 0.05). All six models included cohort (Table 1-7). Females with cubs spent significantly more days at the den than females with yearlings and lone females (lone: cub, estimate = –21.81, 95% CI = –33.37 to –10.26, P = < 0.01; yearling: cub, estimate = –16.68, 95% CI = –29.42 to –3.94, $P = 0.01$; Table 1-8). Lone females and females with yearlings did not spend a significantly different number of days at the den sites (estimate = 5.13, 95% CI = –7.63 to 17.89, $P = 0.43$; Table 1-8). The last frost date was negatively correlated with the number of days spent at the den, meaning the later the last frost occurred the previous spring, the fewer days bears spent at the den (estimate = –0.31, 95% CI = –0.60 to –0.01, $P = 0.04$; Table 1-8). Elevation, spring precipitation, spring temperature, and temperature all had 95% confidence intervals that overlapped zero and were thus not significant (Table 1-8).

In 2011 and 2012 we monitored the dens of 8 lone females, 5 females with yearlings, 13 females with cubs, 5 yearlings, and 23 cubs. All bears spent 9.8% of the post-denning period outside of the den. Lone females spent 4.8% of the post-denning period outside of the den. Females with yearlings spent 6.8% of the post denning period outside of the den while yearlings spent 4.1% of the time outside of the den. Females with cubs spent 11.6% of the time outside of the den and cubs spent 12.7% of the post-denning period outside of the den.

Lone females spent the majority of their time outside of the den standing (46.9%) and walking (31.5%). The females with yearlings and the yearlings cohorts both spent the majority of the time standing (females with yearlings: 61.5%; yearlings: 62.8%). The most prevalent behavior for females with cubs was standing (39.4%), followed by sitting (15.9%). Cubs also spent the most time standing (35.9%), but followed this with walking (23.5%). Many other behaviors were observed, but in smaller proportions (Figure 1-6; Table 1-9). For all cohorts, standing and walking occurred most frequently (Table 1-10).

Behavior proportions were compared across cohorts and no significant difference was found for standing, walking, sitting, and lying down. All adult cohorts (i.e., females with cubs, females with yearlings, and lone females) spent some time gathering nest material; however, only two of eight lone females and one of five females with yearlings were observed doing this, while 11 of 13 females with cubs were observed performing this behavior. Playing and climbing were primarily cub behaviors. Ingesting, grooming self, and defecating were rarely observed for all bears (Table 1-9).

Lone females spent a mean of 5.4 min (range of 1.2–36 min) outside of the den per exit event (n = 51 exits). However, only five of eight lone females were included in this analysis as the other three departed the den after emerging for the first time. Females with cubs spent a mean of 4.2 min (range of 0.6–39.6 min) outside of den per exit (n = 898 exits). Females with yearlings spent a mean of 19.2 min (range of 6–58.8 min) outside of den per exit (n = 18 exits). Yearlings spent a mean of 6 min (range of 0.6–43.2 min) outside of den per exit (n = 53 exits) and cubs spent a mean of 1.2 min (range of 0.01–16.8 min) outside of den per exit (n = 1870 exits). Females with dependent young spent significantly more time out of den per exit than the cubs (Linear mixed effects model, female with cub: cub: $t = 9.017$, $P < 0.05$; female with yearling: cub: $t = 3.143$, $P < 0.05$). No other groups differed in the amount of time spent out of den per exit. We compared the total count of exits for the females with cubs cohort to the total count of exits for the cubs cohort to determine if one cohort exited more frequently than the other. We found, however, that there was no significant difference between the number of times that females with cubs and cubs exited the dens (Wilcoxon Rank Sum Test, $P = 0.7$).

All bears exited dens most often between 12:01 and 15:00 (Figure 1-7). For lone females, 91.8% of den exits occurred between 06:01 and 21:00 (n = 56 exits) and 8.2% occurred between 21:01 and 03:00 (n = 5 exits). No lone females exited from 03:01 to 06:00. For females with yearlings, 78.3% of exits were between 06:01 and 21:00 (n = 18) and 21.7% of exits were between 21:01 and 03:00 (n = 5). No females with yearlings exited between 03:01 and 06:00. For females with cubs, 96.0% of den exits occurred between 06:01 and 21:00 (n = 875), 3.5% occurred between 21:01 and 03:00 (n = 32), and 0.5% occurred between 03:01 and 06:00 (n = 4).

For yearlings, 87.9% of den exits were between 06:01 and 21:00 (n = 51), 10.3% were between 21:01 and 03:00 (n = 6), and 1.7% were between 03:01 and 06:00 (n = 1). For cubs, 97.0% of exits occurred between 06:01 and 21:00 (n = 1829), 2.2% occurred between 21:01 and 03:00 (n = 41), and 0.8% occurred between 03:01 and 06:00 (n = 16).

DISCUSSION

Previous studies have used radio-telemetry to determine the timing of departure from dens (Lindzey and Meslow 1976, O'Pezio et al. 1983, Hellgren and Vaughan 1989). This approach provides an estimation of when bears leave the denning area but does not give an exact date. Additionally, telemetry does not take into account that bears often remain in the denning area for several days after emergence. Our methods give precise dates and times of emergence and departure, and do not require the bear to be handled.

In our study, bears emerged in March and departed in April. This was earlier than bears at more northern latitudes, such as those in Montana (Jonkel and Cowan 1971), Alaska (Erickson et al. 1982, Schwartz et al. 1987, Smith et al. 1992), south-west British Columbia (Allen 2001), Ontario (Kolenosky and Strathearn 1987), Minnesota (Rogers 1987), and Idaho (Beecham et al. 1983). Our emergence dates are similar, however, to those of bears in California (Graber 1990), North Carolina (Hellgren and Vaughan 1989), Arizona (LeCount 1983), Tennessee (Johnson and Pelton 1980), and New York (O'Pezio et al. 1983). Emergence dates in this study are consistent with dates reported by Pederson et al. (2008) for black bears in central Utah. We tested for correlation between latitude and emergence date and found a positive correlation between the two (Pearson's correlation coefficient, $r = 0.62$, $P = 0.008$; Figure 1-8).

Emergence and departure dates were both inversely associated with spring temperatures at the time of emergence. Higher spring temperatures were correlated with earlier emergence dates and earlier departure dates. Early spring temperatures were also found to be correlated with emergence dates in other studies (Rogers 1974, O'Pezio et al. 1983, Schooley et al. 1994). In addition, cohort was included in the model for emergence. Females with cubs were the first to emerge, followed by females with yearlings, and then lone females. However, only the females with cubs cohort was significantly earlier than the lone females cohort. This finding was unanticipated and may be a result of when we placed the cameras at den sites. We are confident the cameras were placed before first emergence due to lack of signs of activity around the dens. One way to be certain of first emergence would be to place cameras earlier in the winter to ensure that true emergence dates are captured.

Mean departure date for females with cubs was later than all other females; however, cohort was not significant enough to be in the final model for departure. Other research has shown that females with cubs leave later than other groups (Lindzey and Meslow 1976, Beecham et al. 1983, O'Pezio et al. 1983, Hellgren and Vaughan 1989, Gaines 2003), so it may be that a larger sample size would yield similar results. Two different ecoregions of Utah (Wasatch and Uinta Mountains ecoregion and Colorado Plateaus ecoregion) were tested and found to be significant for departure dates. Despite elevations being similar, bears in the Wasatch and Uinta Mountains ecoregion departed earlier than bears in the Colorado Plateaus ecoregion. The Wasatch and Uinta Mountains are better habitat than the Colorado Plateaus and so we would expect females in the first area to be in better condition than those in the second. In brown bears, females in better condition give birth to cubs earlier in the year and produce more milk or higher quality milk that would quicken cub growth than females in poorer condition (Robbins et al.

2012). In addition, Pederson et al. (2008) found that black bear cubs in the Wasatch and Uinta Mountains ecoregion have a higher March weight than cubs on the Colorado Plateau. Larger, more mature cubs may allow females to depart dens earlier.

Females with cubs spent significantly more time ($\bar{x}$ = 24 d) at the den site post-emergence than females with yearlings ($\bar{x}$ = 6 d) or lone females ($\bar{x}$ = 3 d). This longer duration is likely needed to allow cubs to mature (Hansson and Thomassen 1983, Smith et al. 2013). Last frost date from the spring before denning was also included in the final model for number of days at den, although not as strongly supported as cohort. This suggests that productivity of the fall before denning influences the duration of time spent at den. Spring frost can affect the success of soft and hard mast in the following fall. A late spring frost can reduce the amount of mast in the fall (Goodrum et al. 1971, Stephenson 1981). Mast production influences when bears enter dens, with higher mast years having later entrance dates (Schooley et al. 1994), and it may also affect post-denning duration. Bears that have not put on as much weight due to reduced availability of mast may not be able to stay as long at their dens, post-emergence. Supporting this, we found that an earlier last frost date the year before correlated with longer time spent active at the den post-emergence.

All bears spent little time outside the den. This has also been observed with polar bears (*Ursus maritimus)*, where family groups spent an average of 2.5% of their time outside during the post-denning period (Smith et al. 2013). Understanding behaviors at den sites provides baseline information that can be used in future research, especially with regard to disturbances near the dens and how they alter natural behaviors. Bears outside their den moved beyond the camera’s field of view 60.3% of the time. Nonetheless, we consider the time within view to add valuable information of their overall activity budget while at their dens. Our cameras captured several instances of nest building, ingestion, and mother-cub interactions. Nest building is known to occur in the fall prior to hibernation, but was only rarely observed occurring in the spring following hibernation (Jonkel and Cowan 1971, Lindzey and Meslow 1976). This behavior was observed in two lone females, one female with yearlings, and 11 of 13 females with cubs showing that it is much more prevalent in females with cubs. Females with cubs also spend the longest time at dens, post-emergence, so building nests may help insulate their dens or keep dens clean during this time.

All cohorts were observed ingesting though it was rare. Bears primarily ingested snow outside of their dens, though we observed one female with one yearling feeding on another yearling that had died of an unknown cause. We also found remains at several other dens (n = 3) of yearlings or cubs that had died of unknown causes and had apparently been fed upon by bears. Cannibalism and scavenging on bear remains was reported in Montana as well (Jonkel and Cowan 1971).

Mother-cub interactions were frequently observed. For example, nearly all females with cubs moved their cubs by picking them up in their teeth and carrying them. At one den where two cubs were different colors, we noted that the mother frequently picked up one cub but rarely the other. Nursing was also observed outside the den, but only rarely. Similarly, polar bears rarely nurse outside (Smith et al. 2007). Play between mother and cub was rare. Cubs mostly played with siblings, but if alone, with some object such as a log or bush. This observation is consistent with that of polar bears where females were rarely observed playing with their cubs at den sites (Smith et al. 2007).

Lone females, females with yearlings, females with cubs, and yearlings spent similar amounts of time out of den per each exit. Females with yearlings and females with cubs, though, spent significantly more time out per exit than cubs. Cubs may spend less time out because they are vulnerable to predation, as well as small and less mobile, particularly early on in the post-denning period. As time passed, cubs became increasingly more active and were out of the den more often. We also found that cubs and their mothers did not differ in the overall number of times they exited dens, although mothers spent more time out per exit. We observed that mothers often exited dens first, followed later by their cubs, and then entered dens after cubs entered. The lone female cohort did not provide sufficient data for comparison to other cohorts as this cohort either exited once and left or stayed only a short time at the den site. Bears exited dens mostly during daylight hours, particularly from 12:01 to 15:00. Occasionally, bears would come out in late hours from 21:01 to 03:00, but rarely would bears exit from 03:01 to 06:00. Our study supports the notion that bears are primarily diurnal with activity at dawn and dusk (i.e. crepuscular), and occasional nocturnal activities (Amstrup and Beecham 1976).

Den cameras recorded a variety of meso-predators investigating dens before and after den occupants departed, including other bears, bobcats (*Felis rufus*), and coyotes (17 predators on 15 occasions; Table 11). The longer bears remain at dens, the greater the risk of being detected by predators, including other bears. This has been observed among polar bears where a male bear killed a female in her den (Amstrup et al. 2006). Jonkel and Cowan (1971) reported cub remains found in a black bear scat, although it could not be determined if this was from predation or carrion eating. They also reported two cases of black bear predation on other bears in Yellowstone National Park. Boyer (1948) reported that two coyotes (*Canis latrans*) attacked and killed a denned sub-adult black bear in California. Tietje and Ruff (1980) observed an adult female that was cannibalized by a large bear and concluded that bears may select den sites that minimize predation by large males. Richardson (1991) observed two cases of black bear cannibalism in southeastern Utah. In addition to predators, we observed many deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), rabbits (*Sylvilagus nuttalli*), squirrels (*Tamiasciurus hudsonicus* and *Otospermophilus variegatus*), ground squirrels (*Spermophilus lateralis*), a variety of birds, and a spotted skunk (*Spilogale gracilis*) in the vicinity of black bear dens.

