

**PENNSYLVANIA GAME COMMISSION  
BUREAU OF WILDLIFE MANAGEMENT  
PR PROJECT FINAL JOB REPORT**

**PROJECT CODE NO.:** W-81-R-1 (PR grant M30052624000)

**TITLE:** Black Bear Research and Management

**TITLE:** Home Range Use of Black Bears in Suburban Habitats Relative to Harvest Vulnerability and Human-Bear Conflicts in Pennsylvania

**PERIOD COVERED:** 1 May 2010 to 1 September 2013

**COOPERATING AGENCIES:** No cooperating agencies

**WORK LOCATION:** Suburban regions within the greater Scranton/Wilkes-Barre, State College, and Johnstown areas of Pennsylvania.

**PREPARED BY:** Mark Ternent

**DATE:** 8 November 2013

**ABSTRACT**

A study of black bear survival and movement in suburban landscapes of Pennsylvania was initiated in May 2010 utilizing 3 study areas centered around the cities of Scranton/Wilkes-Barre, State College, and Johnstown. Seventy-eight bears were captured 112 times, and 76 were fitted with GPS-tracking radio-collars. Approximately two-thirds of the bears captured were male, and 44% of female bears and 69% of male bears were juveniles. We received 110,794 GPS locations from radio-collars and retained 95,509 locations for use in home range analyses, discarding locations collected during denning, after relocation or chemical immobilization, and those judged to be erroneous based on unreasonable travel rates. Bears were relocated on 70 occasions, of which 19 were considered to occur outside the bear's home range. Of these, 5 never returned close enough to the capture site for location data to be used in home range estimations. The mean relocation distance for male bears that failed to return was 35.8 miles, and for the 1 female, 15.4 miles. The mean length of monitoring for individual bears was 181.7 days. Monitoring of 33 bears was disrupted because the radio-collar stopped working, with collar failure occurring twice as often for males than females. Monitoring of 21 bears also was disrupted because bears shed the radio-collar.

We determined the beginning and ending of denning 26 times for 24 bears. Adult females entered dens first with a mean date of 24 November and were the only sex/age group to begin denning before the general bear hunting season. Thirty-six percent of adult females entered dens before the hunting season, 3 of which occurred in 2010. One adult male also denned on the first day of the 2010 bear hunting season. Mean date of denning was 9 December for adult males, 10

December for juvenile females, and 31 December for juvenile males. These dates were consistent with other denning observations conducted in Pennsylvania. Adult females remained in dens longer than any other sex/age group, denning for a mean of 125 days. Juvenile females denned for a mean of 104 days; adult males, 109 days, and juvenile males, 58 days. The earliest emergence date was 17 February (juvenile male) and the latest was 15 April (adult female).

Forty-seven percent of bears died during the study. Mean annual survival rates were 62.3% for adult females, 64.6% for adult males, 74.1% for juvenile females, and 42.0% for juvenile males. Causes of mortality included harvest (23), vehicle collisions (9), illegal shooting (1), agency euthanasia (2) and unknown (2). Bears in our study died from harvest at about the same rate as bears captured elsewhere in Pennsylvania. The hypothesis that bears involved with nuisance activity near residential areas experience less hunting pressure appears to be false. Harvest rates were 13.9% for adult males, 19.2% for adult females, and 30.4% for juvenile males. No juvenile females were harvested. Because harvest rates were similar to other areas of Pennsylvania, there seems to be promise that lengthening bear hunting season at the suburban interface should increase harvest as it does elsewhere. However, success will depend largely on private landowners' willingness to allow additional bear hunting activity on their properties, which is something that has not been measured.

Vehicle mortality rates ranged between 6% and 14% with some occurring in all sex/age classes, which was about 4 times higher than the proportion killed in rural areas of Pennsylvania. Thus, the amount of harvest needed to stabilize or decrease a suburban bear population may be less than traditional harvest goals. We recommend that further modeling be done using survival estimates gained in our study to determine the range of harvest rates necessary to increase, stabilize, or decrease suburban bear populations. Mortality due to other causes was relatively low and ranged between 0 and 6%.

Our results indicate that few bears found in urban/suburban areas are transients. Four percent of radio-collared bears left after being captured, but all other bears exhibited home ranges that intersected or abutted study areas. However, the 3 bears that did leave were noteworthy. A one-year-old female captured in June 2012 in the Johnstown study area traveled more than 700 miles before denning on 4 December approximately 84 miles away. Similarly, a one-year-old male captured in May 2010 at the Scranton International Airport traveled more than 750 miles through 11 counties before being harvested on 20 November approximately 114 miles away. And a two-year-old male captured in June 2012 in State College remained in the study area until 18 November and then traveled south into Maryland and partially back, covering more than 400 miles before his radio-collar stopped transmitting on 29 January. Movements of this scale would likely have gone undetected without the aid of GPS radio-telemetry.

For the remaining bears, mean home range size was 7.1 mi<sup>2</sup> for adult females, 44.9 mi<sup>2</sup> for adult males, 9.9 mi<sup>2</sup> for juvenile females, and 53.9 mi<sup>2</sup> for juvenile males. Annual core use areas followed a similar pattern and encompassed 10 to 13% of the home range area. Mean core use area was 0.7 mi<sup>2</sup> for adult females, 4.9 mi<sup>2</sup> for adult males, 1.3 mi<sup>2</sup> for juvenile females, and 7.3 mi<sup>2</sup> for juvenile males. Annual home ranges extended into developed areas with 11% of the average home range classified as either urban or suburban habitat. Annual home ranges also extended into public lands with 68% of bears having public land in their home range.

Median dates for human-bear conflicts statewide were 24 June in 2010; 18 June in 2011, and 14 June in 2012. During the 10-day periods centered over median dates, there were 116, 112, and 148 conflicts reported statewide, which represented 10, 6, and 8% of each year's total conflicts. Thirty-five bears were monitored during the 10-day peak conflict periods. On average, bears used 42% of their annual home range during the 10-day interval, and 11% of the area used was classified as developed; 8% was public land. The mean distance between capture location and conflict-period center was 3.5 miles. This suggested that although all bears were captured at sites that could be considered conflicts, bears did not remain near those sites and instead spent considerable time in other parts of their home range during the time when human-bear conflicts were greatest. We did not measure conflict activity across home ranges, which is something we recommend be explored using a landowner survey.

Thirty-one bears were monitored during the annual, 10-day fall bear hunting period. Eleven percent of the area used was public land, and when compared to conflict periods, locations were farther from capture sites and less dispersed, with bears using 30% of their annual home range at a mean distance of 4.3 miles. However, for unknown reasons, the area used during hunting periods contained a higher percentage of developed land. This may have been the result of monitoring different bears in the two periods. For bears that were monitored in both periods within the same year, 29% of the area used during a conflict period was used during the hunting season, which confirmed that a slight seasonal shift did occur. The mean distance between paired conflict- and hunting-period centers was 2.0 miles.

Although most bears established home ranges along the suburban interface, collectively their home ranges covered a large geographic area, which should be considered when choosing where to implement a hunting season change. The area where we captured bears during spring and summer conflict situations encompassed 500 mi<sup>2</sup>, but the area used by 31 of those bears during the fall hunting season encompassed 1,401 mi<sup>2</sup>. Polygons drawn around all 95,509 locations collected during the 3 years, excluding the 3 bears that left our study areas covered 5,842 mi<sup>2</sup> and averaged 1,947 mi<sup>2</sup> per study area. The mean size of wildlife management units currently used by the Pennsylvania Game Commission is 1,970 mi<sup>2</sup>, suggesting that management decisions for suburban bear populations at the management unit level are appropriate.

## **OBJECTIVES**

1. To estimate daily and seasonal movements and home range for black bears in suburban habitats.
2. To estimate harvest vulnerability and cause specific mortality of bears in suburban habitats.

## **INTRODUCTION**

During the mid 1970s, Pennsylvania's bear population ranged between 3,000 and 4,000 animals but was showing signs of population decline despite increasingly restrictive hunting regulations. Hunter numbers also were increasing, and together with the declining population trend, led to the closing of all bear hunting seasons in 1977 and 1978 (Giles and Kordek 1979, Lindzey et al. 1983).

Bear hunting reopened for one day in mid December 1979. A surprisingly large number of bears were killed (859) despite the late and short season, which confirmed that the population had grown during the 2-year closure (Alt 1980a). Since then, in conjunction with other management changes implemented in the early 1980s, annual bear population estimates and harvest have steadily increased almost every year.

The growth of Pennsylvania's bear population since 1979 has been substantial and current population estimates now number around 16,000 bears (Ternent 2013a). The bear range also has expanded (Ternent 2006). This trend is not unique to Pennsylvania and has been observed across most of North America during the past 3 decades (Garshelis and Hristienko 2006).

Unfortunately, successful recovery of bear populations has led to increased conflicts with bears (Hristienko and McDonald 2007). Two factors – an increase in bear abundance and distribution, and residential development of traditional bear habitats – have resulted in more human-bear encounters, with many now occurring in urban and suburban settings where bears were once uncommon.

Black bears that use urban and suburban habitats may alter their activity patterns (Beckmann and Berger 2003), have higher reproductive rates (Beckmann and Lackey 2008), and utilize high-calorie foods associated with people and garbage. Positive interactions with humans in the form of access to food generally lead to human-bear conflicts.

In Pennsylvania, over 80% of human-bear conflicts involve bird feeders or garbage near homes (Responsive Management 2008). Yet, despite having minimal property damage or human injury consequences, an increase in these conflicts has directly influenced management decisions for black bears during the past decade and resulted in significant expansion of hunting seasons intended to reduce bear abundance in problem areas (Ternent 2008). Neighboring states of New Jersey (Wolgast et al. 2005) and Maryland (Spiker and Bittner 2004) have likewise implemented new bear hunting seasons, in part, to address growing human-bear conflicts near residential areas.

Hunting has been recommended as a tool for reducing some types of human-bear conflicts (Wills 1980, Poelker and Parsons 1980, Conover 2001, Ziegler 2004, Treves et al. 2010). However, nuisance bears living near residential areas may have low susceptibility to harvest (Wolgast et al. 2005), although few studies have empirically measured the risk.

Harvest vulnerability of black bears can vary with forest composition or hunting method (Malcolm and Van Deelen 2010), and in Pennsylvania, has been shown to vary spatially and temporally according to sex, age class, hunter density, and snow cover during the hunting season (Diefenbach et al. 2004, Alt 1980b). Harvest vulnerability for bears living near residential areas

may be further influenced by other factors such as limited hunter access, smaller property sizes, local ordinances that prohibit discharge of firearms, and laws that prevent hunting near occupied buildings or from roadways.

Pennsylvania's extended bear seasons are timed to correspond with the first week of firearms hunting for white-tailed deer (*Odocoileus virginianus*) in hopes that harvest vulnerability for nuisance bears will increase because hunter densities are greatest during that season, and hunting often occurs in areas not traditionally used by bear hunters, such as small woodlots adjacent to communities. But the effectiveness of this approach is unknown because we lack a fundamental understanding of home range use and movement patterns during fall hunting seasons by bears involved with residential nuisance activity months earlier.

Bears are not presently thought to be at biological carrying capacity in Pennsylvania because density-dependent indicators (Garshelis 1994) have not been observed, although some populations appear to be near sociological carrying capacity (Responsive Management 2008). Without management intervention, bear populations will likely increase. Continued expansion of Pennsylvania's bear population will influence future human-bear conflict levels in suburban habitats, as will continued expansion of suburban development into areas currently occupied by bears. A better understanding of home range dynamics and harvest vulnerability for bears that use urban and suburban areas will be beneficial if attempting to use regulated hunting to reduce abundance or conflicts in these areas.

## ACKNOWLEDGEMENTS

Numerous employees of the Pennsylvania Game Commission provided critical assistance by capturing bears and investigating stationary radio-collars. Special recognition is given to David Allen, Travis Anderson, Shawn Harshaw, James Jolley, Jerry Kapral, Ethan Kibe, Seth Mesoras, Dan Murray, Mike Ondik, Mark Rutkowski, Brian Singer, David Sittler, and Mike Stiengrabber. The cooperation of many homeowners who allowed traps to be placed in their yards also is acknowledged.

## STUDY AREA

Three urban centers were selected for this study (Fig. 1). They included:

*Scranton/Wilkes-Barre.*-- This study area primarily lies within the Wyoming Valley, extending northeast from the town of Mountain Top, north of Interstate 80, to the town of Clarks Summit. It is traversed lengthwise by U.S. Interstate 81 and contains portions of Luzerne, Wyoming, and Lackawanna counties. Both ridges that define the Wyoming Valley are forested with some suburban development.

*State College.*-- This study area primarily lies within the Nittany Valley, extending from the western suburbs of State College near Stormstown, east-northeast to the town of Pleasant Gap, but also includes portions of the Penns Valley between the towns of Centre Hall and Boalsburg. The area is less urbanized than the Scranton/Wilkes-Barre study area (hereafter referred to as Scranton) and contains more interspersed or adjacent farmlands. The ridge between Nittany and

Penns Valley is forested, as are the ridges north and south of the study area. U.S. Interstate 99 traverses part of the area and there are several high-traffic State Routes, namely Route 322, 144, and 220. The study area is entirely within Centre County.

*Johnstown.*-- This study area is the smallest of the three and unlike the other two, is not geographically defined by linear ridges but instead is situated on the Alleghany Plateau. It encompasses the city of Johnstown and surrounding communities. State Route 219 is the largest highway, and the entire study area lies within Cambria County. A moderately large urban area occurs about 20 miles to the east along the U.S. Interstate 99 corridor and the city of Altoona.

## **METHODS**

### **Capture and Handling**

Black bears were opportunistically captured in either barrel- or culvert-style traps baited with waste pastries set at residences or businesses that reported bear sightings or human-bear conflicts. Traps were checked daily and moved when a bear was captured or bear activity subsided.

Captured bears were immobilized with a mixture of ketamine hydrochloride (4.4 mg/kg) and xylazine hydrochloride (1.7 mg/kg) delivered by a CO<sub>2</sub>-propelled dart. Each bear was tagged in each ear with a self-piercing numbered metal tag, style 56-L, size 36.5 × 9.5 mm (Hasco Tag Co., Dayton, Kentucky). A tattoo matching the lowest ear-tag number also was applied to the inside of the upper lip, and a first premolar was collected for age determination from all bears ≥12 months-old (Harshyne et al. 1998). We recorded weight, sex, reproductive status (evidence of lactation, estrous, or descended testicles), date, and capture coordinates.

Anesthesia was reversed with yohimbine hydrochloride (0.15 mg/kg) after handling was complete. We attempted to release bears near their capture site, but if relocation was required, we attempted to release female bears within 5 miles of capture and males within 10 miles, which were approximate home-range widths previously reported for Pennsylvania bears (Alt 1980c, Alt et al. 1980). Some bears that were involved with repeated conflicts were released up to 59 miles away.

We visited dens of radio-collared bears in February and March to confirm den locations and replace batteries in radio-collars. Adult and yearling bears were immobilized with a mixture of ketamine hydrochloride (4.4 mg/kg) and xylazine hydrochloride (1.8 mg/kg), and if necessary, removed from the den for radio-collar maintenance, measuring and weighing, and replacement of missing ear tags or tattoos. Newborn cubs were removed from dens without immobilization, weighed, and fitted with ear tags identical to those used on adults. All bears were returned to dens after handling, and we attempted to seal den entrances with brush or snow.

### **Collecting Location Data**

Captured bears weighing >100 pounds were fitted with Global Positioning System (GPS)-equipped radio-transmitting neck collars (Vectronics, Berlin, Germany). Radio-collars were configured to record a location at timed intervals depending on date. During 1 September to 15 December, locations were attempted every 1.0 hrs between 0600 hrs and 1800 hrs and every 3.25 hrs during the remainder of the day, which resulted in 22 to 23 location attempts/day. Prior to 1 September and after 15 December, locations were only attempted every 3.25 hours, which resulted in 6 to 7 location attempts/day. Data on each location attempt (time, date, and coordinates if successful) were received daily from radio-collars via Short Message Service (cellular text) messages sent through a cellular GSM network (AT&T, Harrisburg, Pennsylvania).

### **Data Preparation**

All location data received from radio-collars were combined into a central database (Microsoft Access 2007, Redmond, Washington) and examined using 4 criteria to determine suitability for subsequent analyses. Locations that met any of the following 4 criteria were removed.

#### *Collected during denning*

I removed all locations that were received during denning except the first and last because they overestimated use at den locations, potentially distorting home range delineations. Denning period was determined by examining location data between October and April for evidence of stationary radio-collars. I considered a radio-collar to be stationary if all locations collected during a 3-day period were within a  $0.06 \text{ km}^2$  circle (138 m radius), which was the mean area encircling locations collected from known stationary radio-collars that had dropped from bears.

I used the first date that a radio-collar became stationary or stopped transmitting data (e.g., the bear had entered an underground den) as the beginning of denning, and the first date that a radio-collar moved to a new location as the end of denning. Occasionally, some bears would briefly travel between prolonged stationary periods, presumably using multiple den sites during the same denning season. For these bears, all time between the first and last stationary episode was considered part of the denning period despite having some location data between den sites.

#### *Collected while homing after relocation*

For bears that were not released at the site of capture, I removed all locations until the bear returned to its home range. A bear was considered to have returned to its home range the moment a location was recorded within 14.1 km of the trap site for males, or 5.4 km for females. These distances represented diameters from  $23.1 \text{ km}^2$  and  $156.6 \text{ km}^2$  circles, respectively, which were the mean sizes of male and female black bear home ranges reported for mid-Atlantic state in eastern North America (Table 1). Once a relocated bear returned to its home range, all subsequent locations were included in home range estimations regardless of distance from the capture site.

#### *Collected during a capture event*

I removed all locations collected during the day of capture, and the subsequent day if the bear was chemically immobilized, because confinement in the trap, exhaustion, and effects from recovery may have influenced movements. Weaver (2004) observed that immobilization suppressed black bear movements for 24 hours after capture in southern West Virginia.

#### *Resulted from GPS error*

I removed all outlying locations that were biologically unlikely based on a calculated rate of travel. I measured rate of travel between consecutive locations as the straight-line distance divided by elapsed time and removed single locations that had rates  $>3.0$  miles/hr. These locations were presumed to be the result of GPS or radio-collar malfunction because the likelihood of a bear traveling at this speed or greater for several hours was low based on daily travel rates reported for other Pennsylvania bears. For example, Alt (1977) reported that the maximum travel rate for 15 radio-collared bears monitored within their home ranges was 4.4 miles/day, corresponding with a peak in breeding season, and 5 translocated black bears averaged 3.4 miles/day when homing.

### **Home Range Estimation**

Fixed kernel (Worton 1989) home ranges and core-use areas were calculated using the Animal Movement Extension (Rodgers and Carr 1998) for ArcView GIS (v. 3.2, ESRI Inc., Redlands, CA). I defined annual home range as the 95% probability area (utilization distribution, 95% UD) and core-use area as the 50% probability area (50% UD). Default values provided by the Animal Movement Extension were used for all fixed kernel smoothing parameters and cell size.