CONCLUSIONS

Understanding the timing of den emergence, departure, and number of days at the den for different cohorts will aid managers in Utah as they determine spring hunt schedules. Females with cubs stay the longest at dens, which means that terminating spring hunt seasons appropriately can minimize the take of females with dependent young. The current spring hunt runs from early April to late May or early June. Moving the hunt up one month to run from early March to late April or early May would minimize the take of females with dependent young. Moreover, understanding the way in which bears partition time and act at den sites in undisturbed settings provides a baseline for comparison when human activities occur near dens. In addition to providing data about denning behaviors, our methods allowed us to collect more accurate data than previously collected by providing exact emergence and departure dates. This can potentially allow researchers to collect data about bear denning without needing to visit dens multiple times. Cameras can also provide reproduction data without needing to sedate mothers.

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Table 1-1. Description of variables used in models of emergence date, departure date, and number of days at the den in Utah, 2011–2013.

Variable	Description
Year	Year in which data were collected (2011, 2012, or 2013)
Cohort	Cohort of denned bear (Lone female, female with yearlings, or female with cubs)
Ecoregion	Ecoregion of Utah where the den was located (Wasatch and Uinta Mountains, Colorado Plateaus, or Southern Rockies
Latitude	Latitude of Utah where the den was located (less than 38°N, 38°N–39°N, 39°N–40°N, and greater than 40°N)
Elevation	Elevation (m) of the den
Precipitation	Mean monthly total precipitation of the spring and summer (April through August) before denning
Temperature	Mean monthly temperature of the spring and summer (April through August) before denning
Frost Date	Last frost date (≤–2.22 °C) the spring before denning
Spring Precipitation	Mean monthly total precipitation of the spring (March and April) following denning
Spring Temperature	Mean monthly temperature of the spring (March and April) following denning

Table 1-2. Behaviors used to code time spent out of den for black bears.

Behavior	Definition
Not Visible	The bear is out of den but not visible either because an object was in front of the bear or because the bear had moved out of view of the camera
Standing	The bear is stationary and is on all fours
Walking	The bear is moving at a normal traveling gait
Sitting	The bear is sitting on its rear haunches
Gathering Nest Material	The bear is pulling material such as needles, branches, or grass into its den
Ingesting	The bear is eating grass, snow, or other material
Moving Cub	The bear picks cub up or moves cub with paw
Grooming Cub	The bear is licking cub
Grooming Self	The bear is licking itself
Lying Down	The bear is lying on the ground
Playing	The bear is exhibiting rapid movements and frequent, irregular shifts of behavior. Play is predominantly a cub behavior and is usually exhibited as play fighting between cubs and play with objects.
Climbing	The bear is climbing a tree or rock
Nursing	The female is feeding her cubs with her milk
Defecating	The bear is defecating outside of the den

Table 1-3. Ranking of supported models ($w_i > 0.05$) describing emergence dates of female black bears in Utah (2011–2013) showing model structure, Akaike's Information Criterion adjusted for small sample size (AIC_c), Change in AIC_c from the most supported model (ΔAIC_c), model weight (w_i), and number of parameters (K).

Model Structure	AIC_c	ΔAIC_c	w_i	K
Cohort + Spring Temperature	289.4	0.0	0.45	5
Spring Temperature	291.2	1.8	0.18	3
Elevation + Spring Temperature	291.8	2.4	0.14	4
Ecoregion + Spring Temperature	293.0	3.5	0.08	5
Precipitation + Spring Temperature	293.6	4.2	0.06	4

Table 1-4. Descriptive statistics of coefficients included in the top 5 models of emergences dates of female black bears in Utah (2011–2013) using linear regression and model averaging. Coefficients with confidence intervals not overlapping 0 flagged with an *.

Coefficient	Estimate	SE	95 % CI
Intercept	96.98	12.88	71.74 to 122.23
Spring Temperature*	–2.54	0.70	–3.92 to –1.17
Females with yearlings	3.19	4.70	–6.01 to 12.40
Lone females*	12.27	4.85	2.76 to 21.77
Elevation	–0.01	0.01	–0.02 to 0.01
Southern Rockies	–12.64	7.29	–26.92 to 1.64
Wasatch and Uinta Mountains	–0.98	4.82	–10.42 to 8.45
Precipitation	–0.51	1.33	–3.12 to 2.09

Table 1-5. Ranking of supported models ($w_i > 0.05$) describing departure dates of female black bears in Utah (2011–2013) showing model structure, Akaike's Information Criterion adjusted for small sample size (AIC_c), Change in AIC_c from the most supported model (ΔAIC_c), model weight (w_i), and number of parameters (K).

Model Structure	AIC_c	ΔAIC_c	w_i	K
Ecoregion + Spring Temperature	175.3	0	0.36	4
Ecoregion + Temperature	177.4	2.1	0.13	4
Spring Temperature	178.8	3.4	0.07	3

Table 1-6. Descriptive statistics of coefficients included in the top 3 models of departure dates of female black bears in Utah (2011–2013) using linear regression and model averaging. Coefficients with confidence intervals not overlapping 0 flagged with an *.

Coefficient	Estimate	SE	95 % CI
Intercept	125.03	20.80	84.26 to 165.81
Wasatch and Uinta Mountains*	–19.23	8.36	–35.61 to –2.84
Spring Temperature*	–2.97	1.19	–5.30 to –0.63
Temperature*	–3.38	1.39	–6.11 to –0.66

Table 1-7. Ranking of supported models ($w_i > 0.05$) describing number of days at den for female black bears in Utah (2011–2013) showing model structure, Akaike's Information Criterion adjusted for small sample size (AIC_c), Change in AIC_c from the most supported model (ΔAIC_c), model weight (w_i), and number of parameters (K).

Model Structure	AIC_c	ΔAIC_c	w_i	K
Cohort + Frost Date	164.9	0	0.46	5
Cohort	166.8	1.83	0.19	4
Cohort + Elevation	167.8	2.89	0.11	5
Cohort + Spring Precipitation	169.0	4.11	0.06	5
Cohort + Spring Temperature	169.0	4.11	0.06	5
Cohort + Temperature	169.3	4.33	0.05	5

Table 1-8. Descriptive statistics of coefficients included in the top 6 models of number of days at den for female black bears in Utah (2011–2013) using linear regression and model averaging. Coefficients with confidence intervals not overlapping 0 flagged with an *.

Coefficient	Estimate	SE	95 % CI
Intercept	45.95	24.30	–1.69 to 93.58
Lone females*	–21.81	5.90	–33.37 to –10.26
Females with yearlings*	–16.68	6.50	–29.42 to –3.94
Frost date*	–0.31	0.15	–0.60 to –0.01
Elevation	–0.01	0.01	–0.03 to 0.01
Spring precipitation	–1.71	1.82	–5.29 to 1.86
Spring temperature	0.80	0.86	–0.88 to 2.49
Temperature	0.70	0.82	–0.92 to 2.31

Table 1-9. The proportion of time spent on each behavior while out of den for each cohort.

Behavior	Lone Females	Females with Yearlings	Females with Cubs	Yearlings	Cubs
Standing	46.9	61.5	39.4	62.8	35.9
Walking	31.5	4.1	10.1	4.3	23.5
Sitting	8.0	21.1	15.9	23.3	17.9
Gathering Nest Material	1.8	0.2	4.1	0.0	0.0
Ingesting	0.5	1.5	0.4	2.3	0.1
Moving Cub	0.0	0.0	1.5	0.0	2.7
Grooming Cub	0.0	0.0	0.3	0.0	0.4
Grooming Self	0.0	1.8	0.2	0.4	< 0.1
Lying Down	11.2	8.9	26.9	3.6	8.6
Playing	0.0	0.3	< 0.1	2.8	6.8
Climbing	0.0	0.0	0.1	0.5	0.7
Nursing	0.0	0.0	1.1	0.0	3.4
Defecating/Urinating	0.0	0.6	0.0	0.0	0.0

Table 1-10. The frequency of behavior bouts by cohort.

Behavior	Lone Females	Females with Yearlings	Females with Cubs	Yearlings	Cubs
Standing	36.2	44.0	33.6	41.7	33.4
Walking	33.4	30.3	38.6	34.4	35.4
Sitting	16.7	9.1	12.1	13.3	17.1
Gathering Nest Material	6.5	1.7	3.5	0.0	0.0
Ingesting	1.7	5.8	0.6	6.0	0.1
Moving Cub	0.0	0.0	3.0	0.0	2.1
Grooming Cub	0.0	0.0	0.6	0.0	0.3
Grooming Self	0.0	4.6	0.3	0.2	< 0.1
Lying Down	5.4	2.0	6.9	1.3	4.9
Playing	0.0	1.7	< 0.1	2.9	5.8
Climbing	0.0	0.0	0.2	0.2	0.3
Nursing	0.0	0.0	0.7	0.0	0.7
Defecating/Urinating	0.0	0.8	0.0	0.0	0.0

Table 1-11. A list of dens that had potential predators pass by the den sites.

Year	Cohort	Camera	Predator	Date	Departure Date of Bear
2011	Cub	157	Coyote	11-May	4-May
2011	Cub	117	Lone bear	1-May	24-Mar
2011	Cub	3	2 bears together	25-May and 26-May	5-Apr
2011	Cub	11	Male Bear	8-May	12-Apr
2012	Cub	146	Lone Female Bear	8-May	8-May
2012	Cub	19	Bobcat	25-Mar	21-Apr
2012	Cub	19	Coyote	23-Apr	21-Apr
2012	Yearling	18	Bear	1-May	29-Mar
2012	Lone	16	Bobcat	31-Mar	25-Mar
2012	Lone	16	Bear	2-May	25-Mar
2013	Cub	23	Coyote	4-Apr	31-Mar
2013	Cub	23	Lone bear	29-Apr	31-Mar
2013	Cub	23	Bear with 2 cubs	31-May	31-Mar
2013	Lone	21	Coyotes (2 together)	26-Apr	21-Apr
2013	Yearling	9	Bear	6-May	8-Apr

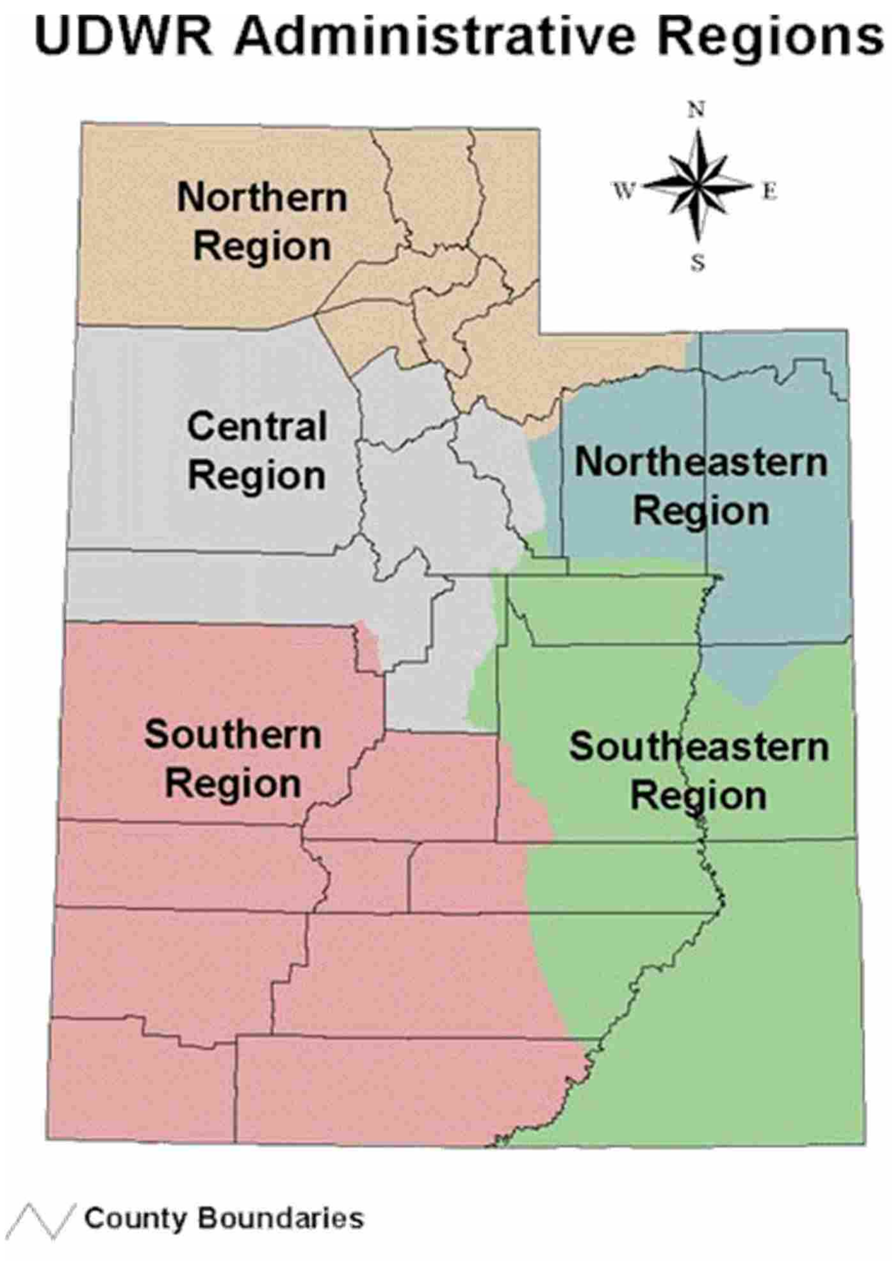

Figure 1-1. Utah Division of Wildlife Resources region map.