Home range and core area were calculated annually for bears monitored  $\geq 60$  days (e.g., approximately 25% of the non-denning period) and reported as mean values by sex and age groupings. I classified 1- and 2-year-old bears as juveniles, and 3-year-old or older bears as adults because 3 was the mean age females produced cubs in Pennsylvania (Alt 1989, Kordek and Lindzey 1980).

I defined the annual home range period as beginning with den emergence or capture, whichever occurred first, and ending with mortality, collar malfunction, or onset of denning in the same year. During 1 September–15 December, when radio-collars were programmed to collect 22 to 23 locations daily, I randomly selected 7 location attempts/day for each bear to use in calculating home range so that number of location attempts/day was approximately equal throughout the year.

### **Home Range Use During Conflict and Hunting Seasons**

To determine where bears were when human-bear conflicts were most numerous, I used data collected by the Pennsylvania Game Commission (PGC) on reported human-bear conflicts. PGC employees annually record the date and location of all reported conflicts that require an action to resolve (e.g., telephone call, site visit, capture attempt, etc.). I treated each report as independent regardless of whether other reports from the same area or address also were received.

Human-bear conflicts in Pennsylvania tend to increase quickly beginning in late March, peak in mid June, and then slowly decline the remainder of the year with minimal variation between years (PGC unpublished data; Fig. 2). I defined the peak human-bear conflict period as the 10-day interval centered on the annual median date of reported incidents statewide, or the closest 10-day period for any bear that had locations censored during part of a peak conflict period. Based on this approach, the dates I used were 20–29 June in 2010, 14–23 June in 2011, and 10–19 June in 2012. I limited the conflict period to 10 days because that is the length of the statewide bear hunting period in Pennsylvania, thereby allowing comparison between the two.

For bears that had sufficient data to estimate annual home range, I determined the area used during the conflict period by placing a 0.5 mile buffer around locations during those dates and calculated an intersect using ArcMap GIS (v. 10.0, ESRI Inc., Redlands, CA). I also calculated the distance between the bear's capture location and the mean center of conflict period locations.

I repeated the same calculations for bears located during the statewide 10-day bear hunting period, which was 15–24 November 2010, 14–23 November 2011, and 12–21 November 2012. If a bear was harvested, I used the 10-day interval ending with their last location as a substitute for the hunting period to avoid under-representing them in the analysis. The 10-day hunting period included both the statewide archery bear hunting season and the statewide firearms bear hunting season. In some areas of the state an extended firearms season also was open, but it was not used to delineate the hunting period because it was not open in all 3 study areas and was closed statewide in 2010.

Not all bears had locations in both periods within the same year because of mortality or delayed capture. For bears that did, I calculated the area of overlap as a percent of the conflict period and the distance between location centers in both periods using ArcMap GIS.

### **Home Range Composition**

I calculated the percent of home range, core area, and conflict or hunting period use area classified as urban, suburban, or rural habitat by overlaying areas with a land classification map and using ArcMap GIS to analyze the resulting intersect. The land coverage map I used was created by the Pennsylvania State University using 30-meter interpretation of remotely sensed data and ancillary data sources representative of the time period 2003–2007 (Pennsylvania State University 2007). The map contained 19 habitat classifications that I grouped into urban, suburban, and rural (Table 2). I considered areas classified as urban or suburban as developed, and areas classified as rural as undeveloped.

I also determined the percent of each home range, core area, and conflict or hunting period use area that was public land using an ArcMap GIS intersect. Public land was defined as any National Forest, State Forest, or State Game Lands. These lands, with few administrative exceptions, were open to public hunting. State Parks were not included as public land because, although most allowed some public hunting, areas closed to hunting were common.

### **Survival and Cause-Specific Mortality**

I estimated annual survival rates by sex and age groupings from telemetry data using the method described by Heisey and Fuller (1985). Then, to determine the influence of specific mortality factors on survival, I calculated the percent of marked bears (tags or collars) recovered by the PGC in their statewide bear monitoring program. Mortalities were grouped into 3 categories: harvest, vehicle collisions, and other causes.

Since the early 1980s, the PGC has annually marked up to 800 bears with ear-tags throughout the bear range and examined all reported mortalities for tags (Diefenbach et al. 2004, Ternent 2006). Marking occurred between March and November each year and was distributed by assigning quotas to all counties in the bear range. Harvested bears were examined for marks at mandatory check stations during the hunting season, and non-harvest mortalities were examined throughout the year. A public interest to report dead bears developed concurrent with recovery of bear populations, and currently about 600 non-harvest mortalities are examined annually by the PGC (Ternent 2013a). For further details on how bears were marked or recovered in the statewide PGC program, see Diefenbach et al. (2004).

Telemetry data (Heisey and Fuller 1985) were not used to estimate cause-specific mortality rates because premature shedding of collars before the fall hunting season was common and some bears were known to later die based on tag-recovery data. Also, by using tag-recovery data, mortality rates could be compared to other areas of the state where the same type of data were available.

To compare cause-specific mortality rates with other areas of the state, I calculated the minimum township density (people/mi<sup>2</sup>) where at least 80% of our captures occurred (i.e., the 20<sup>th</sup> percentile), and used the value to separate all other bears tagged by the PGC during 2010–2012 into two groups: those captured in townships with the same or higher human density (i.e., other urban/suburban bear populations), and those captured in townships with lower human densities (i.e., rural bear populations).

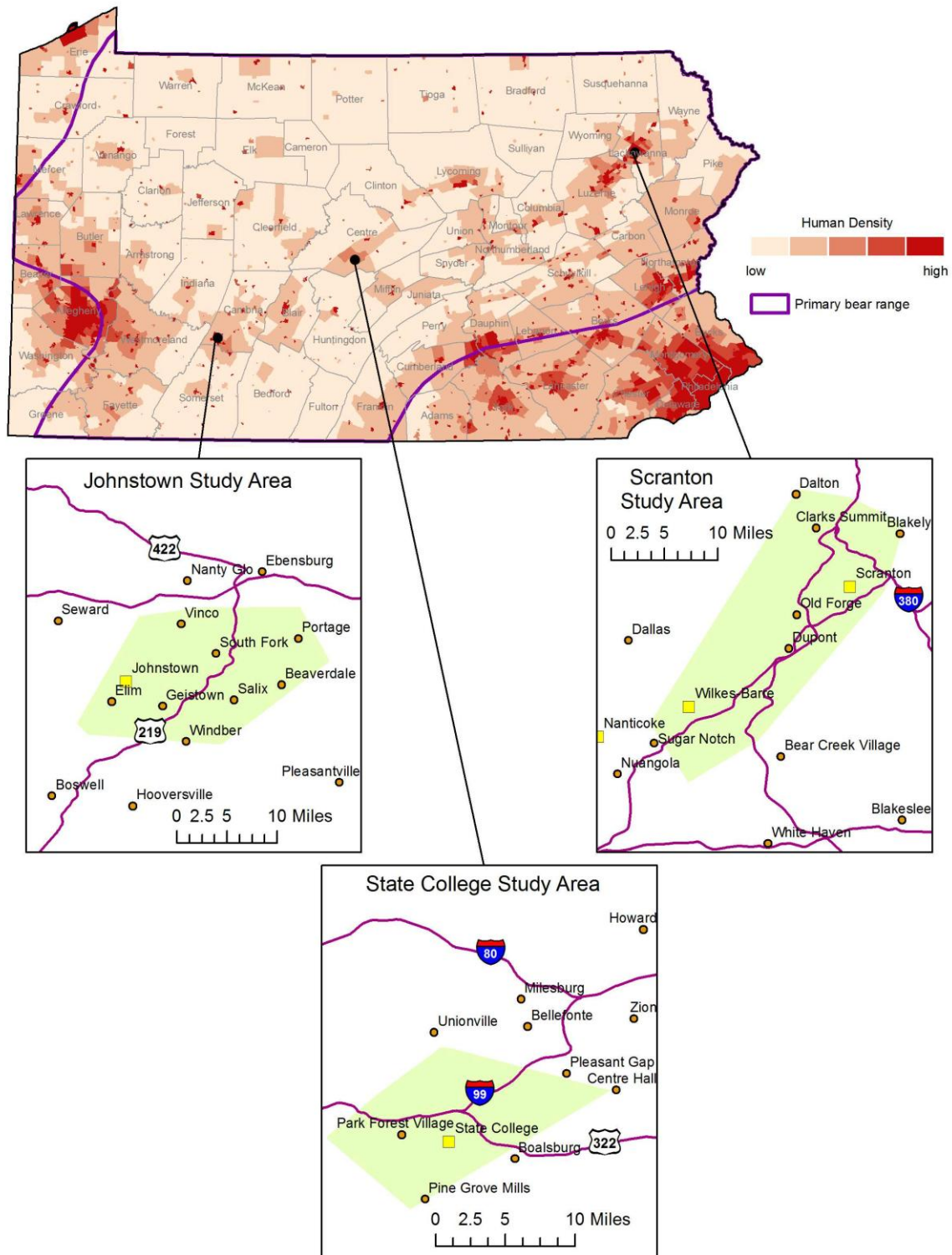


Figure 1. Three urban/suburban study areas where black bears were opportunistically captured and radio-collared at residences or businesses with reported sightings or conflicts.

Table 1. Reported home range size for male and female black bears in the mid-Atlantic region of eastern North America.

| Jurisdiction  | Source                    | Home Range Size (km <sup>2</sup> ) |        |
|---------------|---------------------------|------------------------------------|--------|
|               |                           | Male                               | Female |
| Maryland      | Webster 1994              |                                    | 40     |
| Maryland      | Webster 1994              |                                    | 41     |
| Massachusetts | Elowe 1984                | 318                                | 28     |
| Massachusetts | Fuller 1993               |                                    | 23     |
| Massachusetts | Fuller 1993               | 328                                | 26     |
| New Jersey    | MacKenzie 2003            |                                    | 4      |
| New Jersey    | Shramko 2005              |                                    | 5      |
| New Jersey    | Fimbel 1990               | 182                                | 16     |
| New York      | Rainbolt et al. 2011      |                                    | 12     |
| New York      | Rainbolt et al. 2011      |                                    | 15     |
| New York      | Costello 1992             | 170                                | 31     |
| New York      | Costello 1992             | 383                                | 38     |
| Pennsylvania  | Alt et al. 1980           | 173                                | 41     |
| Pennsylvania  | Eveland 1973              | 102                                | 20     |
| Pennsylvania  | Kordeck 1973              | 148                                | 20     |
| Pennsylvania  | McLaughlin 1981           |                                    | 25     |
| Pennsylvania  | Alt et al. 1976           | 196                                | 37     |
| Virginia      | Hellgren and Vaughan 1990 | 112                                | 27     |
| Virginia      | Higgins 1997              | 7                                  | 6      |
| Virginia      | Higgins 1997              | 11                                 | 7      |
| Virginia      | Higgins 1997              | 7                                  | 6      |
| Virginia      | Higgins 1997              | 11                                 | 7      |
| Virginia      | Schrage 1994              |                                    | 10     |
| Virginia      | Hellgren 1988             |                                    | 15     |
| Virginia      | Offenbuttel 2005          |                                    | 30     |
| Virginia      | Garner 1986               | 116                                | 22     |
| Virginia      | Garner 1986               | 195                                | 38     |
| West Virginia | Rieffenburger 1973        |                                    | 29     |
| West Virginia | Brown 1980                | 204                                | 49     |
| West Virginia | Kraus 1990                |                                    | 26     |
| mean          |                           | 156.6                              | 23.1   |

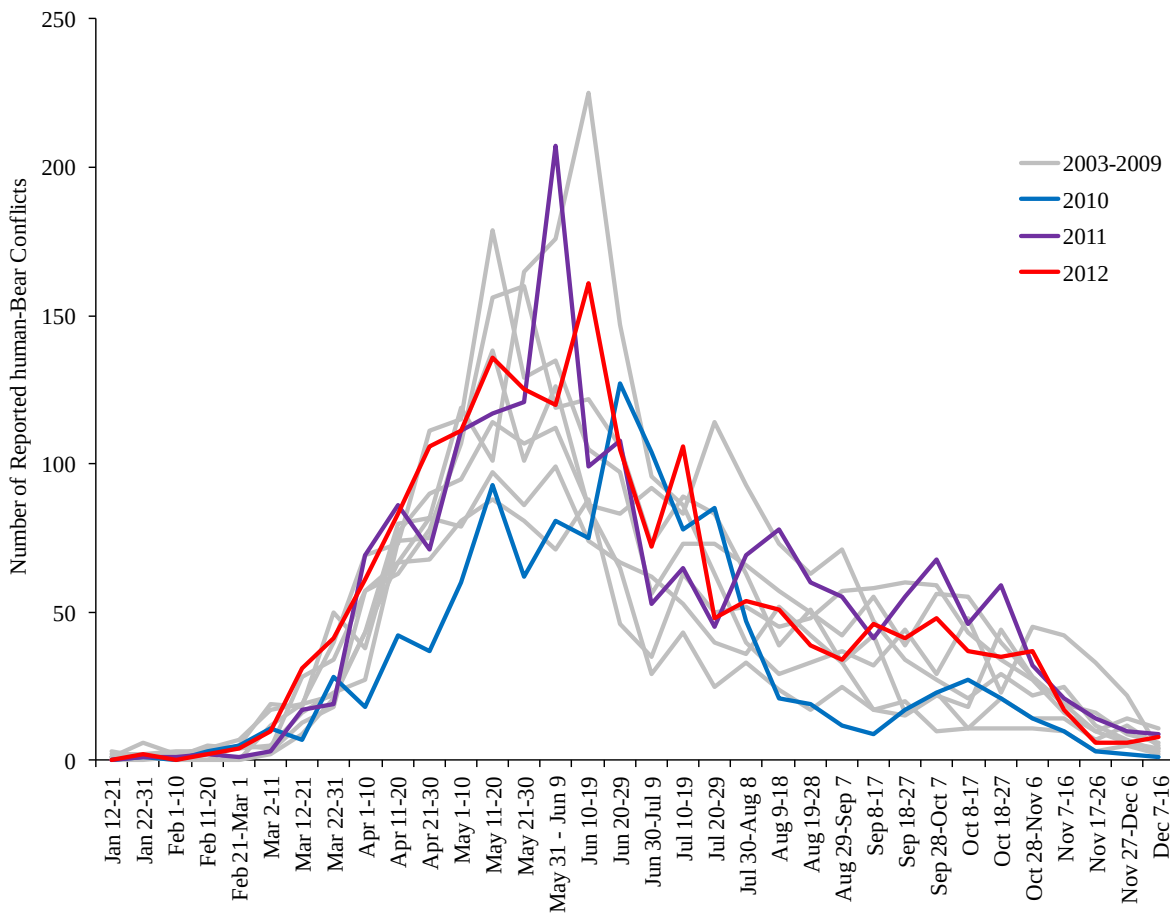


Figure 2. Number of human-bear conflicts reported annually to the Pennsylvania Game Commission. In 2010, the PGC recorded 1,149 human-bear conflicts statewide with a median date of 24 June; in 2011, there were 1,818 conflicts with a median date of 18 June, and in 2012, there were 1,789 conflicts with a median date of 14 June.

Table 2. Land cover classifications from Pennsylvania State University (2007) used to determine proportion of urban, suburban, and rural habitat in black bear home ranges, core areas, and seasonal use periods.

| Category Used In Analysis | Land Cover Classification<br>(from Pennsylvania State University 2007)                                                                                                                                                                                                                                            |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Urban                     | Roads<br>Residential land 31% to 74% impervious<br>Residential land >74% impervious<br>Institutional, industrial, or commercial land 31% to 74% impervious<br>Institutional, industrial, or commercial land >74% impervious<br>Bare, unclassified urban or mine area, exposed rock, or other unvegetated surfaces |
| Suburban                  | Residential land 5% to 30% impervious<br>Institutional, industrial, or commercial land 5% to 30% impervious<br>Airports<br>Golf courses<br>Active mines or disturbed mined areas                                                                                                                                  |
| Rural                     | Row crops<br>Pasture or grass<br>Deciduous forest<br>Evergreen forest<br>Mixed deciduous and evergreen forest<br>Forested wetlands<br>Emergent wetlands<br>Water                                                                                                                                                  |

## RESULTS and DISCUSSION

### Captures

We captured 78 bears during the 3 years of study (Appendix I). Nineteen were captured in the Johnstown area, 25 in the State College area, and 34 in the Scranton area. Captures were skewed toward male in all 3 areas and ranged from 64% to 68% (Table 3). Twenty-six bears were recaptured 34 times resulting in a total of 112 handling events.

Forty-four percent of female bears and 69% of male bears were juveniles (Table 4). The oldest female was 16 years-old, and the oldest male, 10 years-old. Mean weights were larger for males than females in all age classes. The heaviest female weighed 259 pounds and was 14 years-old, and the heaviest male weighed 575 pounds and was 6 years-old.

Table 3. Number of black bears captured in 3 urban/suburban study areas.

| Study Area    | 2010   |      | 2011   |      | 2012   |      | Total  |      | No. Bears Re-captured | Total No. Re-captures | Total No. Handling Events |
|---------------|--------|------|--------|------|--------|------|--------|------|-----------------------|-----------------------|---------------------------|
|               | Female | Male | Female | Male | Female | Male | Female | Male |                       |                       |                           |
| State College | 5      | 7    | 1      | 6    | 3      | 3    | 9      | 16   | 6                     | 9                     | 34                        |
| Scranton      | 8      | 14   | 3      | 6    | 1      | 2    | 12     | 22   | 11                    | 14                    | 48                        |
| Johnstown     | 3      | 7    | 1      | 6    | 2      | 0    | 6      | 13   | 9                     | 11                    | 30                        |
| Total         | 16     | 28   | 5      | 18   | 6      | 5    | 27     | 51   | 26                    | 34                    | 112                       |

Table 4. Age distribution of black bears at time of initial capture.

| Age (yrs) | Females       |             | Males         |             |
|-----------|---------------|-------------|---------------|-------------|
|           | Frequency (n) | Mean Weight | Frequency (n) | Mean Weight |
| 1         | 5             | 108 lbs     | 15            | 130 lbs     |
| 2         | 7             | 136 lbs     | 20            | 223 lbs     |
| 3+        | 15            | 203 lbs     | 16            | 345 lbs     |
| total     | 27            |             | 51            |             |

### Radio-collaring

Seventy-six of the 78 bears we captured were fitted with a radio-collar (Appendix II). An adult male radio-collared in New Jersey also was monitored after denning in Pennsylvania, but is not included in this report because his home range primarily occurred in New Jersey and when in Pennsylvania, was well outside the 3 study areas.

The 2 bears that were not radio-collared weighed 84 and 99 pounds, respectively. Both lived in the State College study area and neither was recaptured. One additional bear in the State College area also was too small for radio-collaring at the time of initial capture, but was eventually radio-collared when recaptured. Radio-collared bears included 12 females and 22 males in the

Scranton study area, 8 females and 15 males in the State College study area, and 6 females and 13 males in the Johnstown study area.