Figure 1-2. An example of a camera attached to a tree near a den.

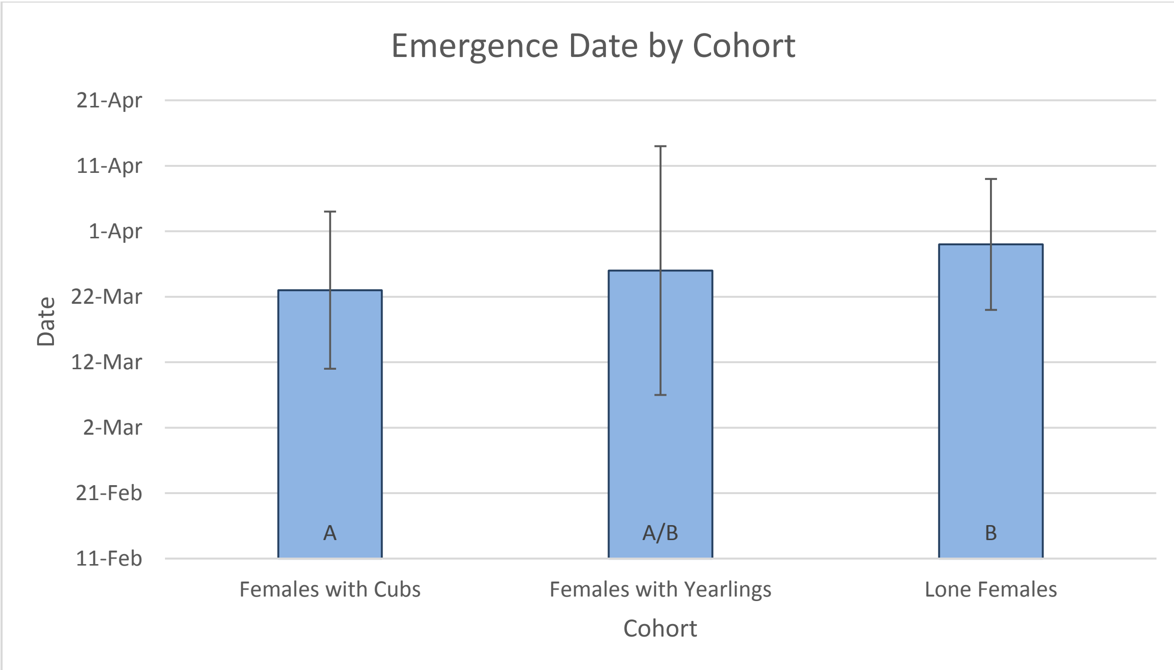

Figure 1-3. Bar graph of mean emergence dates with standard deviation by cohort. Cohorts are labeled with a letter. Cohorts with the same letter are not significantly different while cohorts with different letters are significantly different at P=0.05.

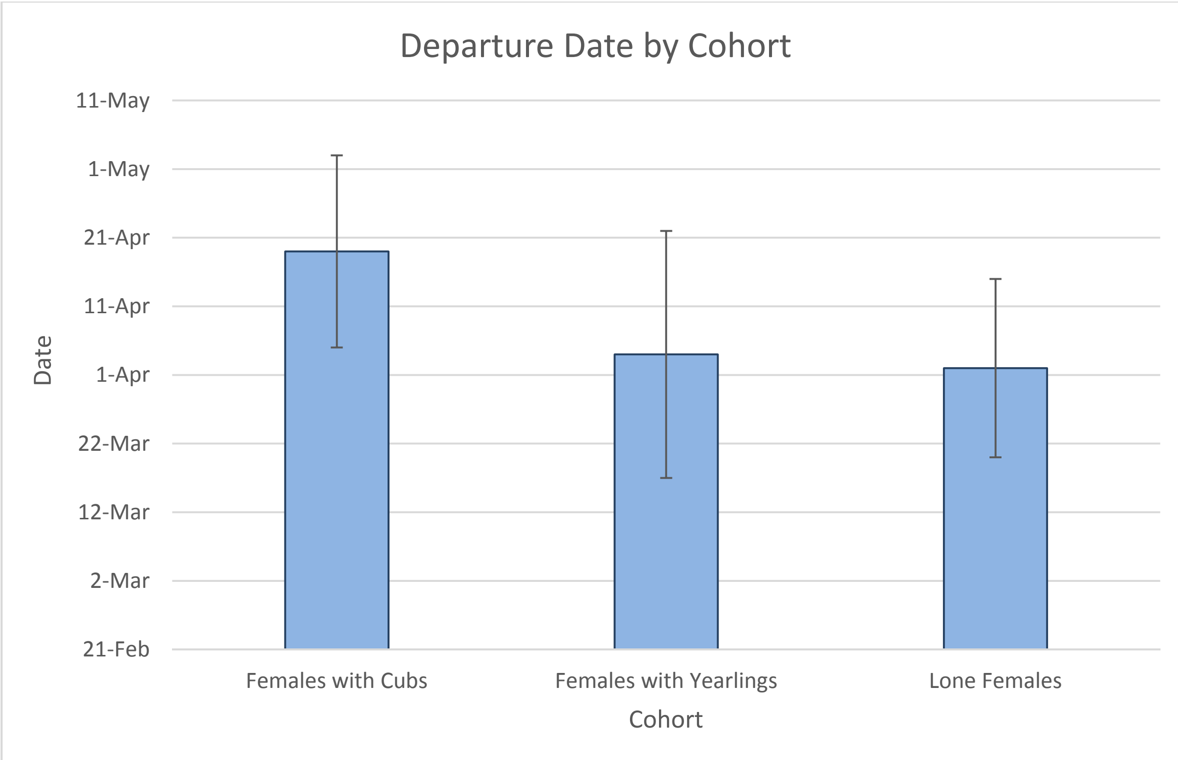

Figure 1-4. Bar graph of mean departure dates with standard deviation by cohort. Cohorts are not significantly different from each other at *P*=0.05.

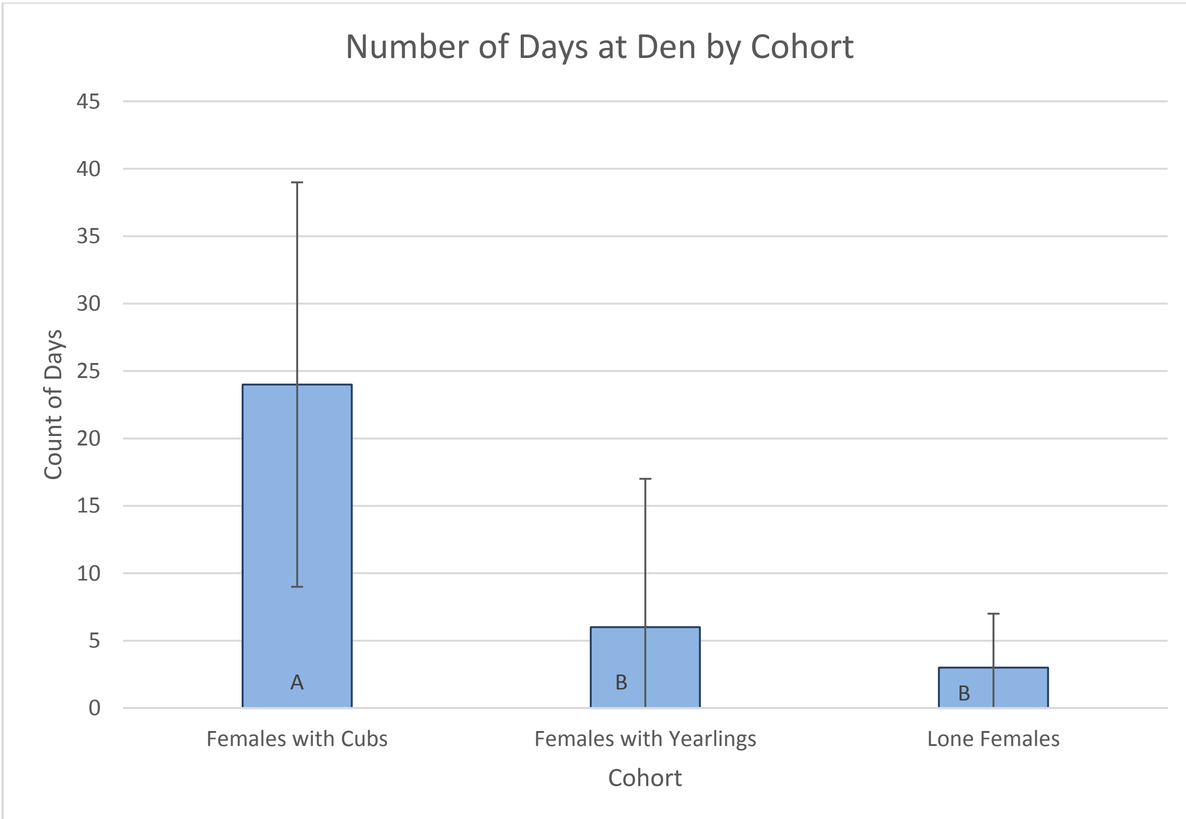

Figure 1-5. Bar graph of mean number of days at den, post-emergence, with standard deviation by cohort. Cohorts are labeled with a letter. Cohorts with the same letter are not significantly different while cohorts with different letters are significantly different at P=0.05.