Monitoring of 33 bears (43%) was disrupted because the radio-collar stopped working. In 9 cases, the bear was later recaptured and fitted with a new radio-collar, but 5 of these bears experienced a second radio-collar failure for a total of 38 failures. We were able to determine the fate of some bears after radio-collar failure through harvest ( $n = 7$ ), vehicle collisions ( $n = 1$ ) or recapture outside the study area ( $n = 4$ ), but for 17 bears (2 in Johnstown, 7 in State College, and 8 in Scranton), collar failure resulted in a significant financial and data collection loss.

Radio-collars that failed were on bears for a mean of 105.6 days (range 4–284 days,  $SD = 82.82$ ,  $n = 38$ ), which did not exceed the anticipated battery life. Collar failure was more common among males, with 27 of 51 radio-collared males (53%) experiencing at least 1 collar failure compared to 6 of 27 females (22%). We tended to attach radio-collars tighter on males because the difference between head and neck circumference was smaller, and in some cases, negative. Subsequent weight gain may also have been greater. Thus, radio-collars worn by males presumably had greater stress at wiring connections imbedded in the collar belting. Collars worn by males also were prone to damage from other bears as evidenced by a greater occurrence of neck and head injuries observed during captures. Most of the non-functioning collars we recovered had damaged belting, and when returned to the manufacturer for repair, were discovered to also have damaged power supply wires.

Monitoring of 21 bears (28%) was disrupted because bears shed the radio-collar. Five of these bears were recaptured and given new radio-collars, of which 1 also was dropped for a total of 22 shed collars. Five bears that shed their radio-collar eventually died and were recovered in the PGC monitoring program, but the fate of 12 was unknown (3 in Johnstown, 2 in State College, and 7 in Scranton).

Shed radio-collars were on bears for a mean of 77.3 days (range 1–512 days,  $SD = 123.18$ ,  $n = 22$ ). Surprisingly, a greater percentage of females shed radio-collars than males, with 12 of 51 males (24%) shedding at least 1 collar compared to 9 of 27 females (33%). Shedding was noticeably more common during the first year of study than subsequent years, with 12 incidents occurring in 2010, 6 in 2011, and 3 in 2012. GPS-style collars had not been previously used on bears in Pennsylvania, therefore we had limited experience fitting larger GPS collars during the first year, which may have resulted in us attaching them more loosely. We may also have been more concerned about future weight gain during the first year, having never studied bears in urban/suburban environments where access to human-related foods is greater.

### **Location Data**

We monitored bears for 15,988 radio-days (1 bear radio-collared for 1 day = 1 radio-day). The mean length of individual monitoring periods was 181.7 days ( $SD = 166.75$ ,  $n = 88$ , range = 1–754 days). Forty-eight bears (63%) were monitored during 1 year, 25 (33%) during 2 years, and only 3 bears were monitored parts of all 3 years. During 2010 we monitored 44 bears; during 2011, 39 bears, and during 2012, 24 bears. We received 110,794 GPS locations from radio-collars (Appendix III).

The proportion of GPS attempts that were successful averaged 82% during 1 September–15 December when radio-collars were programmed to try every hour between 0600 hrs and 1800 hrs, and 62% during the remainder of the year when radio-collars attempted a location every 3.25 hrs. Location success was slightly better in the State College study area (mean = 76%,  $n = 23$ , range = 39–94%), followed by the Scranton study area (mean = 68%,  $n = 34$ , range = 25–100%), and the Johnstown study area (mean = 66%,  $n = 19$ , range = 11–93%). This difference was likely due to variable GSM service between the 3 areas that became increasingly sporadic north of State College and west of Scranton.

We retained 95,509 locations for use in home range analyses and discarded 15,285 locations that included: 7,106 locations collected from bears in dens, 7,444 location collected when bears were relocated outside their home range and before they returned, 578 locations collected on the day bears were captured or during the subsequent day if the bear was chemically immobilized, and 157 locations that were judged to be erroneous because travel speed exceeded 3.0 miles/hr.

#### *Location data collected during denning*

We determined the beginning and ending of denning 26 times for 24 bears (Table 5). Adult females entered dens first with a mean date of 24 November and were the only sex/age group to begin denning before the general hunting season. Four of 11 females (36%) entered dens before the hunting season, 3 of which occurred in 2010. In fact, all sex and age classes entered dens earlier in 2010, with 1 adult male also denning on the first day of the bear hunting season. Natural food conditions were the poorest in 2010 (Fig. 3) and may have contributed to earlier denning.

The earliest any bear denned was 26 October, which was an 8-year-old pregnant female that subsequently produced 3 cubs. The mean denning date for juvenile females was 10 December; juvenile males, 31 December, and adult males, 9 December (Table 5). These dates were consistent with other denning observations conducted in Pennsylvania (Matson 1954, Alt 1983, Alt 1989).

Adult females remained in dens longer than any other sex/age group, denning for a mean of 125 days. Juvenile females denned for a mean of 104 days; adult males, 109 days, and juvenile males, 58 days (Table 5). The earliest emergence date was 17 February (juvenile male) and the latest was 15 April (adult female).

The mean number of locations collected during denning periods was 337 per bear ( $n = 24$  bears), which resulted in removal of 7,106 locations from home range analyses (2,484 during 2010 denning season, 3,127 during 2011 season, and 1,495 during 2012 season). GPS success was notably low during denning periods (mean = 44%), presumably because of inactivity and overhead obstructions.

Table 5. Denning dates for black bears monitored in 3 urban/suburban study areas.

| Age Class | Age | Bear  | Study Area | Year | Entrance Date            | Emergence Date | Duration (days) |
|-----------|-----|-------|------------|------|--------------------------|----------------|-----------------|
| Juvenile  | 1   | 26797 | Scranton   | 2010 | 26 November              | 21 March       | 115             |
| Female    | 2   | 28113 | Scranton   | 2011 | 28 November              | 18 March       | 111             |
|           | 1   | 31716 | Johnstown  | 2012 | 4 December               | c              |                 |
|           | 2   | 33207 | St College | 2012 | 8 December               | 4 March        | 86              |
|           | 2   | 35711 | St College | 2012 | 17 January               | c              |                 |
|           |     |       |            | mean | 10 December              | 14 March       | 104             |
| Juvenile  | 2   | 28111 | Scranton   | 2011 | 7 December               | c              |                 |
| Male      | 1   | 28735 | Scranton   | 2010 | 14 December              | 17 February    | 65              |
|           | 1   | 33838 | Johnstown  | 2010 | 18 December              | 12 March       | 84              |
|           | 2   | 33131 | St College | 2011 | 8 January                | c              |                 |
|           | 2   | 33148 | Johnstown  | 2010 | 10 January               | 23 February    | 44              |
|           | 2   | 33123 | St College | 2010 | 6 February               | 17 March       | 39              |
|           |     |       |            | mean | 31 December              | 3 March        | 58              |
| Adult     | 8   | 26778 | Scranton   | 2010 | 26 October <sup>a</sup>  | 9 April        | 165             |
| Female    | 4   | 21520 | Scranton   | 2010 | 30 October <sup>a</sup>  | 9 April        | 161             |
|           | 5   | 33836 | Johnstown  | 2010 | 2 November <sup>a</sup>  | 18 March       | 136             |
|           | 3   | 28263 | Scranton   | 2012 | 9 November <sup>a</sup>  | c              |                 |
|           | 14  | 26755 | Scranton   | 2010 | 29 November              | 2 April        | 124             |
|           | 3   | 26780 | Scranton   | 2011 | 2 December               | 8 March        | 97              |
|           | >3  | 33151 | St College | 2011 | 5 December               | 26 March       | 112             |
|           | 9   | 26778 | Scranton   | 2011 | 9 December               | 1 April        | 114             |
|           | 18  | 28730 | Scranton   | 2012 | 13 December              | c              |                 |
|           | 4   | 27910 | Johnstown  | 2012 | 2 January                | 31 March       | 88              |
|           | 17  | 28730 | Scranton   | 2011 | c                        | 15 April       |                 |
|           |     |       |            | mean | 24 November              | 30 March       | 125             |
| Adult     | 4   | 26791 | Scranton   | 2010 | 20 November <sup>b</sup> | 30 March       | 130             |
| Male      | 6   | 26473 | Scranton   | 2010 | 4 December               | 3 April        | 120             |
|           | 4   | 33201 | Johnstown  | 2012 | 25 December              | c              |                 |
|           | 3   | 33219 | St College | 2011 | 26 December              | 11 March       | 76              |
|           |     |       |            | mean | 11 December              | 25 March       | 109             |
| Pooled    |     |       |            | mean | 9 December               | 21 March       | 104             |

<sup>a</sup> Began denning before the statewide firearms bear hunting season.<sup>b</sup> Began denning during the statewide firearms bear hunting season.<sup>c</sup> Monitoring began or ended during the denning period preventing determination of den entrance or emergence date.

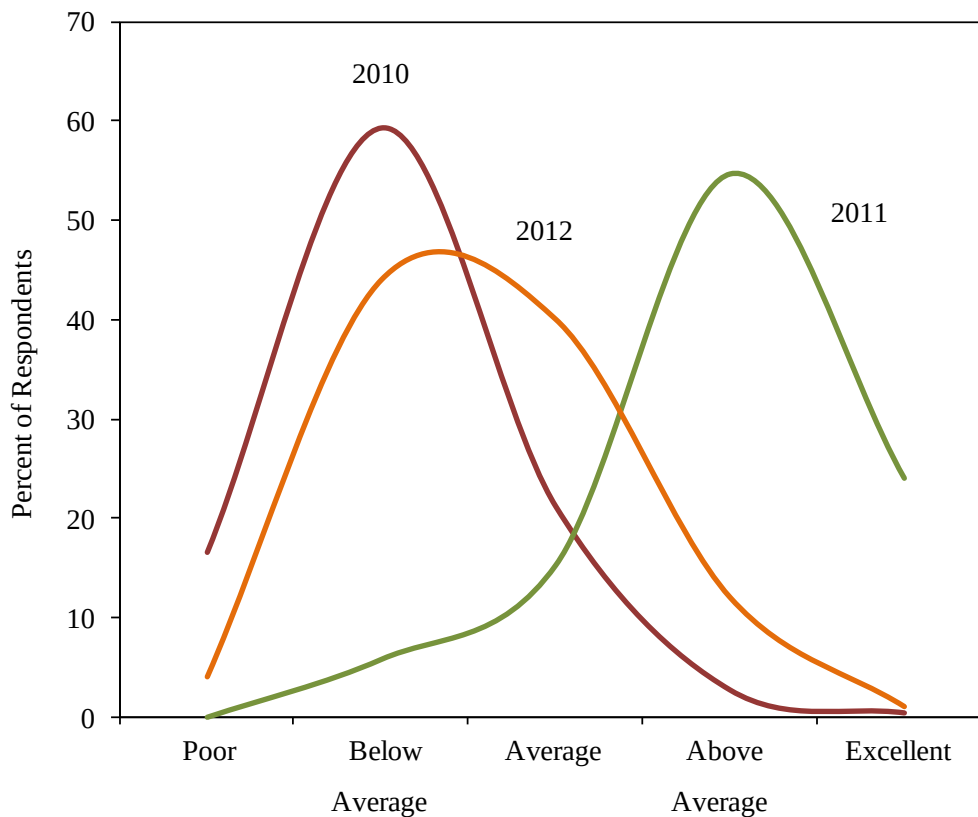


Figure 3. Assessments of natural food conditions in Pennsylvania during 2010–2012. Ratings were determined by surveying employees of the Pennsylvania Game Commission and the Department of Conservation and Natural Resources who subjectively rated the abundance and productivity of 22 foods commonly used by wildlife. For more information see Ternent (2013b).

#### *Location data influenced by relocation or homing*

Fifty-two bears (67%) were relocated during 70 capture events; 70% occurred during an initial capture and 30% occurred during a recapture (Table 6). Mean relocation distance was 9.1 miles for females (SD = 13.444,  $n = 16$ ) and 10.3 miles for males (SD = 11.629,  $n = 54$ ).

Five of 16 female relocations (31%) and 14 of 52 male relocations (27%) were considered to occur outside the bear's home range. Of these 19 bears, 5 (1 female, 4 males) never returned close enough to the capture site for location data to be used in home range estimations (Table 6). Two of these bears were later recaptured and relocated a second time, but data collection still did not resume because both failed to return to the vicinity of the first capture. The mean relocation distance for male bears that failed to return was 35.8 miles, and for the 1 female, 15.4 miles. The mean time elapsed for bears released outside their home range who did return was 10.6 days for males and 13.3 days for females.

Alt (1980d) concluded that bears relocated < 100 air-miles in Pennsylvania generally return. However, 26% of the bears we relocated outside of a home range did not return despite much shorter distances. One possibility is that monitoring ended before some of our bears returned, thereby underestimating values; 3 of the 5 bears that did not return in our study were relocated during the last season of monitoring.

The mean number of locations collected during homing was 47.7 per bear ( $n = 12$  bears). These locations, with the 6,872 locations collected from bears that never returned, resulted in removal of 7,444 locations from home range analyses (3,393 during 2010; 299 during 2011; 3,288 during 2012; and 464 during 2013).

#### *Location data influenced by capture or immobilization recovery*

Bears were captured on 112 occasions, of which 98 involved chemical immobilization of the animal. Radio-collars collected 203 locations on the days bears were captured and 375 locations during the following day for those that were immobilized, resulting in the removal of 578 locations from home range analyses. The mean number of locations removed due to capture or immobilization was 9.5 per bear (range = 1–29).

#### *Location data believed to be erroneous*

Travel speed was determined for 103,598 non-denning locations; 98.6% were under 1 mile/hr, 1.2% were between 1 and 2 miles/hr and 0.1% were between 2 and 3 miles/hr. The mean travel rate for speeds < 3.0 miles/hr was 0.13 (SD = 0.224,  $n = 103,441$ ).

One-hundred and fifty-seven locations had a travel rate  $\geq 3.0$  miles/hr and were excluded from home range analyses. This represented 0.2% of all non-denning locations (i.e., 99.8<sup>th</sup> percentile) and contained 41 locations with rates > 20 miles/hr that clearly were wrong. Why GPS errors occurred is unknown, but possibilities include poor satellite reception or problems with GSM data transmission. We were unable to detect a tendency for errors to occur during specific seasons (e.g., denning) or by specific radio-collars.

Males traveled at greater rates than females (Fig. 4). In the spring, both sexes steadily increased travel speeds until rates peaked for males in June concurrent with the breeding season and at more than twice the rate of females. Travel rates then declined for males while female rates remained constant until September when rates for both sexes again increased. These trends were consistent with previous studies of bear movement in Pennsylvania (Alt 1977).

Table 6. Homing by black bears relocated after capture in 3 urban/suburban study areas.

| Bear  | Sex | Age | Capture Date      | Capture Type | Distance Relocated <sup>a</sup><br>(miles) | Released Out-side Home Range <sup>b</sup> | Days to Return |
|-------|-----|-----|-------------------|--------------|--------------------------------------------|-------------------------------------------|----------------|
| 26780 | F   | 2   | 10 May 2010       | capture      | 0.3                                        | No                                        |                |
| 26537 | F   | 4   | 12 May 2010       | capture      | 0.4                                        | No                                        |                |
| 33110 | F   | 7   | 25 May 2010       | capture      | 1.1                                        | No                                        |                |
| 33836 | F   | 5   | 16 July 2010      | capture      | 1.2                                        | No                                        |                |
| 27961 | F   | 2   | 26 May 2010       | capture      | 1.3                                        | No                                        |                |
| 26797 | F   | 1   | 4 October 2010    | capture      | 1.4                                        | No                                        |                |
| 33113 | F   | 2   | 29 May 2010       | capture      | 1.5                                        | No                                        |                |
| 26778 | F   | 8   | 7 May 2010        | capture      | 2.4                                        | No                                        |                |
| 28113 | F   | 2   | 19 May 2011       | capture      | 3.0                                        | No                                        |                |
| 26797 | F   | 2   | 18 May 2011       | recapture    | 3.1                                        | No                                        |                |
| 26755 | F   | 14  | 12 May 2010       | capture      | 3.4                                        | No                                        |                |
| mean  |     |     |                   |              | 1.7                                        |                                           |                |
| 31716 | F   | 1   | 2 June 2012       | capture      | 15.4                                       | Yes                                       | never          |
| 26778 | F   | 8   | 21 May 2010       | recapture    | 16.1                                       | Yes                                       | 29             |
| 33207 | F   | 2   | 26 April 2012     | capture      | 16.3                                       | Yes                                       | 5              |
| 28263 | F   | 3   | 11 May 2012       | capture      | 31.1                                       | Yes                                       | 6              |
| 31716 | F   | 1   | 21 July 2012      | recapture    | 47.5                                       | Yes                                       | <sup>c</sup>   |
| mean  |     |     |                   |              | 25.3                                       |                                           | 13.3           |
| 26942 | M   | 3   | 14 May 2011       | capture      | 0.7                                        | No                                        |                |
| 26473 | M   | 6   | 13 May 2010       | capture      | 0.9                                        | No                                        |                |
| 26793 | M   | 2   | 11 June 2010      | capture      | 1.1                                        | No                                        |                |
| 26765 | M   | 2   | 14 May 2010       | capture      | 1.5                                        | No                                        |                |
| 28726 | M   | 4   | 15 May 2010       | capture      | 1.8                                        | No                                        |                |
| 26473 | M   | 6   | 21 July 2010      | recapture    | 1.9                                        | No                                        |                |
| 33215 | M   | 2   | 1 June 2011       | capture      | 2.0                                        | No                                        |                |
| 33215 | M   | 2   | 8 June 2011       | recapture    | 2.1                                        | No                                        |                |
| 26776 | M   | 1   | 6 May 2010        | capture      | 2.4                                        | No                                        |                |
| 21799 | M   | 4   | 3 June 2010       | capture      | 2.6                                        | No                                        |                |
| 29380 | M   | 3   | 21 July 2010      | capture      | 2.7                                        | No                                        |                |
| 27466 | M   | 2   | 24 July 2010      | capture      | 2.8                                        | No                                        |                |
| 31530 | M   | 2   | 15 March 2012     | recapture    | 3.3                                        | No                                        |                |
| 28735 | M   | 1   | 18 June 2010      | capture      | 3.3                                        | No                                        |                |
| 33366 | M   | 1   | 1 July 2011       | capture      | 3.7                                        | No                                        |                |
| 33153 | M   | 2   | 3 June 2011       | recapture    | 3.7                                        | No                                        |                |
| 28836 | M   | 2   | 9 May 2011        | capture      | 4.0                                        | No                                        |                |
| 33153 | M   | 2   | 3 May 2011        | capture      | 4.1                                        | No                                        |                |
| 26471 | M   | 2   | 5 June 2010       | recapture    | 4.2                                        | No                                        |                |
| 28733 | M   | 1   | 10 June 2010      | capture      | 4.2                                        | No                                        |                |
| 33148 | M   | 2   | 12 October 2010   | capture      | 4.4                                        | No                                        |                |
| 32726 | M   | 4   | 29 March 2011     | capture      | 4.6                                        | No                                        |                |
| 16259 | M   | 2   | 12 June 2012      | capture      | 4.8                                        | No                                        |                |
| 33201 | M   | 3   | 10 April 2011     | capture      | 5.1                                        | No                                        |                |
| 26784 | M   | 1   | 22 May 2010       | capture      | 5.1                                        | No                                        |                |
| 28737 | M   | 1   | 22 July 2010      | capture      | 5.1                                        | No                                        |                |
| 28739 | M   | 1   | 24 July 2010      | capture      | 5.1                                        | No                                        |                |
| 28015 | M   | 4   | 7 June 2010       | capture      | 5.3                                        | No                                        |                |
| 33201 | M   | 4   | 4 October 2012    | recapture    | 5.5                                        | No                                        |                |
| 32781 | M   | 2   | 7 May 2011        | recapture    | 5.5                                        | No                                        |                |
| 33366 | M   | 2   | 13 April 2012     | recapture    | 7.0                                        | No                                        |                |
| 32781 | M   | 1   | 20 September 2010 | capture      | 7.1                                        | No                                        |                |

Table 6. Continued.

| Bear        | Sex | Age | Capture Date    | Capture Type | Distance Relocated <sup>a</sup><br>(miles) | Released Out-<br>side Home<br>Range <sup>b</sup> | Days to<br>Return |
|-------------|-----|-----|-----------------|--------------|--------------------------------------------|--------------------------------------------------|-------------------|
| 33213       | M   | 2   | 23 May 2011     | capture      | 7.7                                        | No                                               |                   |
| 33215       | M   | 3   | 10 May 2012     | recapture    | 7.9                                        | No                                               |                   |
| 35713       | M   | 3   | 7 June 2012     | capture      | 7.9                                        | No                                               |                   |
| 33366       | M   | 2   | 7 May 2012      | recapture    | 7.9                                        | No                                               |                   |
| 33127       | M   | 1   | 9 July 2010     | capture      | 8.0                                        | No                                               |                   |
| 33211       | M   | 2   | 21 May 2011     | capture      | 8.4                                        | No                                               |                   |
| 28303       | M   | 1   | 16 August 2011  | capture      | 8.4                                        | No                                               |                   |
| 28111       | M   | 2   | 18 May 2011     | capture      | 8.7                                        | No                                               |                   |
| mean        |     |     |                 |              |                                            |                                                  |                   |
| 28257       | M   | 2   | 24 March 2012   | capture      | 10.1                                       | Yes                                              | 4                 |
| 28119       | M   | 2   | 8 June 2011     | capture      | 12.2                                       | Yes                                              | 13                |
| 33838       | M   | 2   | 13 October 2011 | recapture    | 15.6                                       | Yes                                              | 6                 |
| 27340       | M   | 2   | 17 June 2010    | capture      | 19.8                                       | Yes                                              | 8                 |
| 28737       | M   | 1   | 30 July 2010    | recapture    | 20.8                                       | Yes                                              | never             |
| 28735       | M   | 2   | 11 May 2011     | recapture    | 21.5                                       | Yes                                              | 9                 |
| 33221       | M   | 3   | 30 January 2012 | recapture    | 26.0                                       | Yes                                              | 30                |
| 28259       | M   | 3   | 28 April 2012   | capture      | 27.4                                       | Yes                                              | never             |
| 28111       | M   | 2   | 30 July 2011    | recapture    | 29.0                                       | Yes                                              | 9                 |
| 26784       | M   | 1   | 2 November 2010 | recapture    | 29.5                                       | Yes                                              | <sup>c</sup>      |
| 26791       | M   | 4   | 11 June 2010    | capture      | 32.0                                       | Yes                                              | 5                 |
| 28123       | M   | 4   | 27 August 2011  | capture      | 33.1                                       | Yes                                              | 11                |
| 26784       | M   | 1   | 11 June 2010    | recapture    | 36.0                                       | Yes                                              | never             |
| 33219       | M   | 4   | 24 April 2012   | recapture    | 59.0                                       | Yes                                              | never             |
| mean        |     |     |                 |              | 26.6                                       |                                                  | 10.6              |
| all males   |     |     |                 | mean         | 9.1                                        |                                                  | 13.3              |
| all females |     |     |                 | mean         | 10.3                                       |                                                  | 10.6              |

<sup>a</sup> Euclidian straight-line distance.

<sup>b</sup> Based on mean size of home ranges reported in the literature, see Table 1. Considered outside home range if released > 8.8 miles from capture site for males, and >3.4 miles for females.

<sup>c</sup> Recaptured outside of home range after a previous relocation from which the bear had not yet returned.

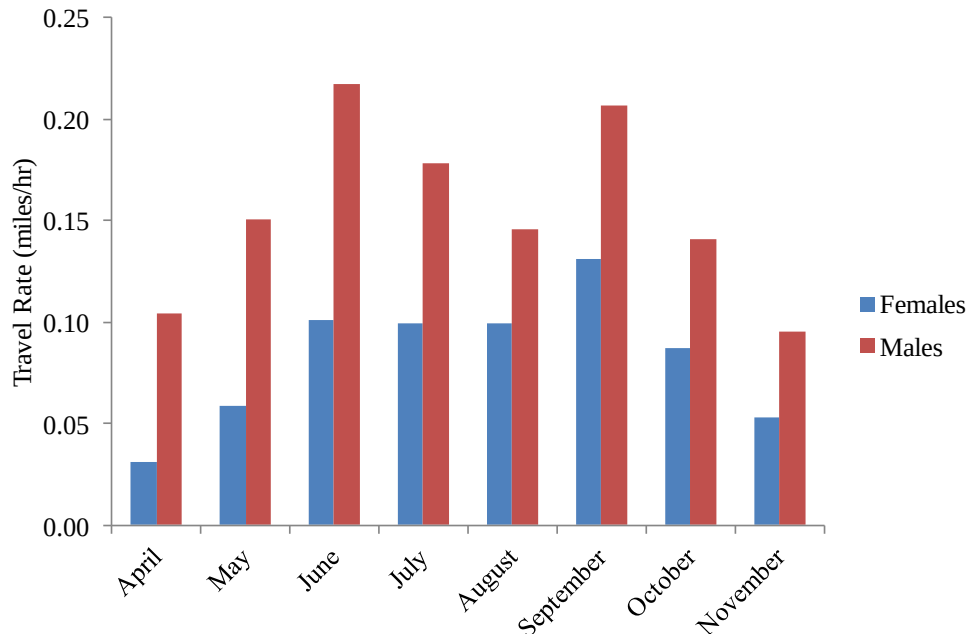


Figure 4. Mean monthly travel rates for male and female black bears captured in 3 urban/suburban study areas. Rates were calculated by dividing the straight-line distance between consecutive locations by the time elapsed. Only rates < 3.0 miles/hr were used because greater rates were considered biologically suspect and the result of GPS or radio-collar error.

## Mortality

Thirty-seven bears (47%) died during the study (Table 7). Mean annual survival rates calculated from telemetry data were 0.623 for adult females, 0.646 for adult males, 0.741 for juvenile females, and 0.420 for juvenile males.

Causes of mortality included harvest ( $n = 23$ ), vehicle collisions ( $n = 9$ ), illegal shooting ( $n = 1$ ), agency euthanasia ( $n = 2$ ) and unknown ( $n = 2$ ). Mean harvest rates were highest for juvenile males (30%) followed by 19% for adult females and 14% for adult males (Table 8). No juvenile females were harvested.

Diefenbach et al. (2004) reported the proportion of tagged bears recovered during the statewide Pennsylvania hunting season to be in the range of 25 to 36% for 1- and 2-year-old males, and 17 to 32% for 1 and 2 year-old females. Among adult bears, the rate ranged between 11 and 22% for males, and 12 to 18% for females. The values we observed were similar except that we recorded no juvenile female harvest during the 3 years of study, and juvenile male harvest was slightly higher. It is unclear why juvenile females were not harvested in our study given that we captured and marked 12 individuals (3 in Johnstown, 6 in State college, and 3 in Scranton).

Mean vehicle mortality rates ranged between 6% and 14% with some occurring in all sex/age classes. Juveniles of both sexes tended to experience slightly higher vehicle mortality than

adults, with adult males having the least (Table 8). Mortality due to other causes was relatively low and ranged between 0 and 6% with juveniles again having slightly higher rates than adults (Table 8).

The assumption that bears living near residential areas experience less hunting pressure appears to be false. The median human density at capture sites was 417.2 people/mi<sup>2</sup> (mean = 850.9, SD = 1356.67,  $n = 106$ ) with a 20<sup>th</sup> percentile of 126.8 people/mi<sup>2</sup>. In the PGC statewide tagging program, median human density at capture sites was 44.7 people/mi<sup>2</sup> (mean = 223.8, SD = 736.31,  $n = 2,101$ ; Fig. 5). Bears captured in townships with high human density, whether in our study areas or the PGC monitoring program, died from harvest at almost the same rate as bears captured in rural townships (Fig. 6). Juveniles had the highest harvest mortality regardless of human density (17 to 30%), with males slightly exceeding females, followed by adult males (9 to 14%) and adult females (10%). However, the expected effect on harvest rates from increasing hunting opportunity in suburban areas is unknown.

Altering timing and length of the bear hunting season has been shown to increase harvest rates when measured across broad management zones in Pennsylvania (Ternent 2008), but the influence of such changes on harvest rates in local suburban/urban areas may depend largely on private landowners allowing additional bear hunting activity on the limited properties where hunting is feasible. A survey of landowners' opinions about bear hunting and the level of hunting currently allowed was initiated in July 2013 using location data from our study to identify survey recipients.

Bears captured in developed areas, both in our study and the PGC statewide monitoring program, experienced notably higher vehicle mortality than bears captured elsewhere (Fig. 6). Bears captured by the PGC in urban/suburban townships generally experienced about twice the vehicle mortality of bears captured in rural townships. In our study the difference was even more dramatic with our bears having about 4 times the vehicle mortality of bears captured in rural townships and about 1.5 times the mortality of bears captured in other urban/suburban townships by the PGC (Fig. 6). The later difference was likely due to a paucity of bears from high-density townships in the PGC data (Fig. 5). Regardless, the difference shows that vehicle mortality can be substantial for bears using urban/suburban areas. Mortality may be additive for some black bear populations (Obbard and Howe 2008), and if true in suburban areas, less harvest mortality may be needed than typically expected because of greater vehicle mortality.

Mortality, as calculated from tag-return data, was higher in our study than in the PGC statewide data regardless of cause, with the greatest disparity occurring in the vehicle and miscellaneous categories (Fig. 6). Several possible explanations exist. First, our study tended to capture more bears in townships with higher human densities. These townships likely had inherently more hazards, particularly from traffic, than townships with lower densities that also were classified as urban/suburban areas in the PGC data. Secondly, although mortality rates were calculated from tag-recovery data, radio-telemetry in our study assisted with documenting at least 3 miscellaneous-caused deaths. In 2 cases, stationary radio-collars led us to dead bears that might not have been discovered by citizens, and in a third case, radio-telemetry was used to locate a bear for euthanasia that might not have been otherwise captured.

Table 7. Mortality documented for 78 black bears tagged in 3 urban/suburban study areas.

| Study Area <sup>a</sup> | Bear ID | Sex | Age <sup>b</sup> | Cause                   | Date             | Days Monitored |
|-------------------------|---------|-----|------------------|-------------------------|------------------|----------------|
| NE                      | 26776   | M   | 1                | Killed by vehicle       | 3 June 2010      | 29             |
| NE                      | 26537   | F   | 4                | Killed by vehicle       | 20 June 2010     | 40             |
| SW                      | 33127   | M   | 1                | Killed by vehicle       | 5 August 2010    | 28             |
| NC                      | 33121   | F   | 1                | Unknown cause           | 25 October 2010  | 110            |
| NC                      | 33125   | F   | 1                | Killed by vehicle       | 26 October 2010  | 110            |
| NC                      | 22310   | F   | 7                | Killed by vehicle       | 28 October 2010  | 106            |
| NE                      | 28733   | M   | 1                | Harvested               | 15 November 2010 | 159            |
| NC                      | 29380   | M   | 3                | Harvested               | 16 November 2010 | 119            |
| NE                      | 26784   | M   | 1                | Harvested               | 20 November 2010 | 183            |
| NE                      | 26471   | M   | 2                | Harvested               | 20 November 2010 | 197            |
| NC                      | 33115   | M   | 2                | Harvested               | 22 November 2010 | 153            |
| NC                      | 12392   | M   | 10               | Killed by vehicle       | 22 November 2010 | 89             |
| NE                      | 28737   | M   | 1                | Harvested               | 23 November 2010 | 125            |
| NE                      | 28739   | M   | 1                | Harvested               | 23 November 2010 | 123            |
| NE                      | 21595   | F   | 8                | Harvested               | 23 November 2010 | 174            |
| NE                      | 33361   | F   | adult            | Killed by vehicle       | 17 May 2011      | 1              |
| NC                      | 23516   | M   | 2                | Killed by vehicle       | 9 June 2011      | 26             |
| NE                      | 28735   | M   | 2                | Killed illegally        | 9 June 2011      | 356            |
| SW                      | 33838   | M   | 2                | Unknown cause           | 12 November 2011 | 444            |
| NE                      | 28836   | M   | 2                | Harvested               | 14 November 2011 | 189            |
| NE                      | 33359   | F   | 8                | Harvested               | 19 November 2011 | 189            |
| SW                      | 27466   | M   | 3                | Harvested               | 19 November 2011 | 483            |
| SW                      | 32726   | M   | 4                | Harvested               | 19 November 2011 | 235            |
| SW                      | 32781   | M   | 2                | Harvested               | 19 November 2011 | 425            |
| SW                      | 33153   | M   | 2                | Harvested               | 19 November 2011 | 200            |
| SW                      | 33836   | F   | 6                | Harvested               | 19 November 2011 | 491            |
| NC                      | 33119   | M   | 6                | Harvested               | 21 November 2011 | 510            |
| NC                      | 33213   | M   | 2                | Harvested               | 21 November 2011 | 182            |
| NE                      | 28726   | M   | 5                | Harvested               | 21 November 2011 | 555            |
| SW                      | 27961   | F   | 3                | Harvested               | 21 November 2011 | 544            |
| NC                      | 33131   | M   | 3                | Euthanized <sup>c</sup> | 1 February 2012  | 564            |
| NE                      | 26797   | F   | 3                | Euthanized <sup>c</sup> | 2 July 2012      | 283            |
| SW                      | 33366   | M   | 2                | Killed by vehicle       | 18 August 2012   | 96             |
| NC                      | 33151   | F   | adult            | Harvested               | 19 November 2012 | 388            |
| NE                      | 28257   | M   | 2                | Harvested               | 19 November 2012 | 49             |
| SW                      | 31530   | M   | 2                | Harvested               | 20 November 2012 | 324            |
| NC                      | 35713   | M   | 3                | Harvested               | 21 November 2012 | 61             |

<sup>a</sup> SW = Johnstown (southwest region); NC = State College (northcentral region); and NE = Scranton (northeast region).

<sup>b</sup> At time of mortality.

<sup>c</sup> Due to repeated nuisance activity.

Table 8. Cause-specific mortality rates for ear-tagged black bears calculated as the mean proportion of marks recovered annually during inspection at hunter check stations or from mortalities reported to the Pennsylvania Game Commission.

| Sex/Age Class    | (n) | Mean Proportion Recovered Annually From |                    |              |
|------------------|-----|-----------------------------------------|--------------------|--------------|
|                  |     | Hunter Harvest                          | Vehicle Collisions | Other Causes |
| Adult Females    | 26  | 0.192                                   | 0.104              | 0.000        |
| Adult Males      | 36  | 0.139                                   | 0.056              | 0.028        |
| Juvenile Females | 13  | 0.000                                   | 0.139              | 0.056        |
| Juvenile Males   | 36  | 0.304                                   | 0.108              | 0.044        |

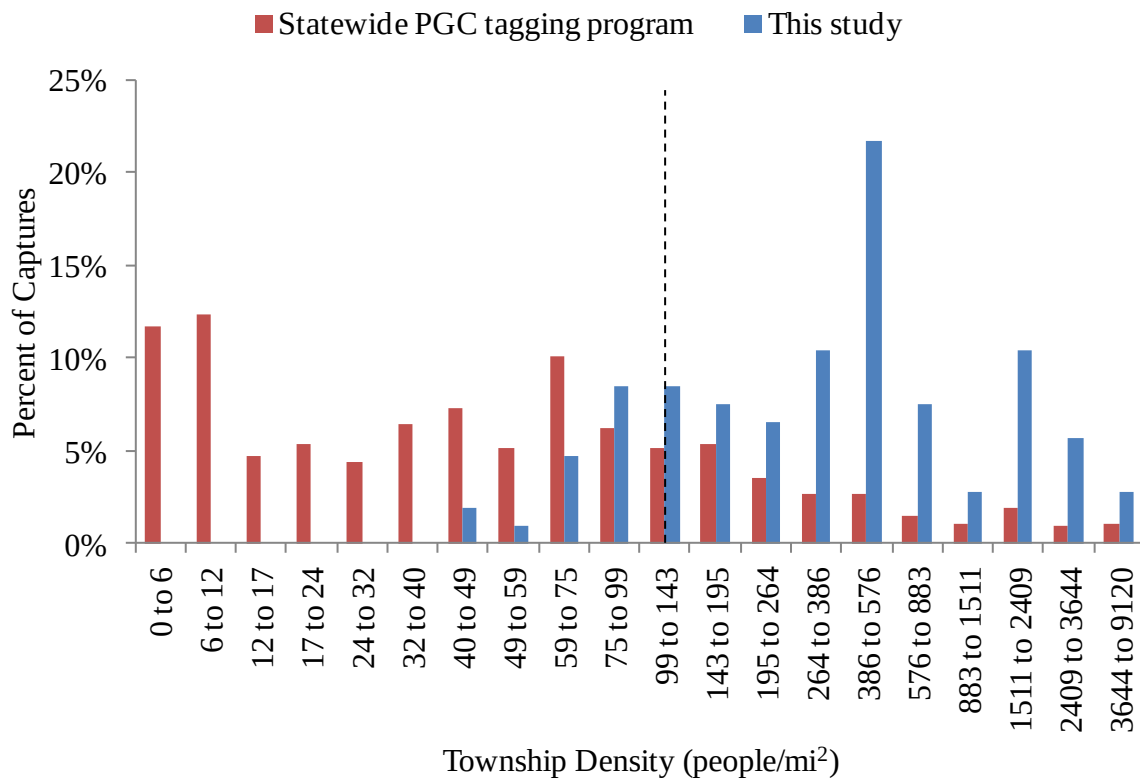


Figure 5. Percentage of black bear captures in this study and the 2010–2012 statewide Pennsylvania Game Commission (PGC) bear-marking effort that occurred in townships of varying human density. Density categories along the x-axis were determined using the Jenks natural breaks classification method (Jenks 1967). The 20<sup>th</sup> percentile for captures in this study is indicated by a vertical dashed line.