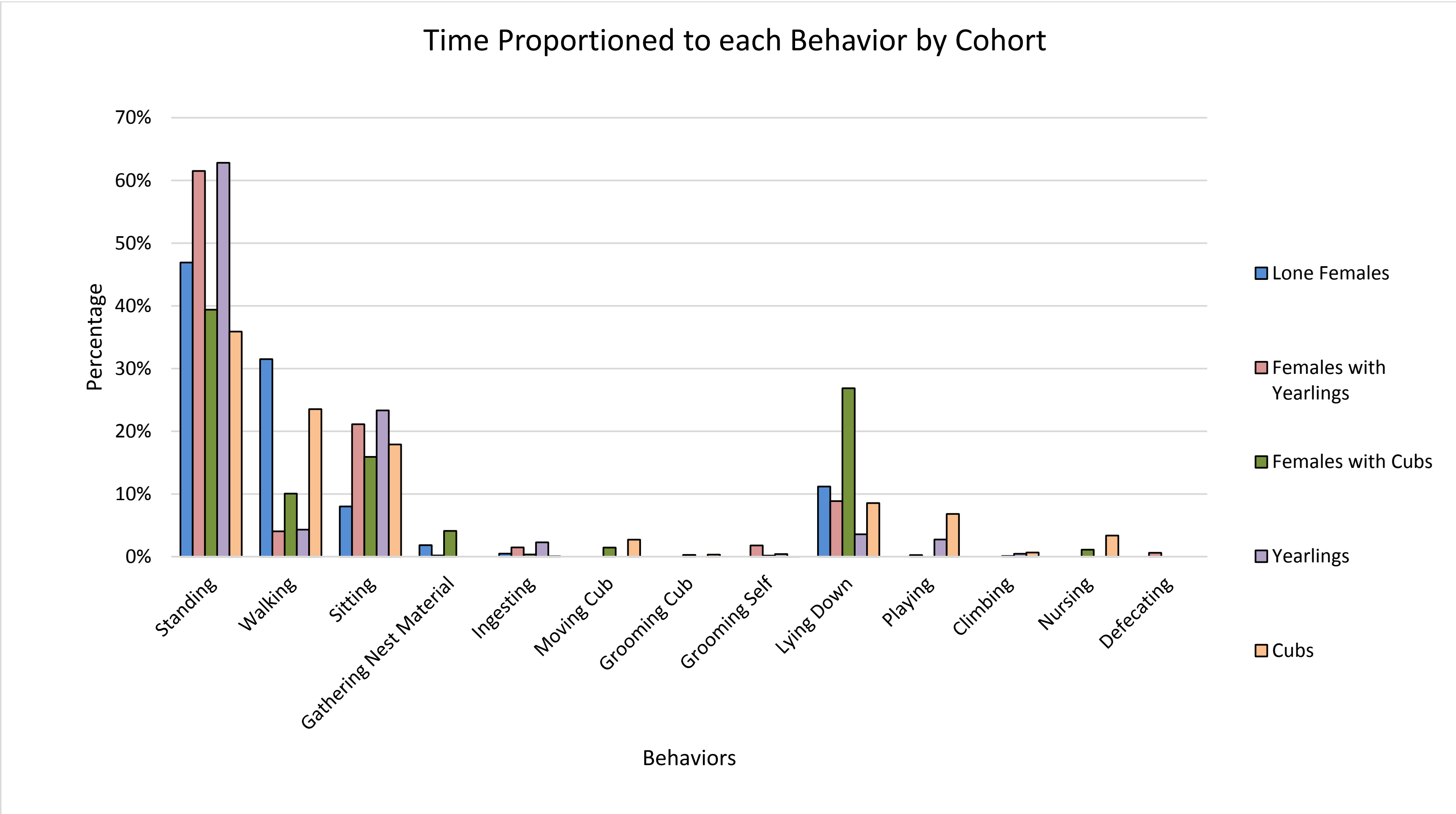

Figure 1-6. Percent of time out of den spent on each behavior while visible, by cohort.

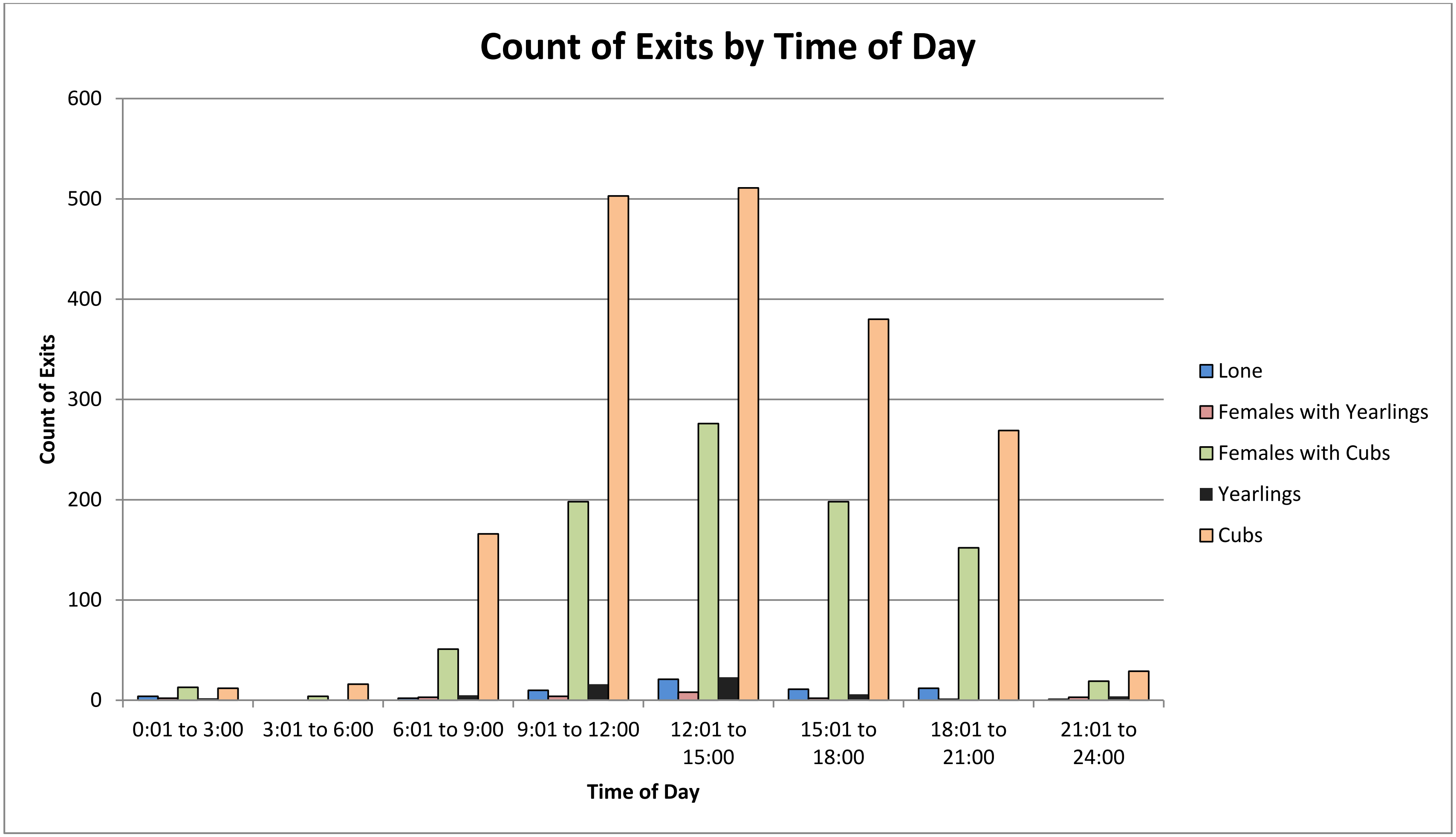

Figure 1-7. A comparison of the number of exits by time of day for each cohort.

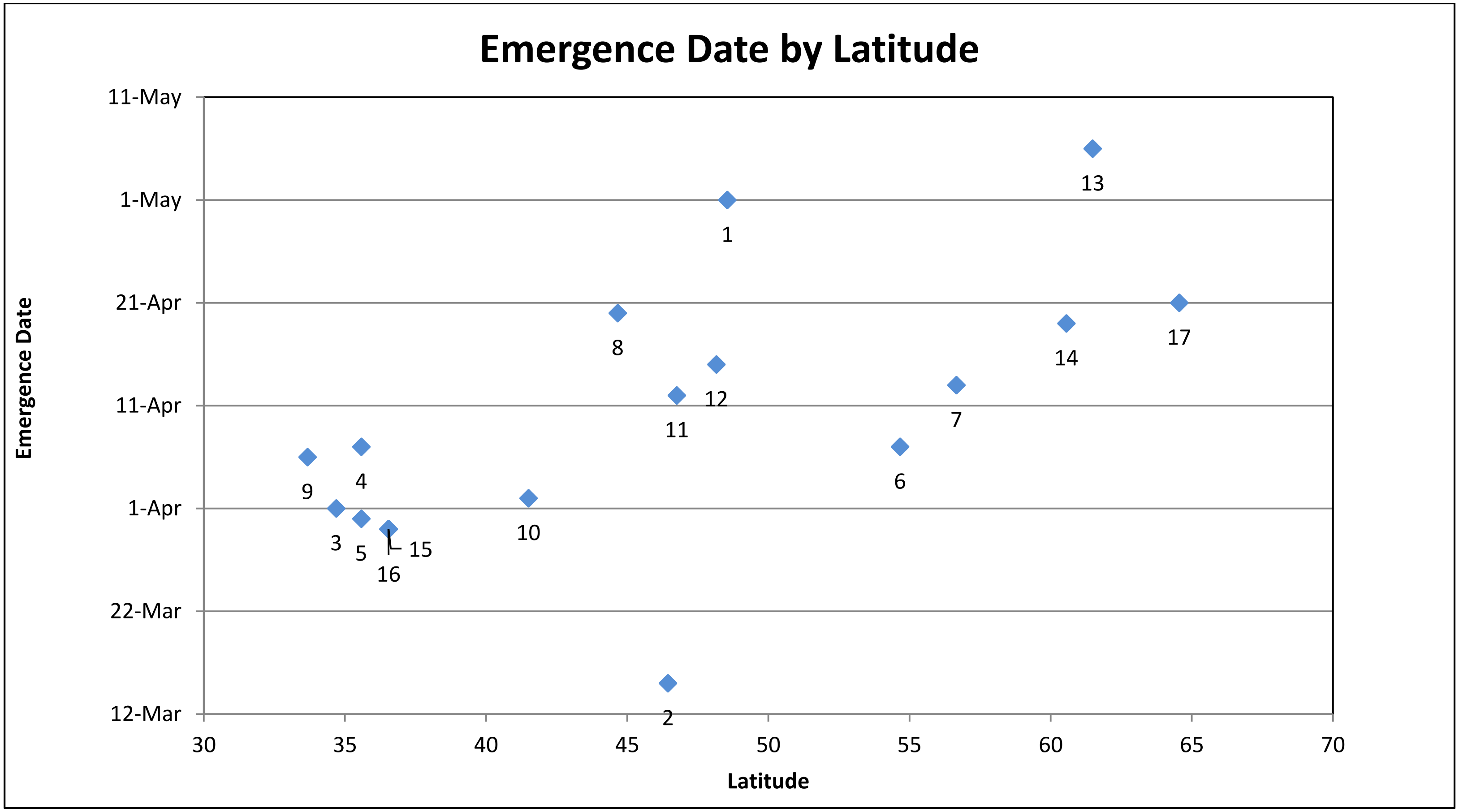

Figure 1-8. A comparison of emergence date by latitude, taken from previous studies (1=Jonkel and Cowan 1971, 2=Lindzey and Meslow 1976, 3=Hamilton and Marchington 1980, 4=Johnson and Pelton 1980, 5=Pelton et al. 1980, 6=Tietje and Ruff 1980, 7=Erickson et al. 1982, 8=Beecham et al. 1983, 9=LeCount 1983, 10=O'Pezio et al. 1983, 11=Kolenosky and Strathearn 1987, 12=Rogers 1987, 13,14=Schwartz et al. 1987, 15=Hellgren and Vaughan 1989, 16=Graber 1990, 17=Smith et al. 1992).

CHAPTER 2

AN ANALYSIS OF BLACK BEAR-HUMAN CONFLICT IN UTAH

ABSTRACT

Conflict between black bears (*Ursus americanus*) and humans has occurred in Utah, but the records are largely incomplete. In an attempt to document these events, the Utah Division of Wildlife Resources initiated a black bear sightings and encounters database in 2003. We modified this database by including more data per incident and by gathering available records and organizing them into a new database for analysis using Microsoft Access®. From 2003—2013 there were 943 records, with 499 bear-human encounters, 33 incidents, 10 attacks, 208 property damages, 187 sightings, and 6 vehicle collisions. Utah county had the highest number of events (n = 115). The majority of events took place at campsites (n = 363). The most common season for events was summer (n = 715). Often, time of day was not reported, but when it was, most bear-human conflict occurred at night (n = 173). We found no significant increase in the number of events over the last ten years. We also found no significant relationship between the number of events per year and drought data. The highest number of events involved single bears (n = 843), and over half of events had food or garbage available for the bear (n = 475).

INTRODUCTION

Conflicts between humans and carnivores are common wherever both species exist (Kaczenskya et al. 2004, Löe and Röskaft 2004). A better understanding of where, when, and why these conflicts occur will lead to fewer overall conflicts, as well as conservation of the species involved. Often, attacks by carnivores result in a negative public image, thus undermining conservation efforts (Miller and Chihuly 1987, Löe and Röskaft 2004). Additionally, species involved in conflict are more likely to go extinct (Ogada et al. 2003). As managers more fully understand the nature of human-carnivore conflicts, they will be better able to educate the public, make informed conservation decisions, and subsequently reduce the total number of conflicts.