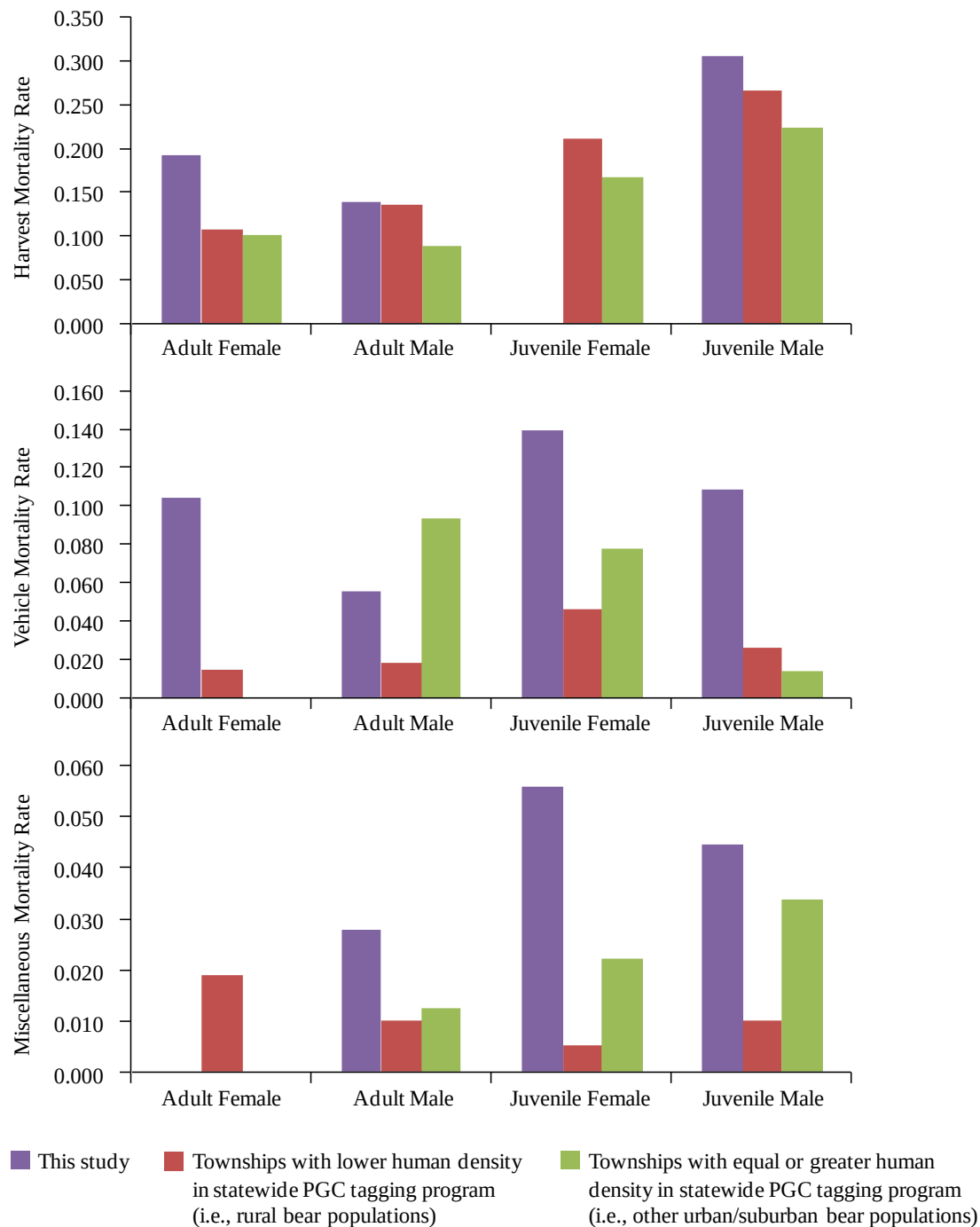


Figure 6. Cause-specific mortality rates for black bears marked in this study and the statewide Pennsylvania Game Commission (PGC) tagging program calculated as the mean proportion of marks recovered annually during inspection at hunter check stations or from reported mortalities. PGC captures were divided into two categories based on human density in the township. See Figure 5 for the density percentile used to separate townships.

## Home Range Size and Composition

Three bears had unusually large home ranges because of long, linear movements (Fig. 7). Bear 31716 was a 1-year-old female that weighed 115 pounds when captured on 2 June 2012 in the Johnstown study area. She traveled more than 700 miles based on the distance between consecutive locations before denning on 4 December, approximately 84 miles away. Bear 26784 was a 1-year-old male that weighed 127 pounds when captured on 22 May 2010 at the Scranton International Airport. He traveled more than 750 miles, first west-northwest into Potter County, and then southeast to Union County before turning southwest. He was harvested on 20 November in Huntingdon County approximately 114 miles from his original capture site. Bear 16259 was a 2-year-old male that weighed 173 pounds when captured on 12 June 2012 in State College. He remained there until 18 November, and then traveled south, arriving near Hancock, Maryland in mid December. He was returning toward State College when his radio-collar stopped transmitting on 29 January in Huntingdon County. Between 18 November and 29 January, he traveled more than 400 miles.

Movements of this scale would likely have gone undetected without the aid of GPS radio-telemetry. Given that both sexes were involved and included 4% of the bears we radio-collared, with 1 in each study area, such movements may occur more than previously suspected. All 3 bears were excluded from home range, core use, and seasonal period calculations because they dramatically skewed mean values.

### *Annual home range and core use areas*

Annual home ranges were calculated for 21 bears in 2010, 26 bears in 2011, and 12 bears in 2012 that had at least 60 days of location data. The mean number of locations used for estimating an annual home range was 806.7 (SD = 357.333,  $n = 59$ , range = 174–1,796).

Male home ranges were significantly larger than female home ranges. Both adult and juvenile males had annual home ranges that were approximately 6 times larger than adult and juvenile female home ranges, respectively (Table 9). Mean home range size was 7.1 mi<sup>2</sup> for adult females, 44.9 mi<sup>2</sup> for adult males, 9.9 mi<sup>2</sup> for juvenile females, and 53.9 mi<sup>2</sup> for juvenile males.

There are few comparative studies of black bear home range size in Pennsylvania. Most reported values coming from Alt (1980c), who monitored 20 radio-collared black bears in northeastern Pennsylvania during 1973–1976. Alt's groundbreaking work collected 2,450 locations over a 40-month period, averaging 122.5 locations per animal. From these data, he reported a mean home range size (minimum convex polygon) of 10.8 mi<sup>2</sup> for adult females, 59.2 mi<sup>2</sup> for adult males, and 75.7 mi<sup>2</sup> for juvenile males. An earlier report by Alt et al. (1976) reported a home range of 7.7 mi<sup>2</sup> for a single juvenile female.

Despite monitoring almost 4 times the number of bears and collecting 40 times the number of locations, our results are very similar. Our data support the hypothesis that bears captured in suburban areas of Pennsylvania have home ranges similar to other bears, including those studied 35 years ago when abundance was significantly lower.

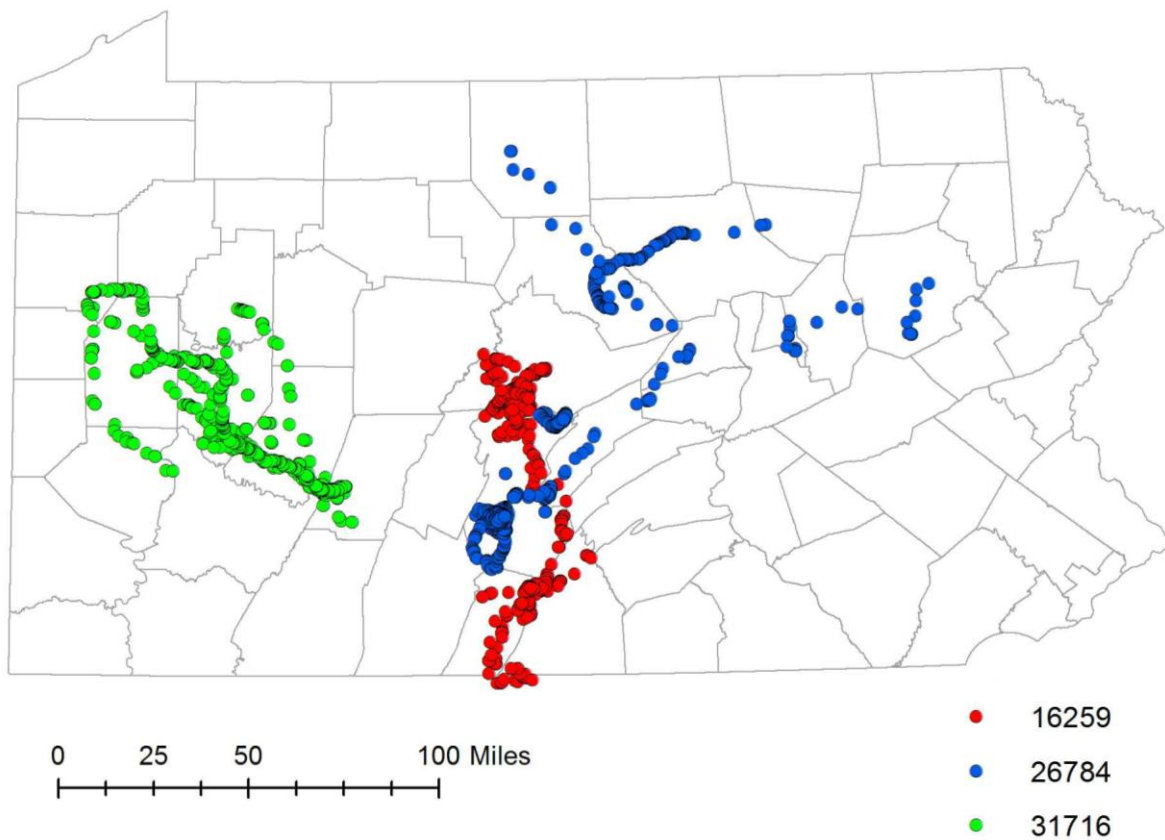


Figure 7. Locations collected for 3 radio-collared bears that made exceptionally long movements. Bear 16259 was captured 12 June 2012 in State College and began moving south toward Maryland on 18 November; he was returning toward State College when his radio-collar stopped transmitting on 29 January 2013. Bear 26784 was captured 22 May 2010 at the Scranton International Airport and traveled to Potter County before turning southwest; he was harvested on 20 November 2010 in Huntingdon County. Bear 31716 was captured on 2 June 2012 near Ebensburg and traveled northwest on 3 different occasions before denning on 4 December near Grove City. All 3 bears were excluded from home range area calculations because they dramatically skewed mean estimates.

Table 9. Annual home range, core area, and conflict- or hunting-period area statistics for black bears radio-collared in 3 suburban/urban study areas.

| Statistic                                                                                 | Johnstown | State College | Scranton | Pooled |
|-------------------------------------------------------------------------------------------|-----------|---------------|----------|--------|
| Number of bears radio-collared                                                            | 19        | 23            | 34       | 76     |
| Size of capture area (mi <sup>2</sup> )                                                   | 185.7     | 88.3          | 262.1    | 536.1  |
| Number of radio-collared bears with sufficient data for home range estimation             | 10        | 15            | 21       | 46     |
| Size of capture area (mi <sup>2</sup> )                                                   | 81.6      | 52.5          | 262.1    | 396.2  |
| Area encompassing all home ranges (mi <sup>2</sup> )                                      | 435.7     | 244.1         | 570.4    | 1250.2 |
| Area encompassing all core areas (mi <sup>2</sup> )                                       | 51.1      | 47            | 87.4     | 185.5  |
| Mean home range size, adult females (mi <sup>2</sup> )                                    | 7.5       | 13.3          | 6.1      | 7.1    |
| Mean home range size, adult males (mi <sup>2</sup> )                                      | 41.2      | 27.6          | 73.6     | 44.9   |
| Mean home range size, juvenile females (mi <sup>2</sup> )                                 | ----      | 7.9           | 13.8     | 9.9    |
| Mean home range size, juvenile males (mi <sup>2</sup> )                                   | 70.4      | 49.7          | 45.4     | 53.9   |
| Mean core area size, adult females (mi <sup>2</sup> )                                     | 0.5       | 1.4           | 0.6      | 0.7    |
| Mean core area size, adult males (mi <sup>2</sup> )                                       | 2.5       | 2.4           | 10.4     | 4.9    |
| Mean core area size, juvenile females (mi <sup>2</sup> )                                  |           | 1.0           | 1.7      | 1.3    |
| Mean core area size, juvenile males (mi <sup>2</sup> )                                    | 7.8       | 9.0           | 5.9      | 7.3    |
| Number of radio-collared bears with locations in annual conflict period (CP) <sup>a</sup> | 8         | 9             | 25       | 42     |
| Size of capture area (mi <sup>2</sup> )                                                   | 76.5      | 50.2          | 242.2    | 368.9  |
| Mean % of home range used during CP <sup>b</sup>                                          | 21%       | 38%           | 50%      | 42%    |
| Mean distance (mi) from capture location <sup>c</sup>                                     | 6.7       | 2.5           | 3.4      | 3.6    |
| Number of radio-collared bears with locations in annual hunting period (HP) <sup>d</sup>  | 5         | 10            | 16       | 31     |
| Size of capture area (mi <sup>2</sup> )                                                   | 27.3      | 29.8          | 182.1    | 239.2  |
| Mean % of home range used during HP <sup>b</sup>                                          | 38%       | 21%           | 32%      | 30%    |
| Mean distance from capture location <sup>c</sup>                                          | 4.6       | 3.7           | 4.6      | 4.3    |
| Number of radio-collared bears with locations in both the CP and HP within the same year  | 2         | 6             | 13       | 21     |
| Size of capture area (mi <sup>2</sup> )                                                   | ----      | 27.5          | 116.8    | 144.3  |
| Mean % of CP area also used during HP <sup>e</sup>                                        | 29%       | 13%           | 37%      | 29%    |
| Mean % of HP area also used during CP <sup>e</sup>                                        | 28%       | 40%           | 46%      | 42%    |
| Mean distance between CP and HP location centers                                          | 1.2       | 3.1           | 1.6      | 2.0    |

<sup>a</sup> 24 June–3 July 2010, 20 June–29 June 2011, and 23 June–2 July 2012. See Figure 2.

<sup>b</sup> Determined using a 0.5 mile buffer inscribed around locations in the period, overlaying them on the home range, and calculating the area of intersect.

<sup>c</sup> Determined as the mean of all straight-line capture-to-location distances within the period.

<sup>d</sup> Statewide archery and general bear hunting seasons; 15–24 November 2010, 14–23 November 2011, and 12–21 November 2012.

<sup>e</sup> Determined using a 0.5 mile buffer inscribed around locations collected in both periods and calculating the area of intersect.

Core use areas varied in size between sex/age groups similar to how home range size varied. Core areas encompassed 10 to 13% of the home range area, with adults using a slightly smaller proportion of the home range than juveniles (10–11% vs. 13%; Table 9). Mean core use area was 0.7 mi<sup>2</sup> for adult females, 4.9 mi<sup>2</sup> for adult males, 1.3 mi<sup>2</sup> for juvenile females, and 7.3 mi<sup>2</sup> for juvenile males.

Core use areas were generally located near the center of home ranges, but capture areas did not always corresponding with core use areas (Fig. 8, 9, 10), meaning that some captures occurred near the periphery of home ranges. This was most noticeable in the Johnstown and Scranton study areas.

Annual home ranges extended into developed areas. On average, 11% of a home range was developed, and ranged from 6% in Johnstown to 14% in Scranton (Table 10). Percentages for core areas were almost identical, indicating that bears remained close to developed areas much of the time, but only periodically used their periphery.

Annual home ranges also extended into public lands. Sixty-eight percent of bears had public land in their home range (55% in Scranton, 76% in State college, and 85% in Johnstown), with a mean area of 5.5 mi<sup>2</sup> (Table 11). More bears had State Game Lands, which are managed by the PGC for public hunting, in their home range than State Forest lands (34 vs. 21 bears), highlighting the potential importance of State Game Lands for determining harvest vulnerability of bears near the suburban interface. The mean percent of home range area classified as public was 11% and ranged from 6% in Scranton to 16% in Johnstown (Table 10).

Table 10. Percentage of black bear home range, core area, and areas used during conflict or hunting periods that was classified as developed or public land. See Table 2 for habitat classifications used to define developed lands (urban or suburban). Public land included State Forest and State Game Lands, but not State Parks.

| Study Area    | Percentage of Area That Was Developed |           |                                  |                                 |
|---------------|---------------------------------------|-----------|----------------------------------|---------------------------------|
|               | Home Range                            | Core Area | Area Used During Conflict Period | Area Used During Hunting Season |
| Johnstown     | 6%                                    | 5%        | 5%                               | 5%                              |
| State College | 10%                                   | 12%       | 7%                               | 13%                             |
| Scranton      | 14%                                   | 11%       | 15%                              | 17%                             |
| Pooled        | 11%                                   | 10%       | 11%                              | 14%                             |

| Study Area    | Percentage of Area That Was Public Land |           |                                  |                                 |
|---------------|-----------------------------------------|-----------|----------------------------------|---------------------------------|
|               | Home Range                              | Core Area | Area Used During Conflict Period | Area Used During Hunting Season |
| Johnstown     | 16%                                     | 9%        | 17%                              | 12%                             |
| State College | 14%                                     | 14%       | 9%                               | 12%                             |
| Scranton      | 6%                                      | 3%        | 5%                               | 10%                             |
| Pooled        | 11%                                     | 7%        | 8%                               | 11%                             |

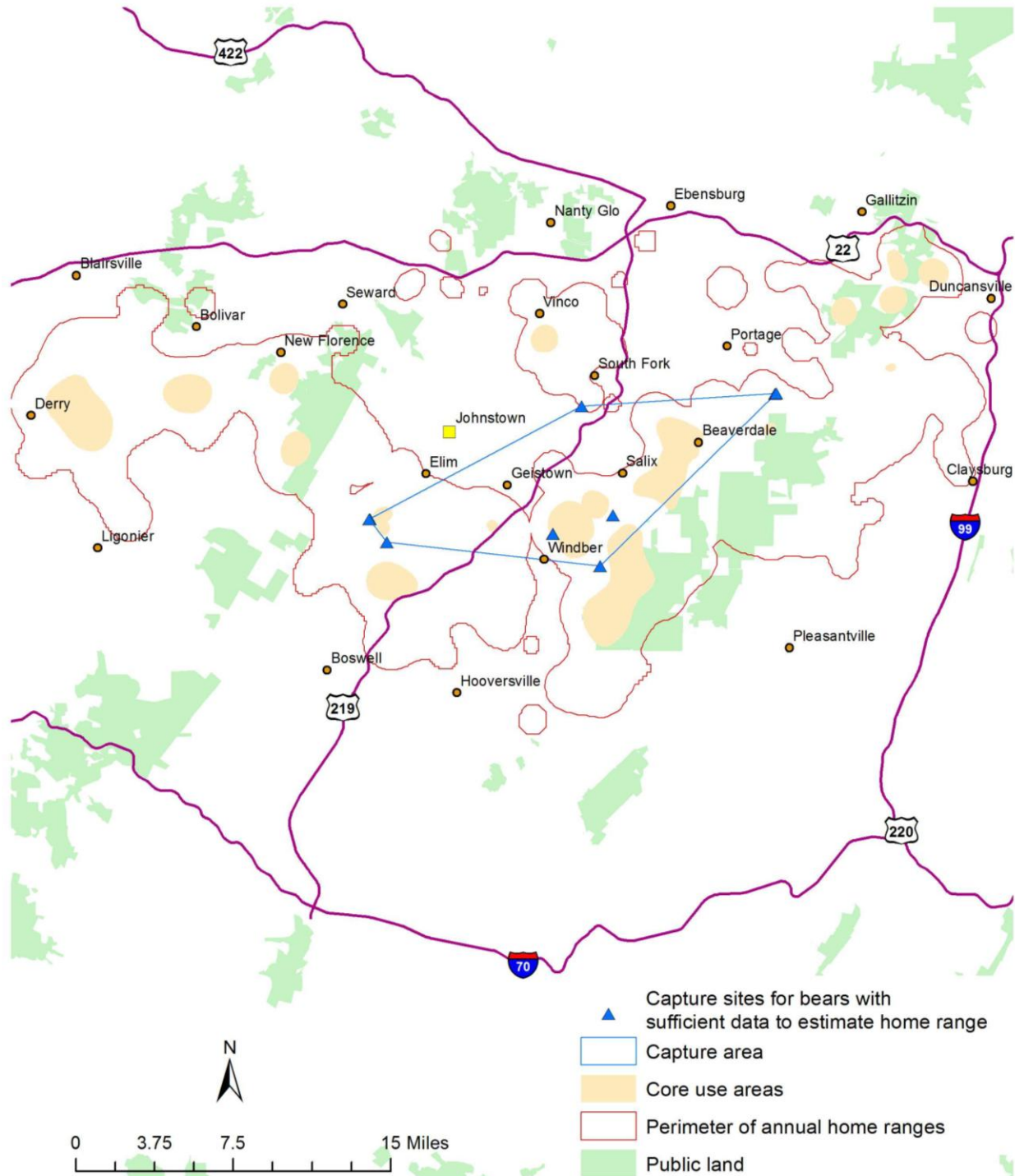


Figure 8. Perimeter of annual home ranges and core areas calculated for 10 radio-collared black bears in the Johnstown study area. Home ranges (95% probability area) and core areas (50% probability) were estimated using a fixed kernel method.