The first step toward understanding the causes of conflict is to construct a history. A database containing information about conflict will reveal insights as to why conflicts occur (Herrero 2002, Löe and Röskaft 2004). Wilder et al. (2007) developed the National Park Service Alaska Region Bear-Human Information Management System and entered bear-human conflict data from national parks in Alaska. This information corrected previous misconceptions regarding bear-human interactions. As a result, management funds were reallocated to more effective bear management programs. Stephen Herrero (University of Calgary) has also created a database to study encounters with grizzly (*Ursus arctos*), black (*Ursus americanus*), and polar (*Ursus maritimus*) bears in North America. From this research, Herrero (2002) identified the most effective responses for a variety of encounters with different species of bears. Herrero (2002) also wrote a popular book aimed at educating the public on bear attacks and their avoidance. Further, Herrero et al. (2011) studied fatal black bear attacks in North America and identified variables that influenced the risk of fatal attacks by black bears. These types of studies and works are educating the public and helping to minimize bear-human conflict.

Interactions between black bears and humans have occurred in Utah, but the historical record is largely incomplete. These interactions include property damage, livestock depredation, and attacks on humans. Before 2007, a fatal bear attack had not been recorded in Utah. This changed when a black bear attacked and killed an 11 year old boy in June 2007, on the north flank of Timpanogos Mountain in Utah County. Prior to this event, however, other similar predation attempts had occurred in the state, but poorly kept records and the lack of a central database, obscured this little-known fact. In an effort to better document bear-human interactions, the Utah Division of Wildlife Resources (UDWR) initiated a black bear sightings and encounters database in 2003. It presently contains more than 900 records, including sightings, instances of property damage, and incidents of bear-human conflict. We modified this database to include more specific questions for our analysis, added new records, and present analysis results here.

METHODS

We contacted the UDWR, National Parks, U. S. Forest Service, and the Bureau of Land Management to collect available records of human-bear conflict in Utah. We also used Google™ to search newspaper articles and hunters' blogs for incidents that occurred in Utah. Data from all of these sources was entered into the redesigned database.

We redesigned the black bear database using Microsoft Access®. We created a classification system for bear-human events, including definitions consistent with other scientists (Smith et al. 2005, Hopkins III et al. 2010). We classified events as sightings (person sees bear, bear is apparently unaware), encounters (person and bear are mutually aware of each other, bear approaches person, acts indifferently, or leaves), incidents (person and bear are mutually aware of each other, bear acts aggressively but no contact), attack (person and bear are mutually aware of each other, intentional contact by bear), property damage, (no people present, bear damages property of person), and vehicle collisions with bears. Because of the large number of bear sightings in Utah, we included only sightings that occurred in areas of concern, such as near towns or campsites. Other fields in the database included date, time, location, primary person involved, management action, availability of food or garbage, and notes specific to the event. Food or garbage included human food and garbage as well as livestock, edible agricultural products, and, on one occasion, a deer carcass.

For the purpose of this study, we have only analyzed records from 2003 to 2013 as this time period had the most complete set of records. We determined the total number of events for each category, as well as the effects of cohort, location, season, and time of events. We created maps of events using ArcGIS and identified problem areas using the kernel density probabilistic contouring tool. We also analyzed the relationship between total number of events and drought and precipitation data using the Palmer Z-index to measure drought for each event (Palmer 1965). Historical weather data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NOAA 2014). NOAA has divided Utah into seven climatic regions and provided historical Palmer Index data for each of these regions. In our analyses, weather variables included the mean Palmer Index from the winter prior to the event (October to June), the spring prior to the event (March to June), and the month of the event. We also explored potential relationships between the total precipitation for the winter and spring prior to the event. Precipitation data were obtained from the Northwest Alliance for Computational Science and Engineering (NACSE 2013). All drought and precipitation variables were tested using linear regression to determine whether water conditions correlated with number of events per year. All statistical analyses were performed using Program R v2.15.2. Statistical significance was set at $\alpha \leq 0.05$.

RESULTS

A total of 943 events were recorded for the years 2003–2013. These records included 499 encounters, 33 incidents, 10 attacks, 208 property damages, 187 sightings, and 6 vehicle collisions. Most of these events occurred in Utah's central and eastern mountain ranges (Figure 2-1).

Utah County had the highest number of events ($n = 115$) followed by Duchesne ($n = 98$), Summit ($n = 95$), Uintah ($n = 70$), and Carbon ($n = 65$; Figure 2-2) counties. We found no relationship between mean human population and total number of bear-human events by county for 2003 to 2013 (linear regression, estimate = ≤ –0.01, $P = 0.77$). Areas with the highest density of events include northern Utah County, Beaver/Piute Counties, and Daggett/Uintah Counties (Figure 2-3). The majority of events were encounters and so the areas with the most encounters were similar to the areas with the most events (Figure 2-4). Incidents between humans and bears occurred most often in Utah County ($n = 5$) and Daggett County ($n = 5$; Figure 2-5). The highest number of attacks occurred on the Green River in Carbon and Uintah Counties ($n = 4$, Figure 2-6). The highest incidence of property damage occurred in Summit County and Beaver/Piute County (Figure 2-7). These events include damage to livestock, agriculture (crops such as corn, watermelon, and fruit trees), cabins, and campsites. When we specifically looked at events that included damage to livestock and agriculture, the greatest occurrence was around Green River, Utah (Figure 2-8).

From 2003 to 2013, the majority of events took place at established and dispersed campsites (38.5%, n =363) and cabins (24.1%, $n = 227$). Campsites were also the most common location for individual event types with the exception of vehicle collisions (Table 2-1). All ten attacks and 40.3% ($n = 201$) of encounters occurred at campsites. The only years that didn't have the highest proportion of events occur in campsites were 2003 and 2013. In 2003, there was a higher proportion that occurred in the wilderness (30%) than in campsites (20%). In 2013, only 19% of events occurred in campsites, and 44% occurred in rural residential and urban areas (Figure 2-9).

Summer (June–August) was the most common season for events (76%, n = 715), followed by fall (September–November; 14%, n = 131) and then spring (March–May; 10%, n = 95). Only two events occurred in winter (December–February, 0.2%). The time of day for many events was not reported (48%, n = 450). For events that had a time of day reported, the highest number occurred at night (35%, n = 173), followed by morning (sunrise–12:00; 28% n = 138) and then afternoon (12:01–18:00; 22%, n = 109). The fewest number of events occurred during the evening (18:01–dark; 15%, n = 73). Eight of ten attacks (80%) and 100 of 217 encounters (46%) occurred at night.

The mean annual number of events was 85.7. The number of events that occurred in any given year was not significantly correlated to year (linear regression, t = 0.33, P = 0.7), meaning that the number of events has not increased or decreased in the last ten years (Figure 2-10). The greatest number of events occurred in 2007 (n = 202), followed by 2009 (n = 131) and 2011 (n = 120). For each climatic region, the year with the highest number of events was also a year of drought. However, there was no significant relationship between drought or precipitation data and the total number of events in a year (linear regression, October to June Palmer Index: estimate = 0.3, P = 0.9; March to June Palmer Index: estimate = –0.3, P = 0.8; monthly Palmer Index: estimate = < –0.01, P = 1.0; October to June precipitation: estimate = 0.1, P = 0.8; March to June precipitation: estimate = –0.2, P = 0.8).

Single bears were involved in events 89.3% of the time (*n* = 843). Of these, 81.3% were single bears of unknown sex (*n* = 767), 2.9% were female (*n* = 27), and 5.2% were male (*n* = 49). Female with young were involved in events 6.4% of the time (*n* = 60). A pair of bears were involved 0.7% of the time (*n* = 7). On one occasion, multiple bears were harassing a camp over a period of several days, including a female with a yearling and two male bears. Bear cohort was not specified 3.6% of the time (*n* = 34). All ten attacks involved single bears, two of which were males, one a female, and the other seven single bears of unknown sex. Single bears were involved in 89.6% of encounters (*n* = 448) and 97.0% (*n* = 31) of incidents. Single bears were involved in 80.7% of property damage events (*n* = 168). Cohort was reported for property damage events 13.5% of the time (*n* = 28). Finally, for sightings, single bears were involved 95.7% of the time (*n* = 179).

Food or garbage was involved in 50.4% (*n* = 475) of events. These events may be under-reported due to reluctance of people to offer up information that implicates improper behavior on their part. In addition, out of 173 events that occurred at night, 118 had food or garbage involved (68.2%). Out of 943 records, 102 (10.8%) resulted in the bear being killed either by the person involved (*n* = 35) or by management (*n* = 67). Of these 102 events, 66.7% (*n* = 68) involved food or garbage.

DISCUSSION

The majority of events took place during the summer (June–August), similar to other such studies. Herrero et al. (2011) found that most fatal attacks by black bears occurred between May and September. Herrero and Higgins (1998) also found that grizzly and black bear-inflicted injuries in British Columbia were clustered from May to October. During summer months, bears are active, searching for food, mates, and shelter. This is also when human activity outdoors is highest, thus increasing the chances of conflict with bears.

Food or garbage was involved in over half of bear-human conflict events in Utah. Food was stored improperly in 30% of incidents in Great Smoky Mountain National Park (Singer and Bratton 1977). Similarly, food or garbage was noted in 25% of black bear incidents in Alberta (Herrero and Higgins 2003). When looking at attacks in all of the United States and the Provinces and Territories of Canada, Herrero et al. (2011) found that 38% of attacks were likely influenced by the presence of human food or garbage. Although we cannot say with certainty whether bears received food prior to the recorded event, our data clearly show that food or garbage has been a factor, and was at least a possible attractant, in many events. This suggests that more secure handling of anthropogenic foods in areas such as campsites, cabins, and parks would reduce the number of bear-human conflicts in Utah. Such is the case in Canada where proactive food and garbage measures have greatly reduced food-conditioning in bears (Herrero 2002). Areas such as orchards and fields can be protected with electric fencing (Jonker et al. 1998), and these options should be evaluated for efficacy in Utah.

In areas of low human use, black bears are typically diurnal or crepuscular (Amstrup and Beecham 1976). However, where time of day was known, the majority of bear-human conflict events in Utah occurred at night. Specifically, eight of ten attacks happened at night, whereas the other two occurred in the early morning hours. When comparing bears that foraged on natural foods to bears that foraged in campgrounds, Ayres et al. (1983) found a dramatic difference in their activity schedules. Bears that foraged on natural foods were crepuscular and diurnal, whereas bears that foraged in campgrounds were nocturnal, presumably to avoid detection while foraging in the midst of a campground. In contrast, the majority of bear-inflicted injuries in

British Columbia and black bear attacks in North America took place during the day, between 1600 hours and 1800 hours (Herrero and Higgins 1998, Herrero et al. 2011). Our data, however, show that bear-human conflict in Utah typically occurs at night likely because this is when bears can avoid detection by people.

We found no increase in the number of bear-human conflict events from 2003 to 2013. Contrary to this, previous studies have found an increase in the number of attacks and injuries inflicted by bears (Herrero and Higgins 1998, Herrero et al. 2011). However, both studies compared incidents by decade and found an increase in the number of bear attacks from one decade to the next. This study looked at only one decade and so decade comparable analysis cannot be made.

The majority of Utah events involved a single bear of unknown sex. All ten attacks on humans involved a single bear, which is consistent with other findings (Herrero and Higgins 1998, Herrero and Higgins 2003). However, Utah black bear attacks differ from those involving grizzly bears where females with dependent young caused the most injuries (Herrero and Higgins 1998, Herrero 2002).

All ten Utah attacks occurred at campsites. Excluding collisions with cars, all other events occurred most often at campsites. Herrero and Higgins (2003) also found that hiking, walking, and camping were common activities preceding both black and grizzly bear-inflicted injuries. It is likely that campsites are the most common place for black bear-human events in Utah because they are foci for anthropogenic foods.