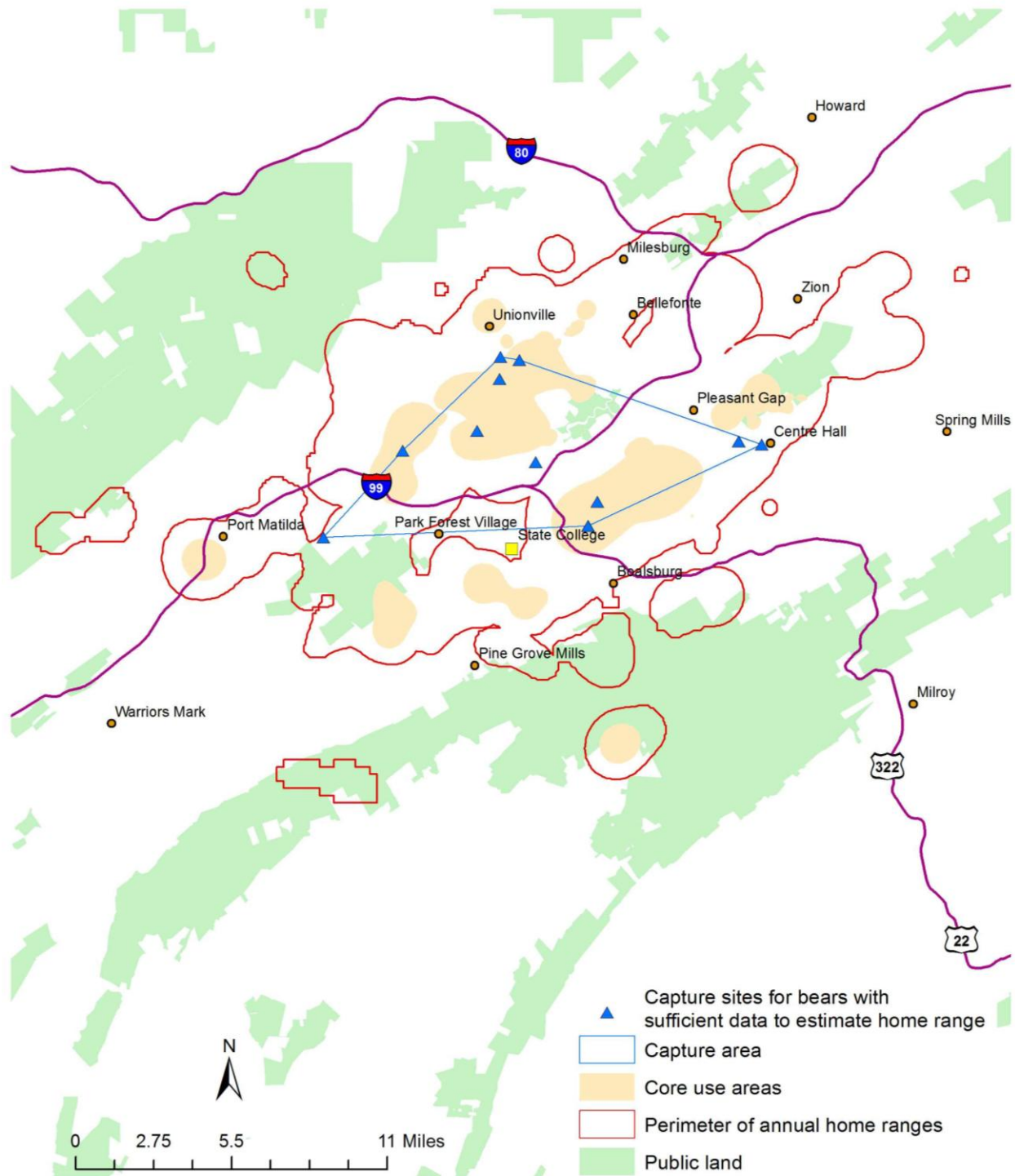


Figure 9. Perimeter of annual home ranges and core areas calculated for 15 radio-collared black bears in the State College study area. Home ranges (95% probability area) and core areas (50% probability) were estimated using a fixed kernel method.

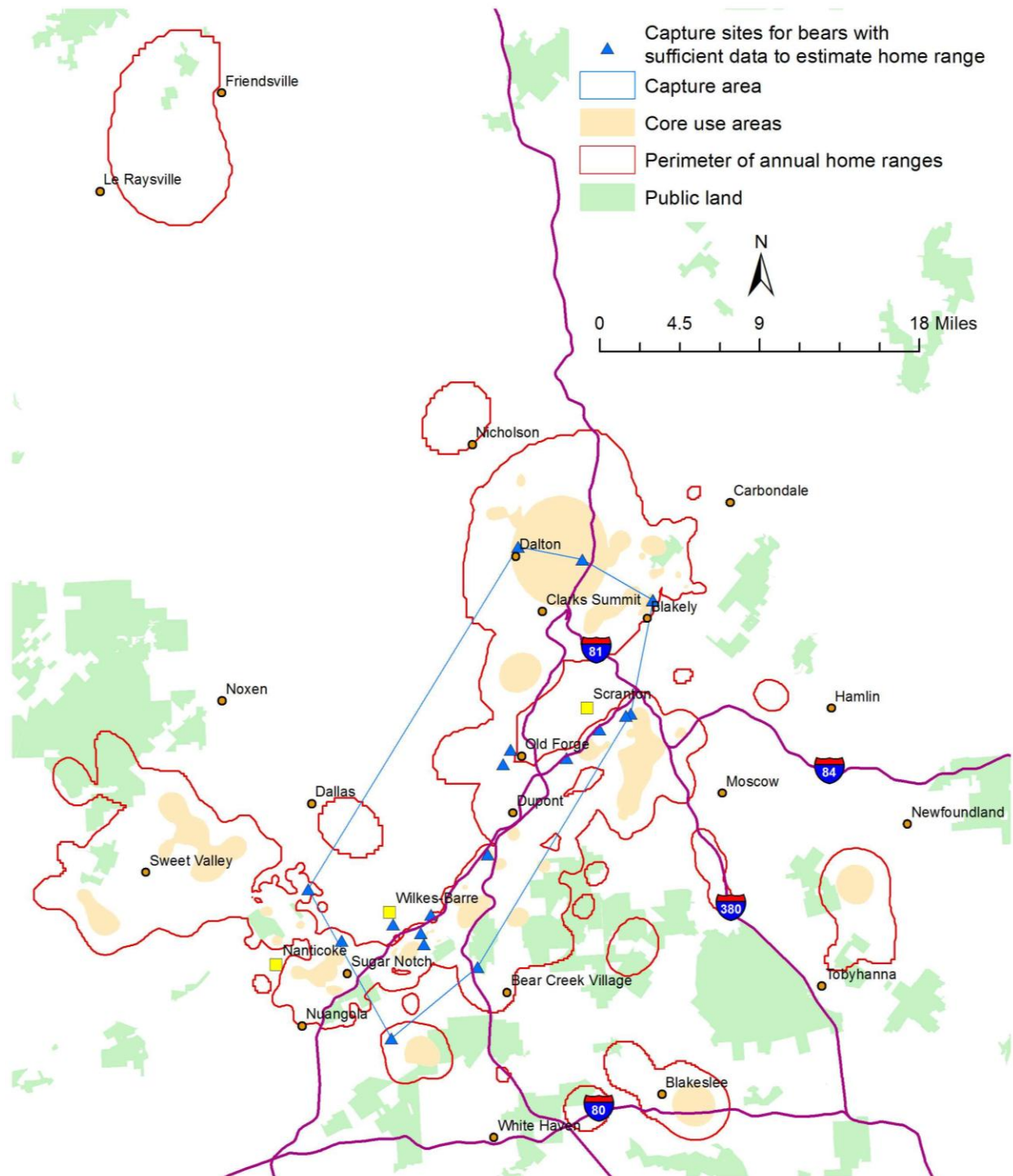


Figure 10. Perimeter of annual home ranges and core areas calculated for 21 radio-collared black bears in the Scranton study area. Home ranges (95% probability area) and core areas (50% probability) were estimated using a fixed kernel method.

Table 11. Public land use by radio-collared black bears captured in 3 urban/suburban study areas.

| Study Area    | Percent of Bears with Public Land in Their Home Range | Mean Size of Public-land Area in Home Range (mi <sup>2</sup> ) | Number of Bears with State Forest Lands in Home Range | Number of Bears with State Game Lands in Home Range |
|---------------|-------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------|
| Johnstown     | 85%                                                   | 9.2                                                            | 7                                                     | 9                                                   |
| State College | 76%                                                   | 4.6                                                            | 10                                                    | 9                                                   |
| Scranton      | 55%                                                   | 3.9                                                            | 4                                                     | 16                                                  |
| Pooled        | 68%                                                   | 5.5                                                            | 21                                                    | 34                                                  |

### *Area used during peak human-bear conflict periods*

In 2010, the PGC recorded 1,149 human-bear conflicts statewide with a median date of 24 June; in 2011, there were 1,818 conflicts with a median date of 18 June, and in 2012, there were 1,789 conflicts with a median date of 14 June (Fig. 2). During the 10-day peak conflict periods centered over median dates, there were 116, 112, and 148 reported conflicts statewide, which represented 10, 6, and 8% of each year's total conflicts, respectively.

Thirty-five bears were located 1,929 times during the 10-day peak conflict periods (11 bears in 2010, 21 in 2011, and 10 in 2012). The mean number of location per bear was 45.9 ( $n = 42$ , range = 7–114).

GPS locations were widely distributed throughout home ranges during the conflict period. On average, bears used 42% of their annual home range during the 10-day interval, ranging from 21% in the Johnstown study area to 38% in the State College study area and 50% in the Scranton study area (Table 10). Locations during this time extended to the periphery of home ranges in at least 2 study areas and were well beyond central capture locations. In Johnstown, locations were recorded as far east as the I-99 corridor near Claysburg and west to Derry and Ligonier (Fig. 11); in State College, locations were recorded as far northeast as Milesburg and southwest to Port Matilda (Fig. 12). In the Scranton study area, locations appeared more clumped within the capture area, but they still occurred throughout the entire length of the Wyoming Valley and west (Fig. 13).

The mean distance between capture location and conflict-period center was 3.5 miles and ranged between 2.5 miles in State College, 3.4 miles in Scranton, and 6.7 miles in Johnstown (Table 10). It is unknown if bears were involved with human-bear conflicts while away from capture locations, but these mean distances suggest that many were not involved with ongoing conflicts or sightings in the central part of our study areas.

On average, 11% of the area used during conflict periods was classified as developed. Mean values were highest in Scranton (12%) and lowest in Johnstown (5%; Table 10). However, despite using non-developed areas, very little was public land. In Scranton, public land accounted for 5% of the area used during the conflict period; in State College, 9%, and in Johnstown, 17% (Table 10). The mean value across all 3 study areas was 8%.

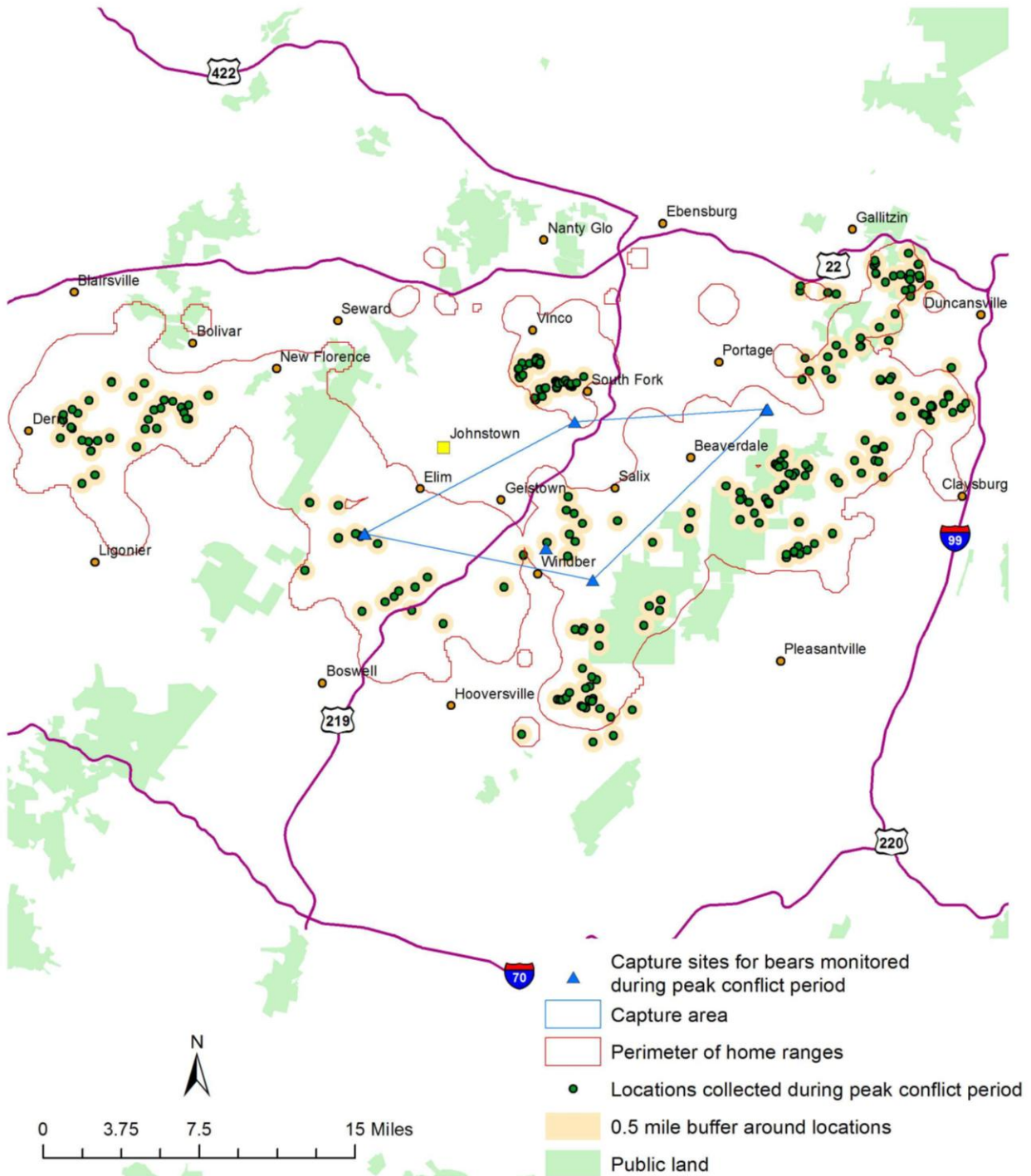


Figure 11. GPS locations for 8 radio-collared black bears during 10-day peak human-bear conflict periods in the Johnstown study area. Conflict periods were defined as 24 June–3 July 2010, 20–29 June 2011, and 23 June–2 July 2012, and were centered on median dates for all reported conflicts in Pennsylvania during those years, respectively (see Figure 2).