We found no significant relationship between drought and the number of events in a year. This was contrary to the reports of others who have found drought to cause food stress for bears, thus increasing the likelihood that they would seek out other food sources (Rogers et al. 1988, Herrero and Fleck 1989). The Palmer Drought Severity Index for severe drought ranges from –3.0 to –3.9. The range for extreme drought is ≤ –4.0 (Utah Division of Water Resources 2002). For all climatic regions of Utah, the average Palmer Index for the winter before events occurred was never lower than –1.94 for the years of 2003 to 2013. The average Palmer Index the spring prior to events had only one occasion where the Palmer Index was below –3.0. The Palmer Index in the month of the event had only two occasions where the Palmer Index was below –3.0. For both of these variables, there was never a time where the Palmer Index was below –4.0. It has been reported that drought affects the number of bear-human conflict events (Baruch-Mordo et al. 2008), but we did not find a relationship in Utah. It is clear that bears seek out non-traditional food sources when there are multiple years of drought, or during an extreme drought year, as evidenced in Aspen, Colorado recently (Baruch-Mordo et al. 2013). As we continue to monitor bear-human conflict, such a pattern may emerge. In addition, it may be that a more direct measure of plant productivity will reveal a correlation between plant productivity and number of bear-human conflict events. Although there was not a significant relationship between drought and the total number of events in a year, we did note that for each climatic region the years with the highest number of events were always drought years.

CONCLUSIONS

As people continue to participate in outdoor activities, it is important for them to understand how to avoid conflict with bears, for both their own safety and the conservation of bears. It is commonly known that food attracts bears, and our findings support this. This suggests that efforts to reduce bear-human conflict in Utah should focus on ways to remove bears' access to anthropogenic foods. Clearly, it is particularly important to secure food at night when bears are most active around camping areas. Official campgrounds would benefit from installing bear-proof dumpsters to eliminate the food reward for bears visiting these areas. In addition, our study highlights the need for educating the public on camping in bear country. Many events occurred at dispersed campsites where people had food readily available for bears. It is important to make people aware that camping in Utah is camping in bear country, that bears must be respected, and that to do so we must properly store food and garbage. The identification of areas where bears have repeatedly attacked livestock and damaged crops highlights where future management efforts will be most productive. Electric fencing, guard animals, or bear-proof containers may be deployed in these areas to discourage bear depredations. It is necessary for the conservation of species involved in conflict that managers, biologists, and the general public understand what causes the conflicts and how best to avoid those causes.

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Table 2-1. Number of black bear-human events by area use and event type.

Area Use	Attack	Encounter	Incident	Property Damage	Sighting	Vehicle Collision
Unknown	0	9	0	0	0	0
Agricultural	0	9	0	9	4	0
Cabin	0	122	6	68	31	0
Campsite	10	201	12	79	61	0
Other	0	4	0	2	5	2
Rural Residential/Urban	0	76	4	34	48	2
Wilderness	0	78	11	16	38	2

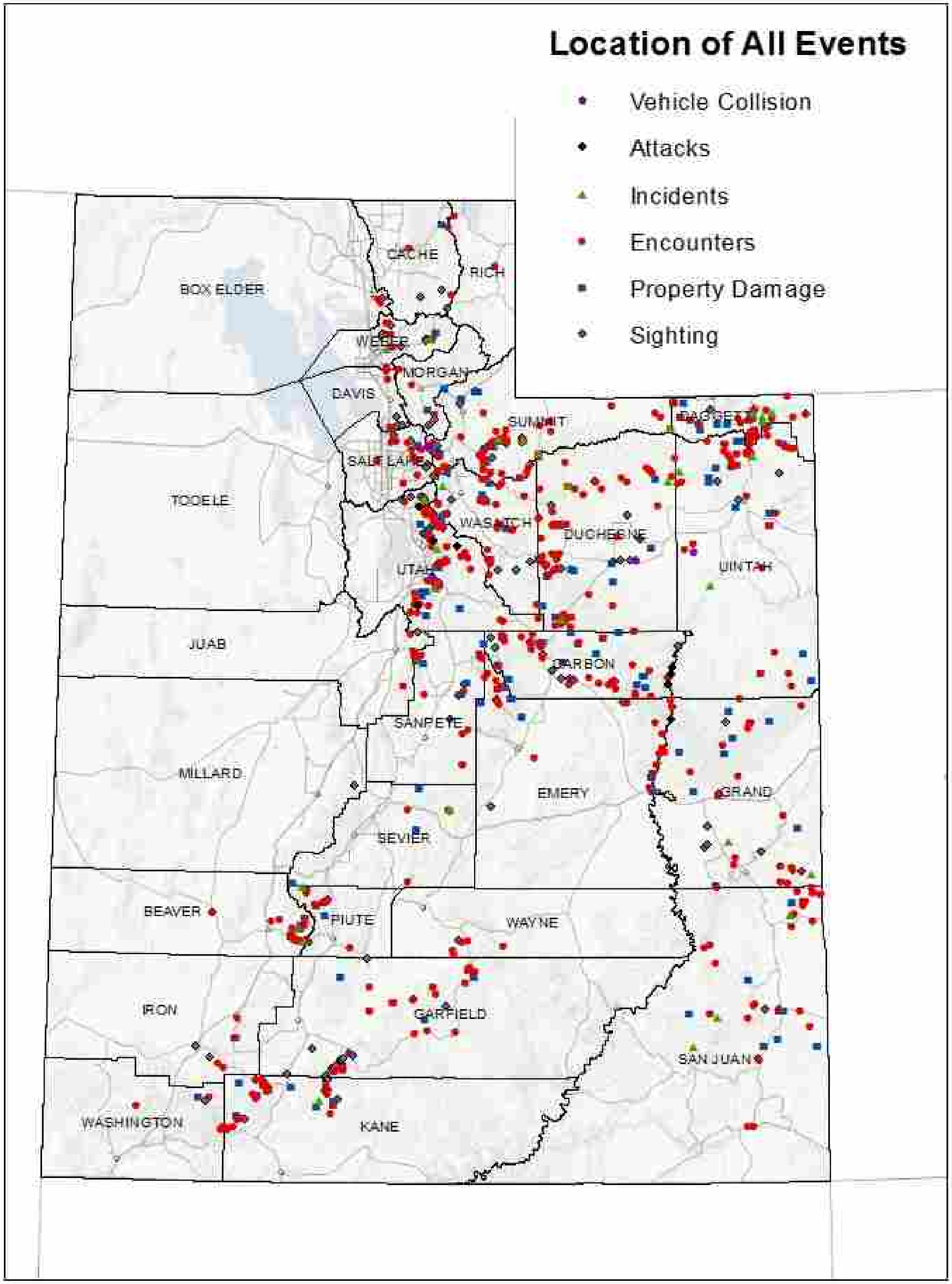

Figure 2-1. Location of all black bear-human events in Utah, 2003–2013.

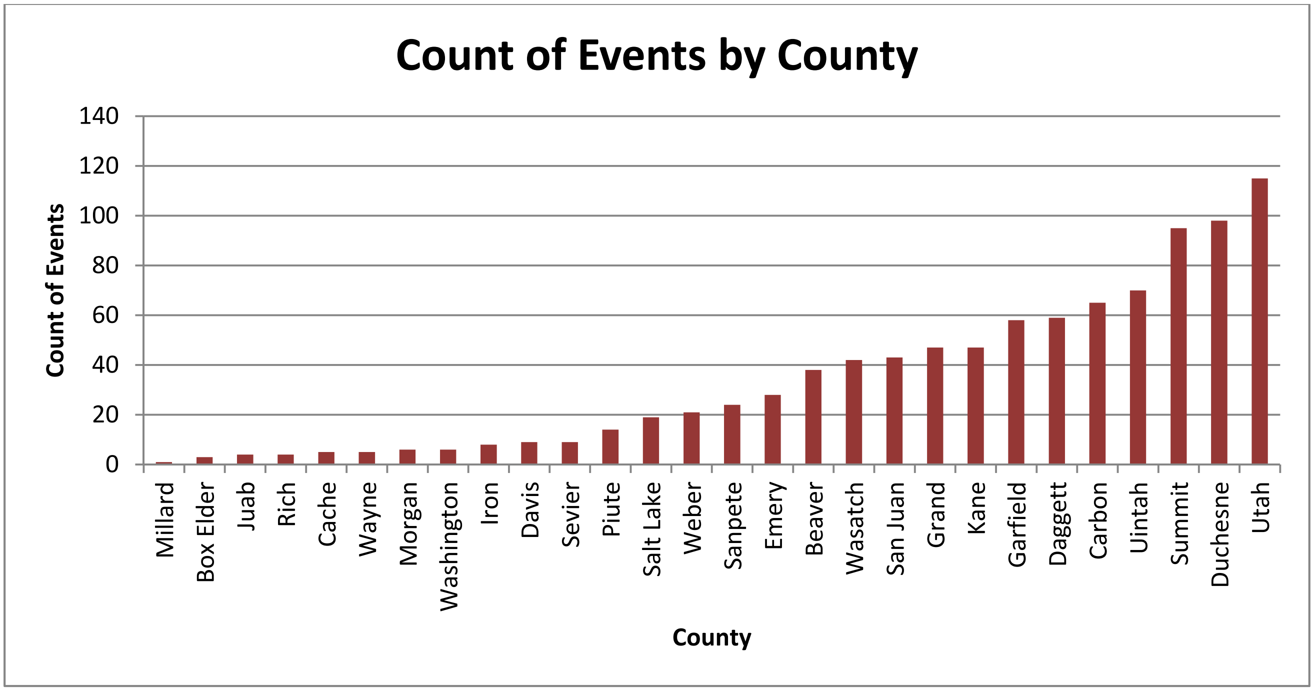

Figure 2-2. Number of black bear-human events in Utah by county, 2003–2013.

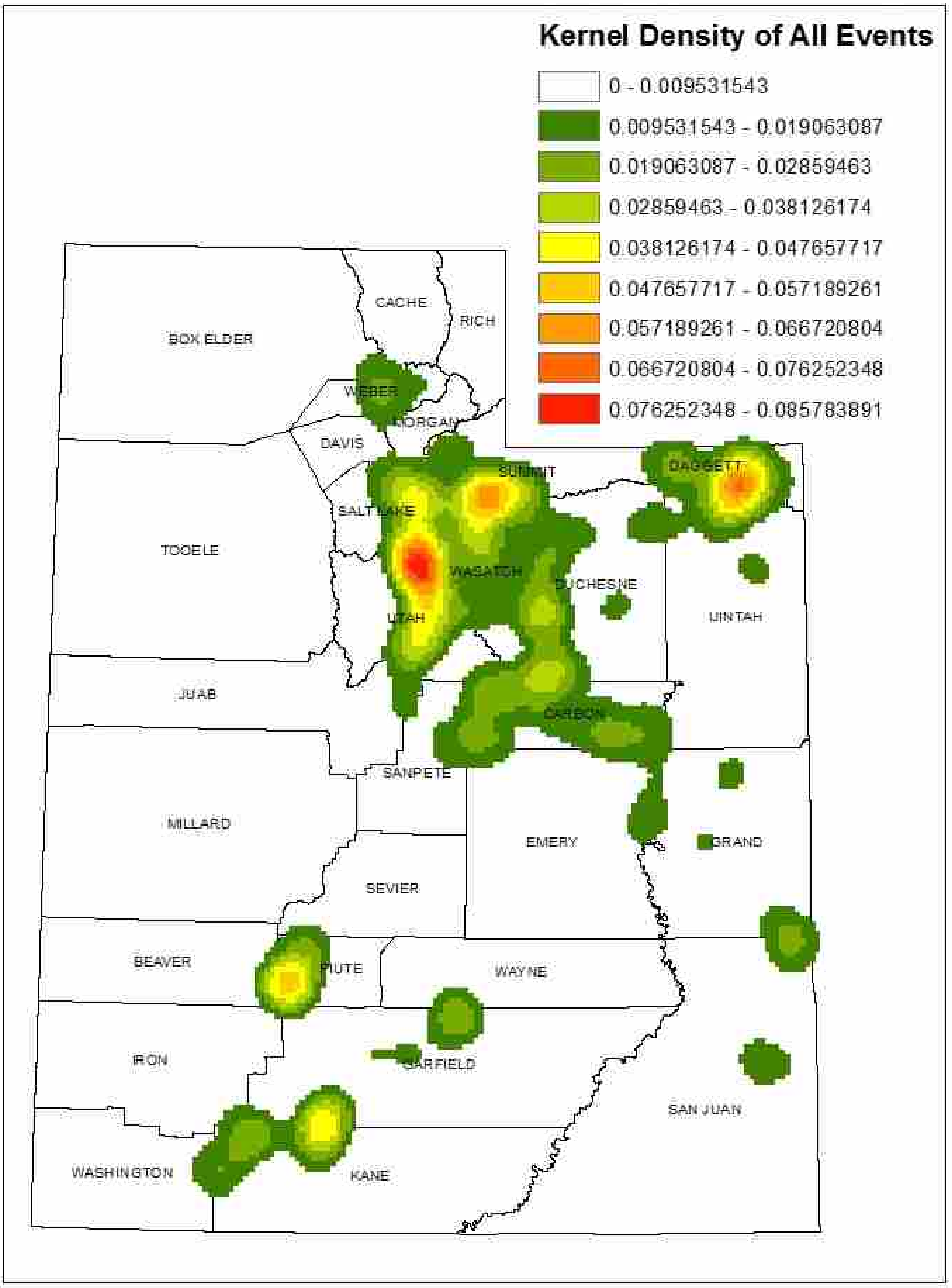

Figure 2-3. Kernel density of all black bear-human events in Utah, 2003–2013.

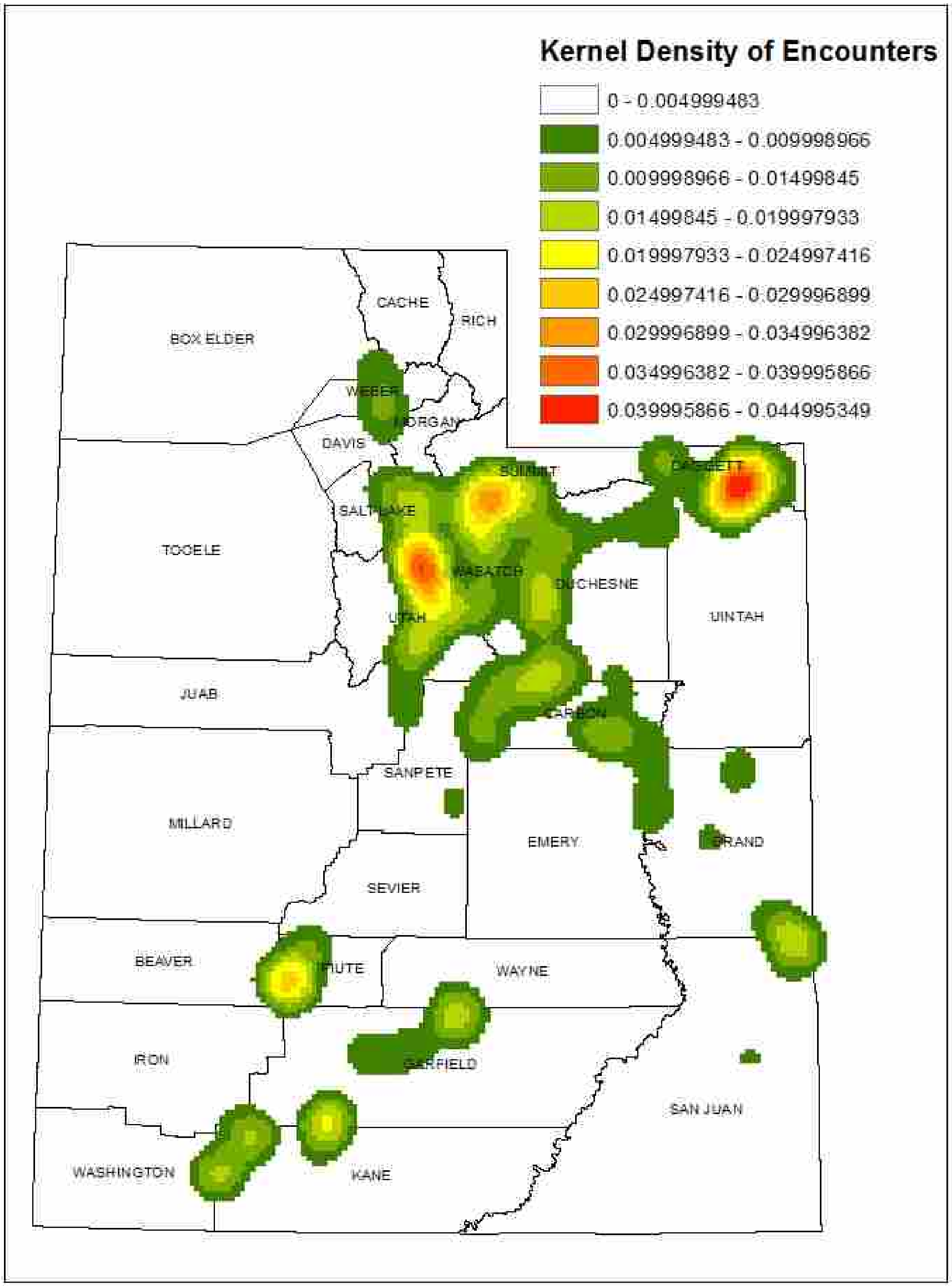

Figure 2-4. Kernel density of all black bear-human encounters in Utah, 2003–2013.

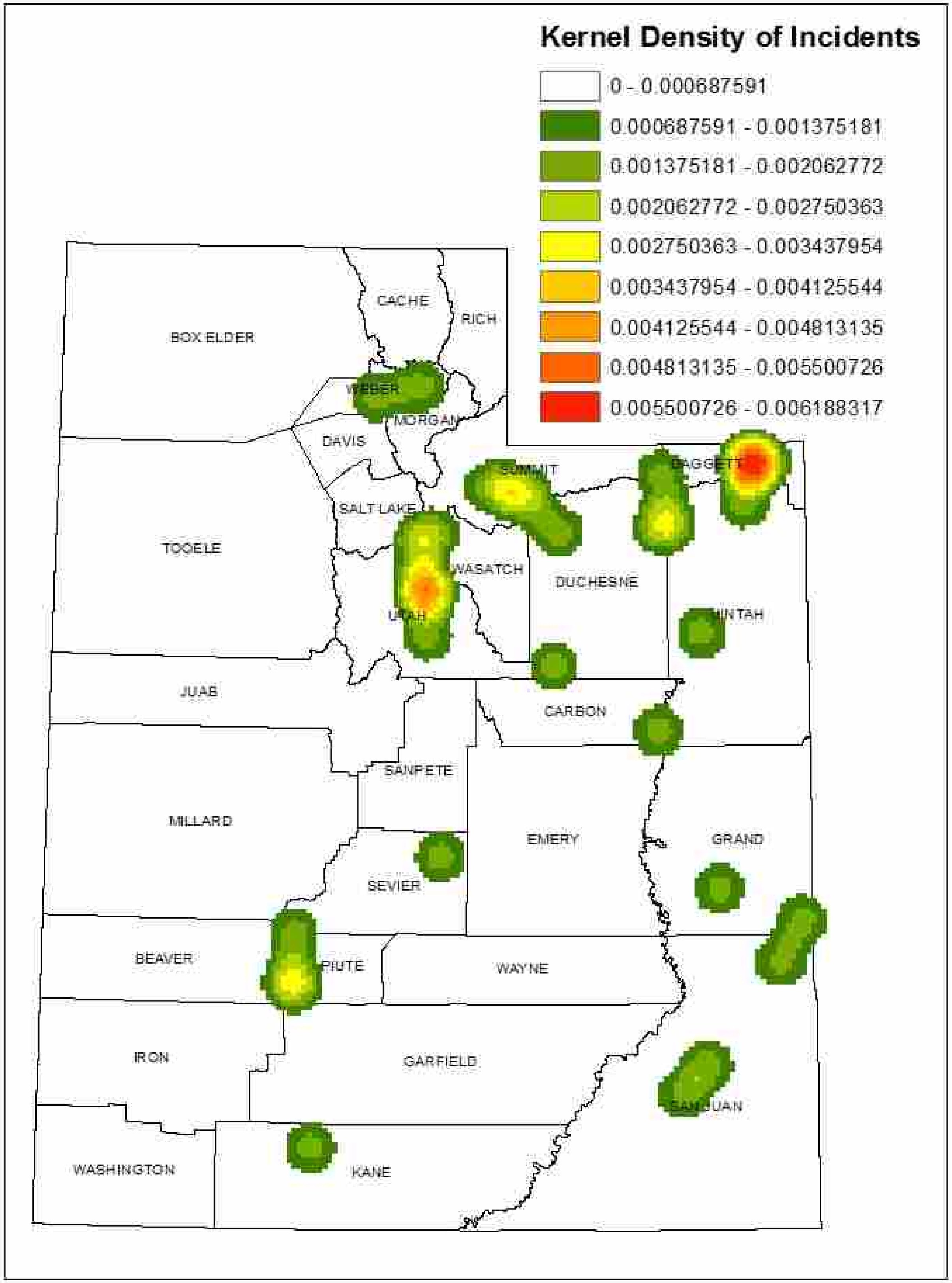

Figure 2-5. Kernel density of all black bear-human incidents in Utah, 2003–2013.

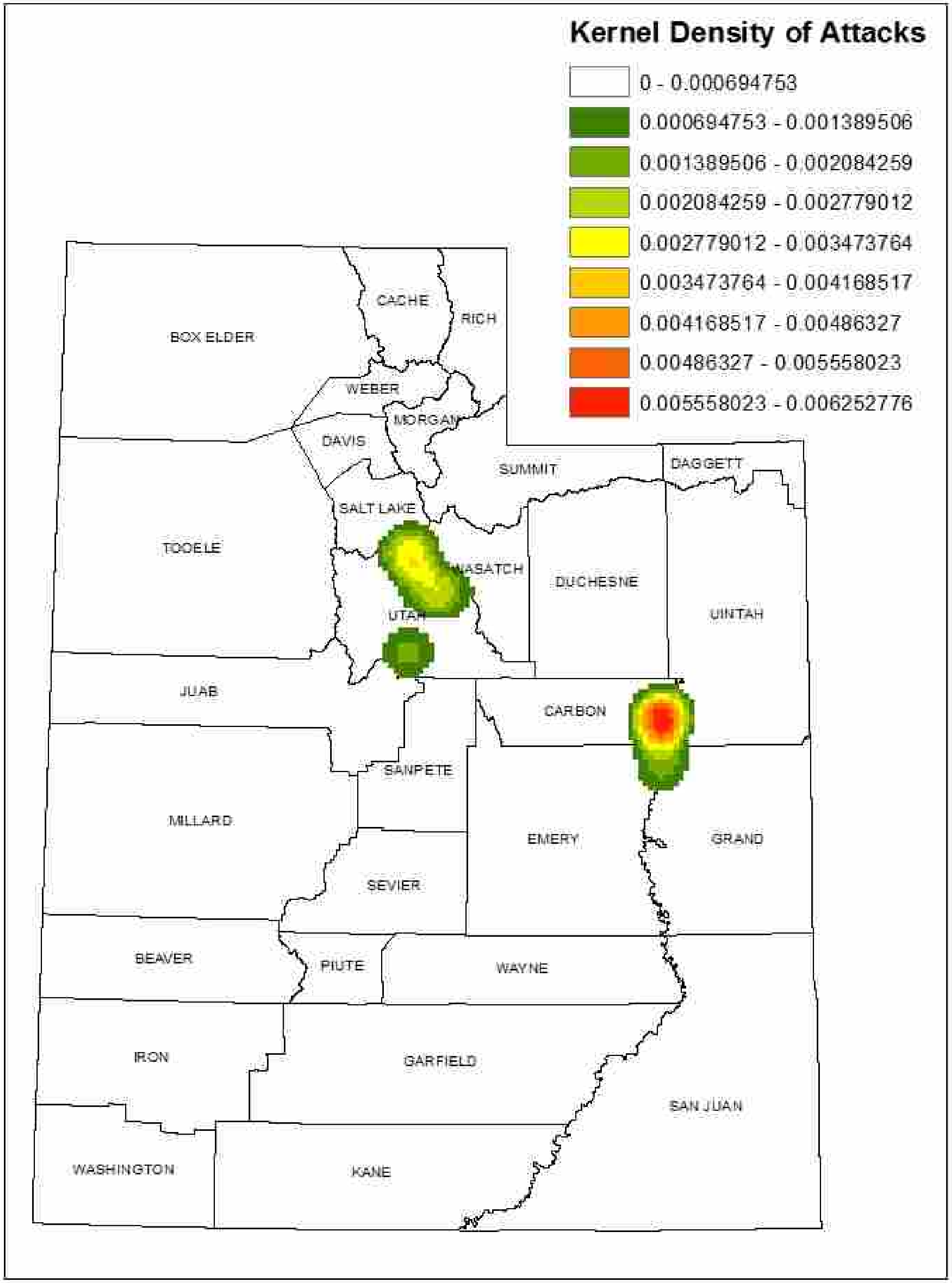

Figure 2-6. Kernel density of all black bear attacks, 2003–2013.