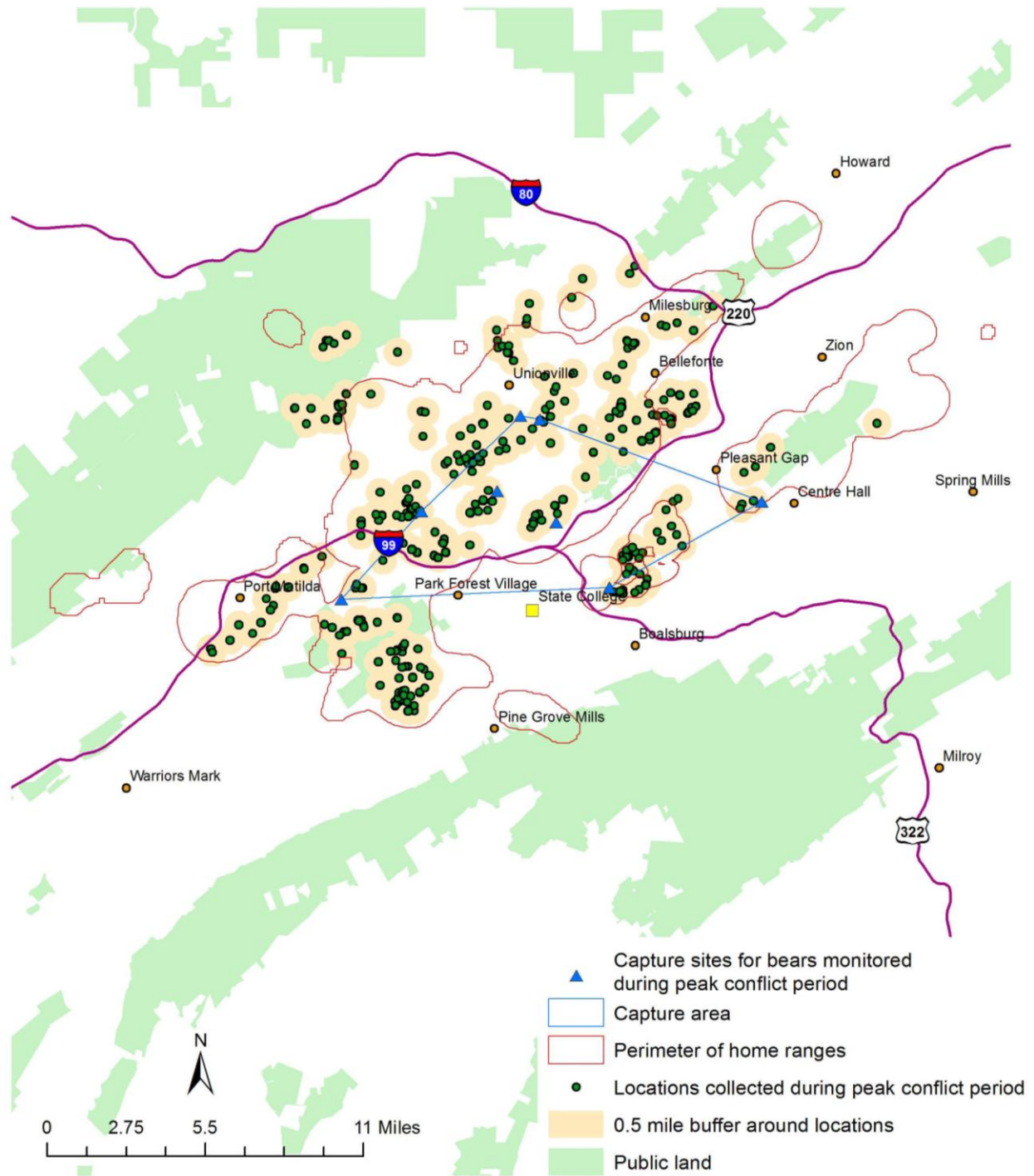


Figure 12. GPS locations for 9 radio-collared black bears during 10-day peak human-bear conflict periods in the State College study area. Conflict periods were defined as 24 June–3 July 2010, 20–29 June 2011, and 23 June–2 July 2012, and were centered on median dates for all reported conflicts in Pennsylvania during those years, respectively (see Figure 2).

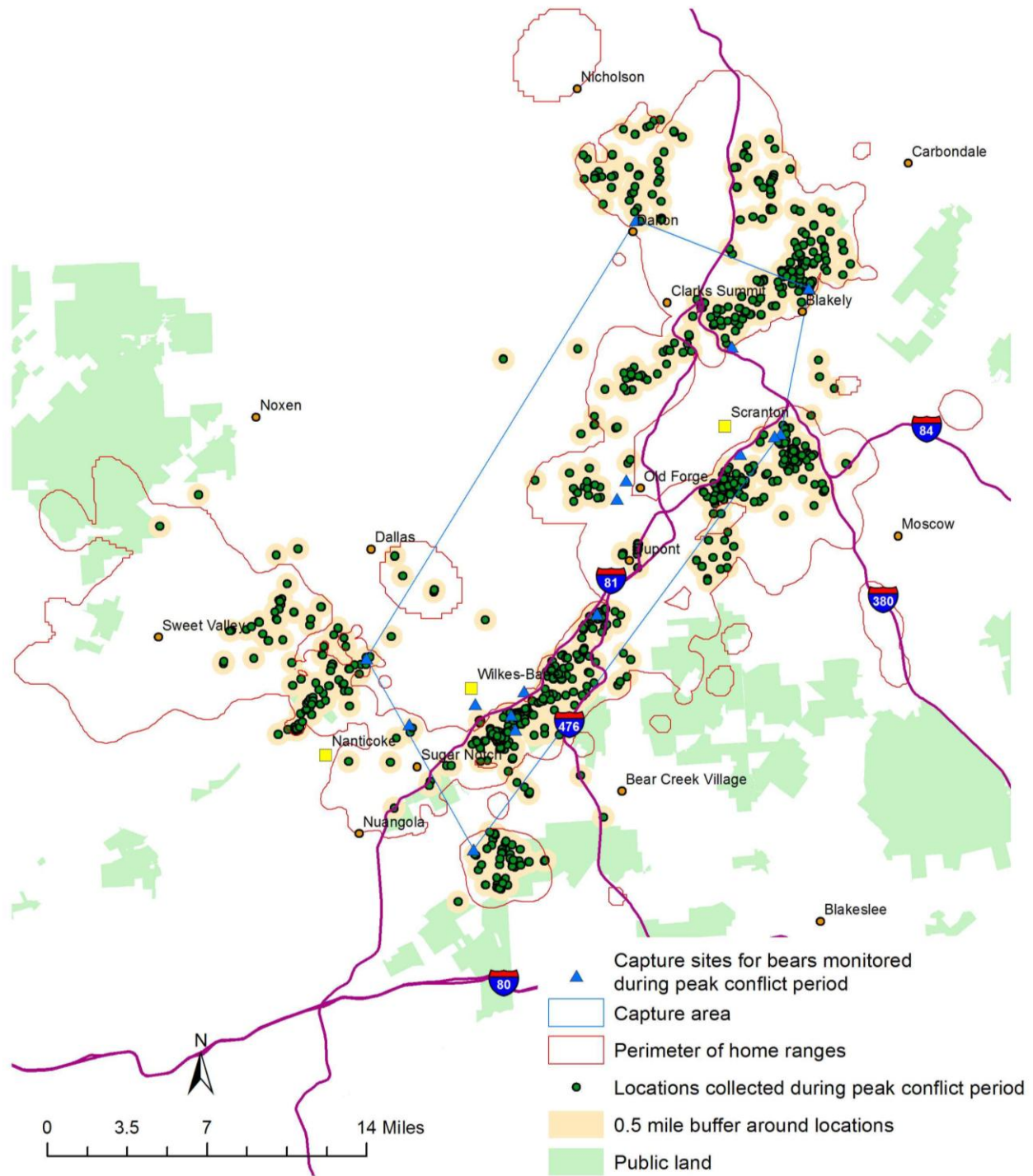


Figure 13. GPS locations for 25 radio-collared black bears during 10-day peak human-bear conflict periods in the Scranton study area. Conflict periods were defined as 24 June–3 July 2010, 20–29 June 2011, and 23 June–2 July 2012, and were centered on median dates for all reported conflicts in Pennsylvania during those years, respectively (see Figure 2).

### *Area used during bear hunting seasons*

Thirty-one bears were located 4,602 times during the 10-day bear hunting periods (12 bears in 2010, 14 in 2011, and 5 in 2012). The mean number of location per bear was 148.5 ( $n = 31$ , range = 2–220).

Bears tended to use a smaller proportion of their annual home range during the hunting period when compared to the conflict period. The mean proportion of home range area containing locations during the hunting period was 30%, and ranged between 21% in State College, 32% in Scranton, and 38% in Johnstown (Table 10).

In Johnstown, radio-collared bears were located almost exclusively outside of the capture area during the hunting period (Fig. 14), but in the State College and Scranton study areas, locations occurred within and outside capture areas (Fig. 15 and 16). The mean distance between capture location and hunting-period center was 4.3 miles, which was greater than the mean distance observed during the conflict period (3.5 miles), suggesting that bears moved farther from suburban areas in the fall than during the spring. By study area, the mean distance from capture sites during the hunting period was 2.5 miles in State College, 3.4 miles in Scranton, and 6.7 miles in Johnstown (Table 10).

However, despite being farther from capture sites, the area used during hunting periods contained a slightly higher percentage of developed land than the area used during conflict periods (mean = 14% vs. 11%; Table 10). The reason for this observation is unclear, especially since the area used during hunting periods also contained more public land than during conflict periods (mean = 11% vs. 8%), except in Johnstown.

Bears in Johnstown used less public land during the hunting period than during the conflict period, but they experienced the highest level of harvest (7 of 19 radio-collared bears; 37%) compared to bears in State College (6 of 23; 26%) and Scranton (10 of 34 bears; 29%). One possibility is that bear hunting pressure on private lands varied by region, and may need to be considered when developing area-specific harvest strategies. This highlights again the need to survey landowners' opinions about bear hunting in our 3 study areas.

### *Area used during both conflict and hunting seasons*

Twenty-one bears with data sufficient to estimate annual home range had locations in a conflict period and hunting period within the same year (7 in 2010, 11 in 2011, and 3 in 2012). In all 3 study areas, bears that were monitored in both periods tended to shift their locations seasonally and use only a proportion of the area where they were during the spring conflict period (Fig. 17, 18, 19). The proportion of area from the conflict period used during the hunting season ranged between 13% in State College to 37% in Scranton, with a mean of 29% (Table 10). The mean distance between conflict-period and hunting-period centers was 2.0 miles, and varied between 1.2 miles in Johnstown, 1.6 miles in Scranton, and 3.1 miles in State College.

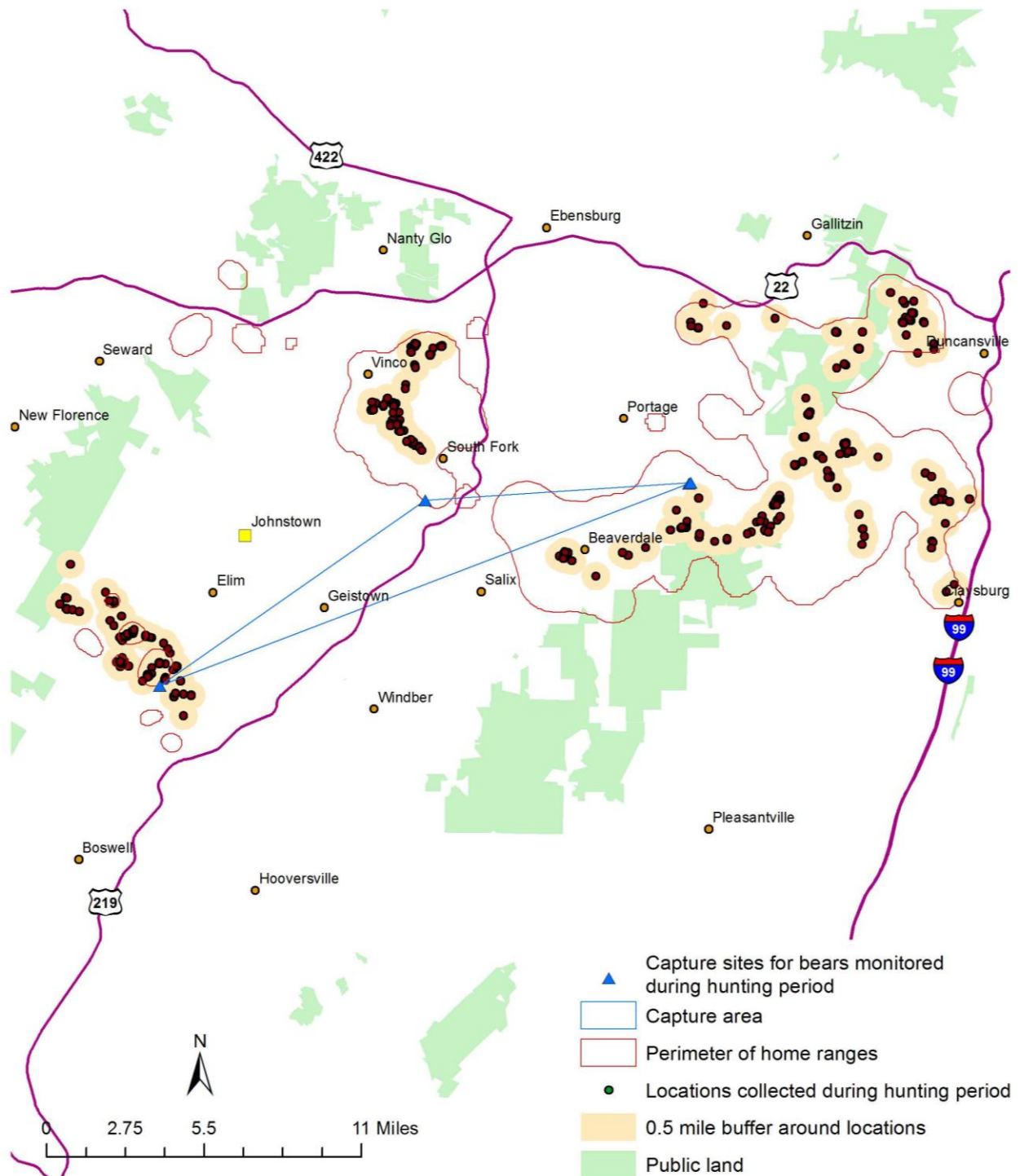


Figure 14. GPS locations for 5 radio-collared black bears during annual 10-day bear hunting periods in the Johnstown study area. Hunting period included the statewide archery and firearms seasons, and was defined as 15–24 November 2010, 14–23 November 2011, and 12–21 November 2012.

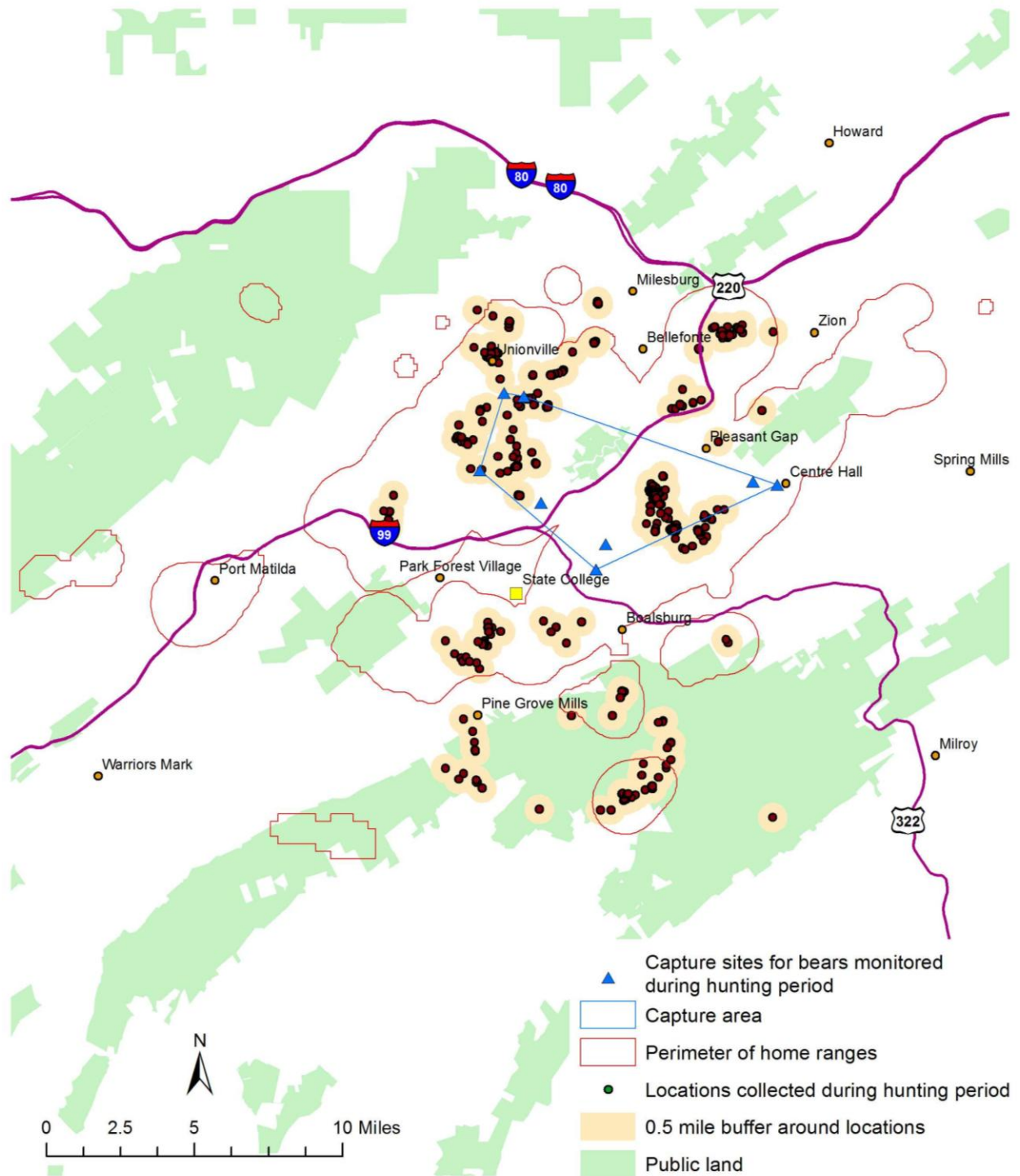


Figure 15. GPS locations for 10 radio-collared black bears during annual 10-day bear hunting periods in the State College study area. Hunting period included the statewide archery and firearms seasons, and was defined as 15–24 November 2010, 14–23 November 2011, and 12–21 November 2012.