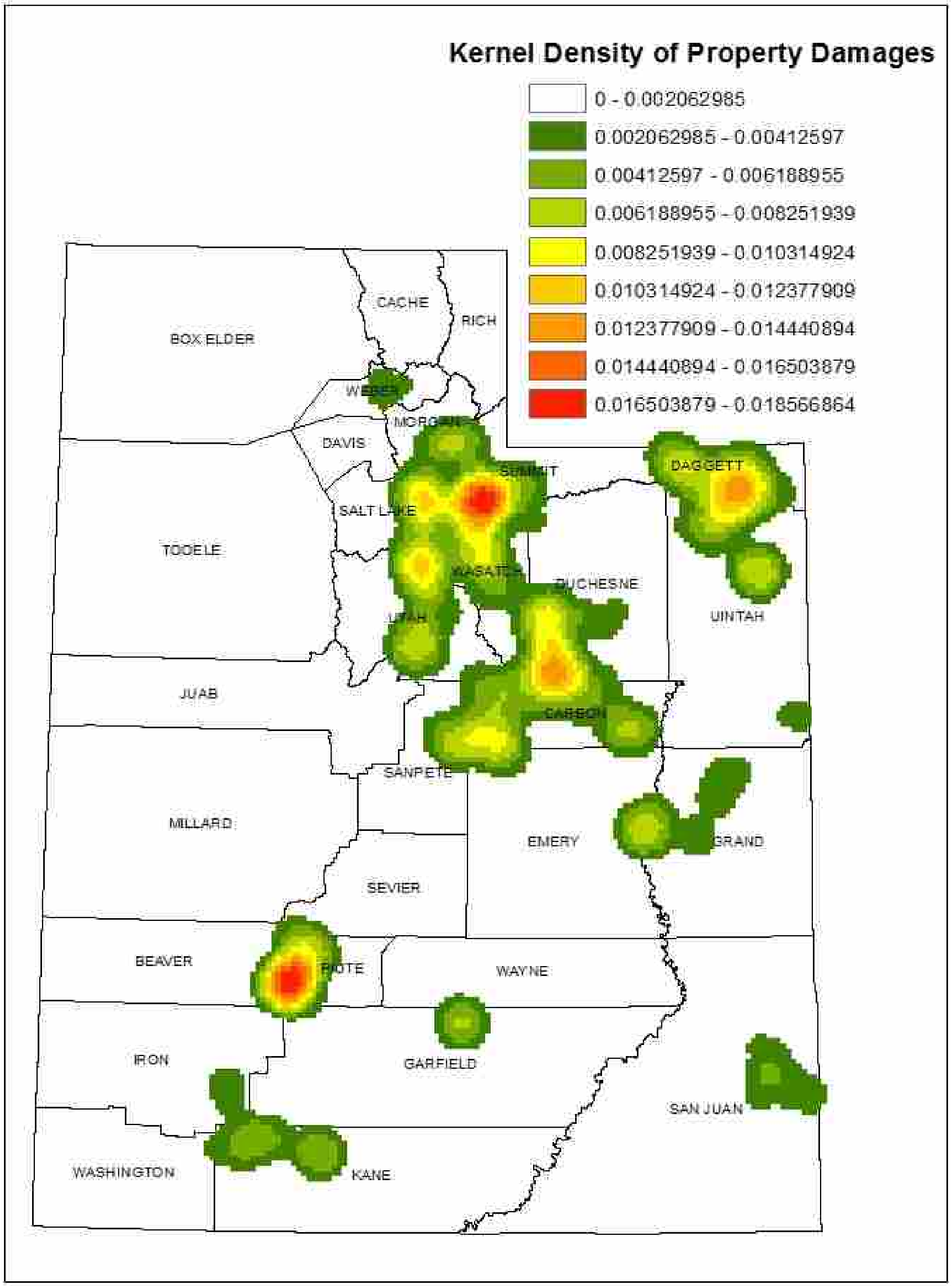

Figure 2-7. Kernel density of all black bear property damage events in Utah, 2003–2013.

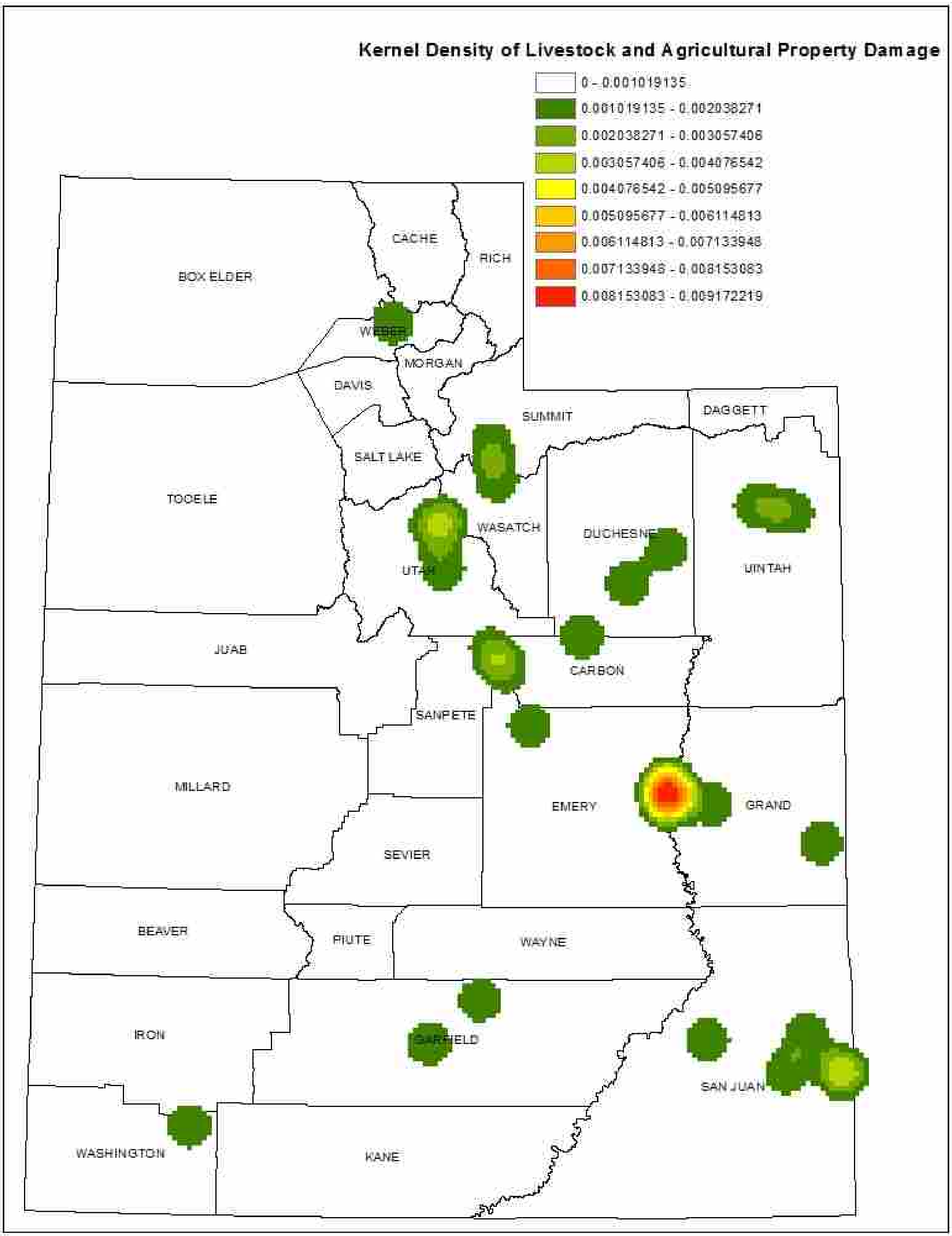

Figure 2-8. Kernel density of livestock and agriculture property damage done by black bears in Utah, 2003–2013.

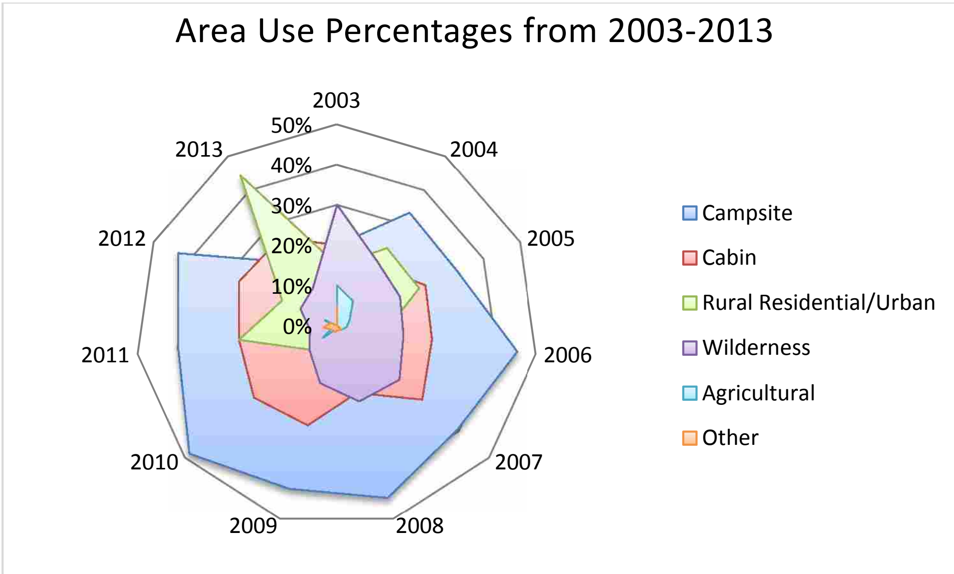

Figure 2-9. Percentage of black bear-human events by area use from 2003–2013.

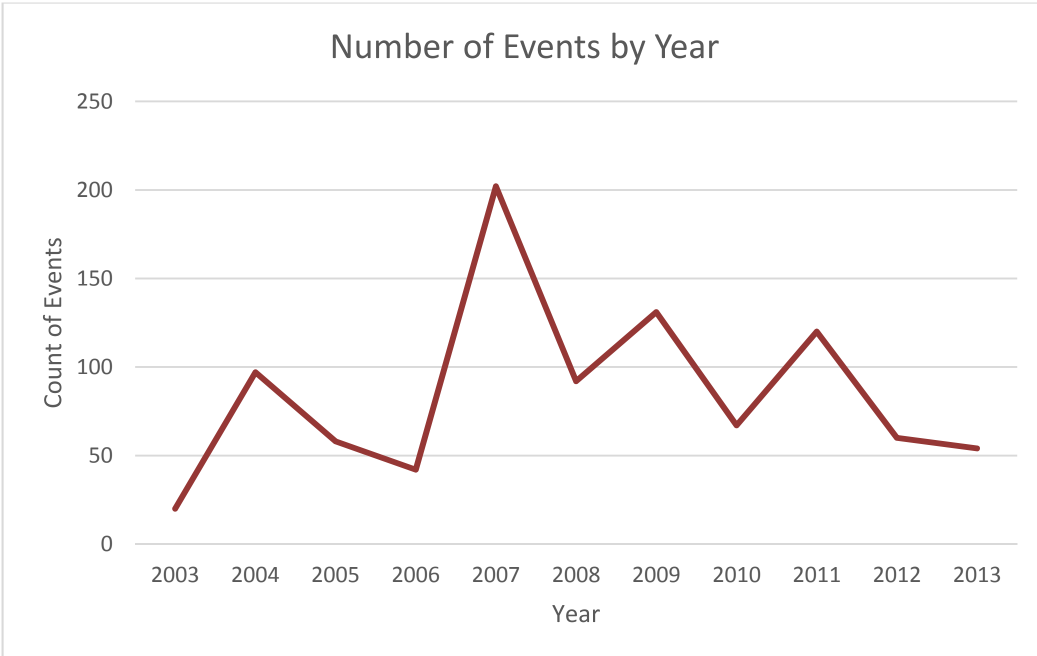

Figure 2-10. Count of total number of black bear-human events by year, 2003–2013.