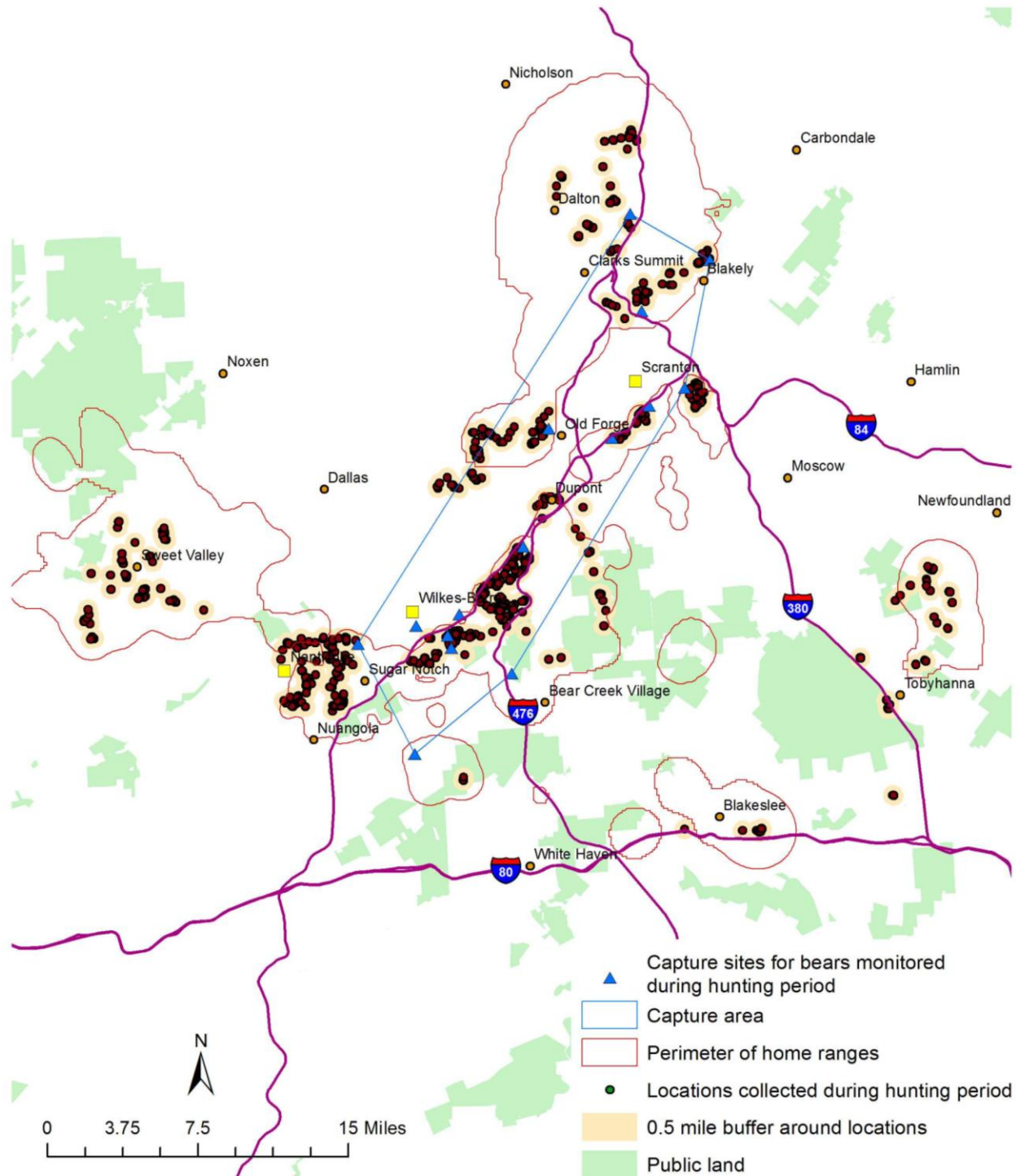


Figure 16. GPS locations for 16 radio-collared black bears during annual 10-day bear hunting periods in the Scranton study area. Hunting period included the statewide archery and firearms seasons, and was defined as 15–24 November 2010, 14–23 November 2011, and 12–21 November 2012.

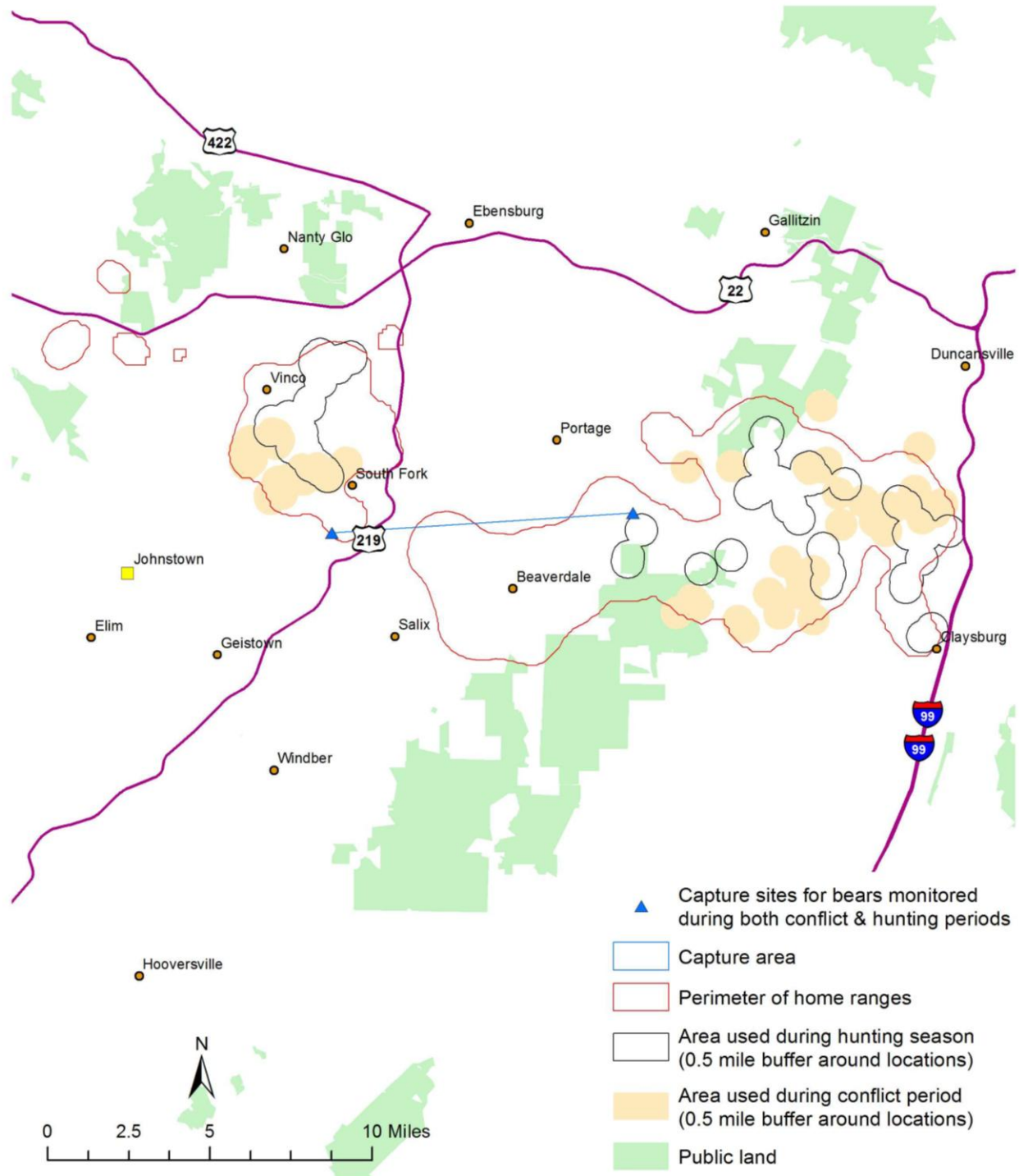


Figure 17. Area used by 2 radio-collared black bears in the Johnstown study area that were monitored during a 10-day spring period when human-bear conflicts were most numerous, and during a 10-day fall hunting period in the same year. Note the degree of overlap while areas of use shifted between the two periods.

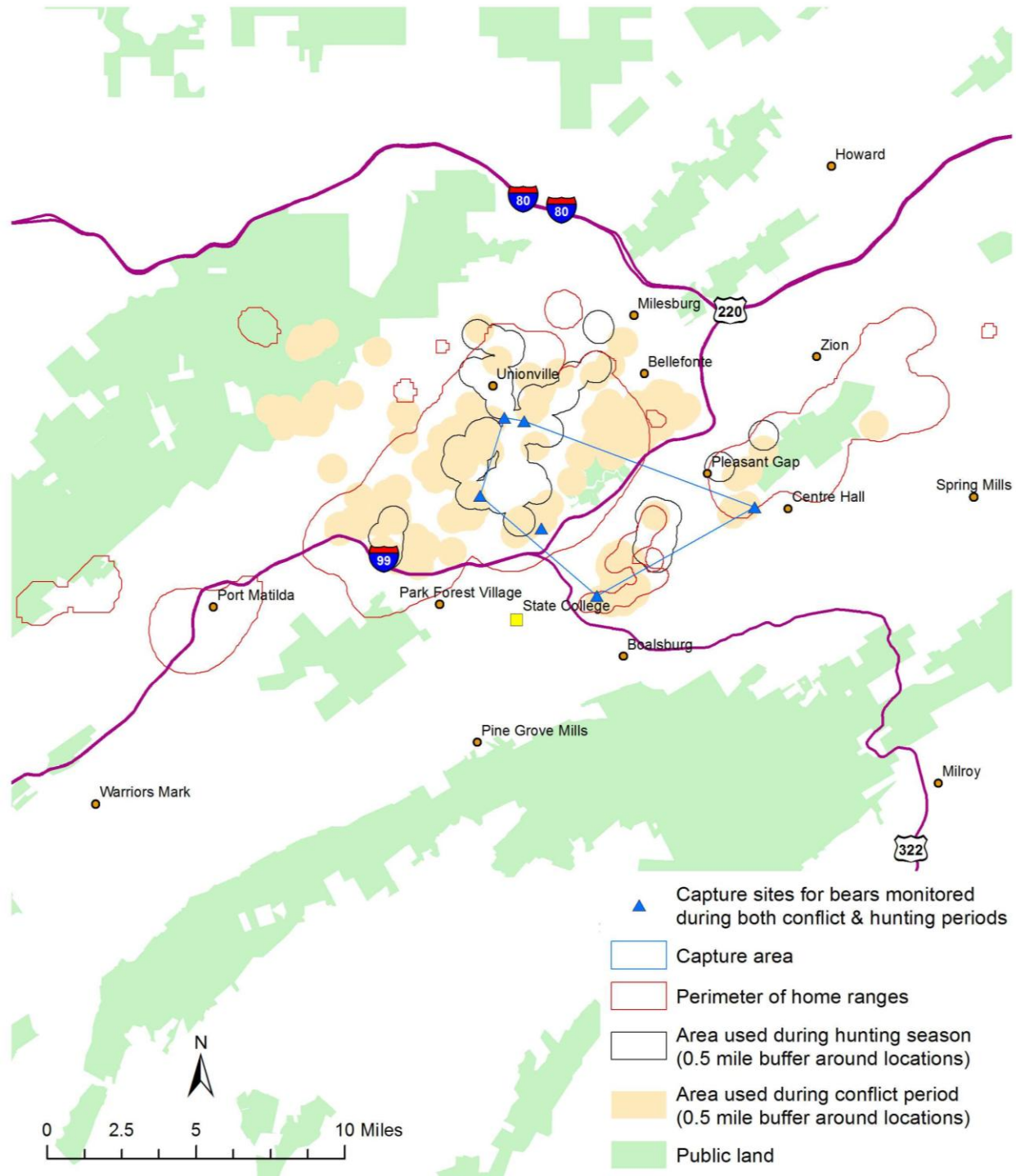


Figure 18. Area used by 6 radio-collared black bears in the State College study area that were monitored during a 10-day spring period when human-bear conflicts were most numerous, and during a 10-day fall hunting period in the same year. Note the degree of overlap while areas of use shifted between the two periods.

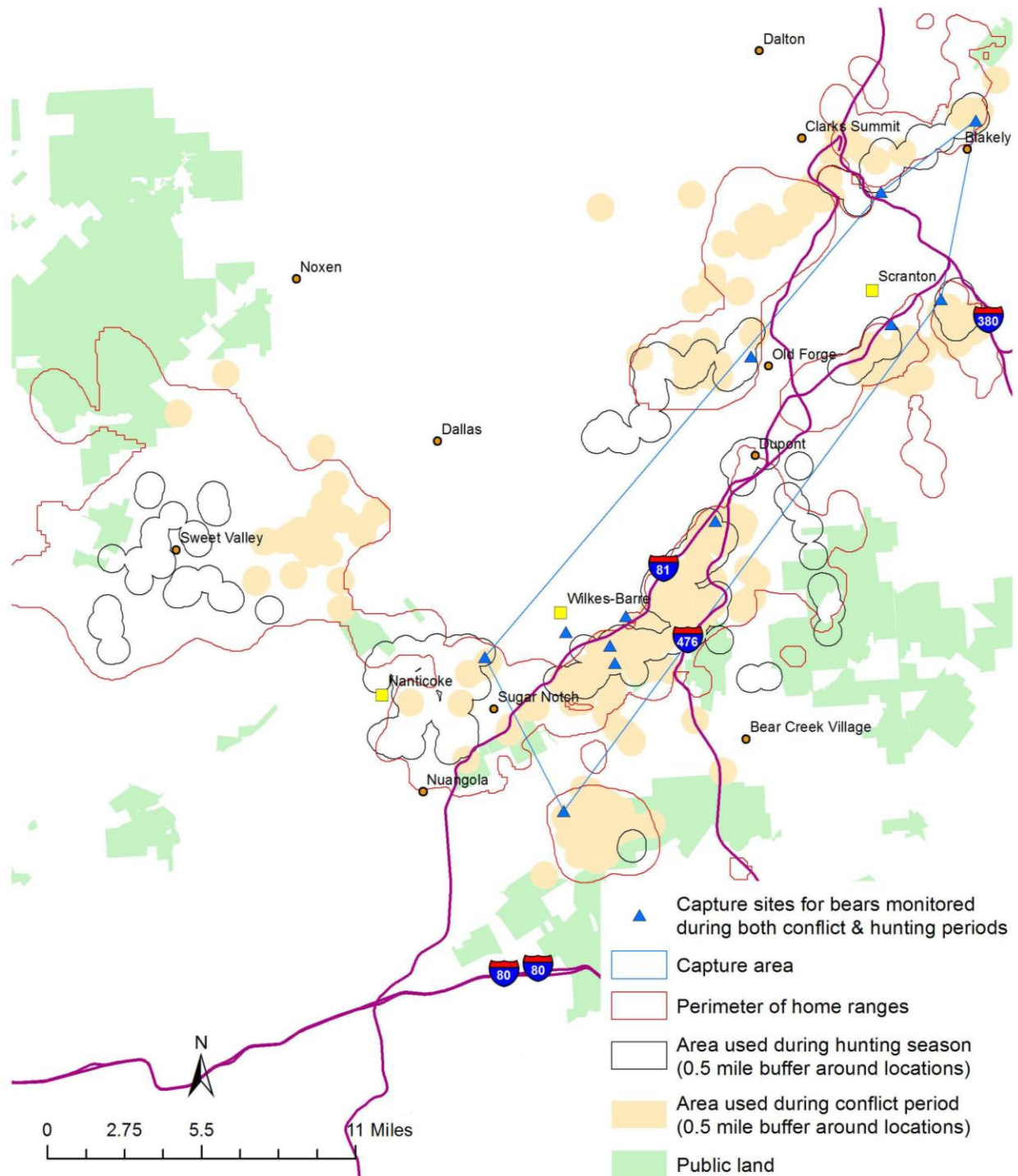


Figure 19. Area used by 13 radio-collared black bears in the Scranton study area that were monitored during a 10-day spring period when human-bear conflicts were most numerous, and during a 10-day fall hunting period in the same year. Note the degree of overlap while areas of use shifted between the two periods.

## MANAGEMENT IMPLICATIONS

Bears can successfully use developed landscapes in Pennsylvania and have the potential to reach high densities as seen by the capture of 78 individuals over 3 years in our study. Moreover, many of the bears that we monitored exhibited home ranges near capture areas, with developed areas comprising 11% of the average home range. Only 3 bears traveled well-beyond our study areas after release, despite 26% of the bears we handled being 1-year-old. Thus, our results indicate that most bears found in urban/suburban areas are not transients. They may be new arrivals due to dispersal, but if captured there, will likely remain near the suburban interface after release.

Further evidence that suburban bear management will involve resident populations of bears and not just transient individuals was apparent from the number of females we captured. Forty percent of the bears we handled were female, with more than half being of reproductive age.

These observations have clear management implications for deciding what to do with bears captured in suburban conflict situations. Because most bears are residents, short-distance relocations will not remove individuals. Of the 52 bears we relocated, mean relocation distance was 9.1 miles for females and 10.3 miles for males, of which all but 5 returned to the capture area. The PGC presently relocates approximately 400 bears annually in an attempt to resolve human-bear conflicts.

However, fewer bears returned to capture areas when we relocated them farther away. Nineteen of the 52 bears we relocated were considered to be released outside of their home range, of which 5 (26%) never returned close enough to the capture site for subsequent location data to be used in home range estimations. The mean relocation distance for male bears that failed to return was 35.8 miles, and for the 1 female, 15.4 miles. These distances were considerably shorter than values previously thought to be necessary for reducing homing (Alt 1980d).

Reviewing PGC policies related to relocation or removal may benefit how individual bears are managed in suburban areas, but the greater question of how to manage a population of bears at the suburban interface remains. The question central to our study was: how much mortality do bears living in developed landscapes experience and will increasing hunting pressure be an effective management tool? We learned that bears in these areas do experience high mortality. Forty-seven percent of the bears we handled died during 3 years. Our data confirmed that annually, 38% of adult females, 35% of adult males, 26% of juvenile females, and 58% of juvenile males who enter urban/suburban area die.

Harvest was the greatest mortality factor, and surprisingly, harvest rates among the bears we studied were similar to harvest rates among bears in more rural areas of Pennsylvania. Thus, regulated hunting does appear to be a viable tool for managing bear populations in developed landscapes. Because harvest rates were comparable to rural bear populations, but public land only accounted for 11% of the area where bears were found during the hunting season, a moderate amount of bear hunting must be occurring on private lands in the suburban interface. This conclusion seems to suggest that lengthening hunting opportunity would lead to increased harvest rates. That is, if bear hunting is occurring on private lands in the suburban interface enough to produce harvest rates similar to rural areas, then lengthening the hunting season

should increase harvest because that is the outcome we observe when seasons are lengthened in rural areas.

But success with this management approach will depend largely on private landowners allowing additional bear hunting activity on their properties, which is not as great a concern in rural areas that contain significant public lands. Any actions the PGC can take to facilitate cooperation by those landowners, such as alternative seasons or focused outreach, will benefit suburban bear management but the opinions of those landowners are currently unknown. A survey of landowners within the home ranges delineated in our study was initiated in 2013 to address this deficiency.

Although most of the bears we studied established home ranges along the suburban interface, it is important to note that collectively their home ranges covered a large geographical area. Thus, a large area may be required when deciding where to implement new harvest strategies. The 46 home ranges we calculated encompassed 1,250 mi<sup>2</sup>. In the Johnstown study area, 10 bears used 436 mi<sup>2</sup>; in the State College study area, 15 bears used 244 mi<sup>2</sup>, and in the Scranton area, 21 bears used 570 mi<sup>2</sup>. Polygons drawn around all 95,509 locations collected during the 3 years covered 5,842 mi<sup>2</sup> and averaged 1,947 mi<sup>2</sup> per study area, excluding the 3 bears that left our study areas. The mean size of wildlife management units currently used by the Pennsylvania Game Commission is 1,970 mi<sup>2</sup>, suggesting that management decisions for suburban bear populations at the management unit level are appropriate.

The area where we captured bears during spring and summer conflict situations encompassed 500 mi<sup>2</sup>, but the area used by 31 of those bears during the fall hunting season encompassed 1,401 mi<sup>2</sup>. Limiting harvest strategies to the area where suburban conflict are observed may not intersect the area used by those bears in the fall.

Finally, because bears in our study experienced moderate vehicle mortality, the amount of harvest needed to meet population objectives may not be as high as current thresholds used to manage rural bear populations. In our study, the proportion of bears killed by vehicles was about 4 times higher than the proportion killed in rural areas of the state. Mean vehicle mortality rates ranged between 6% and 14% with some occurring in all sex/age classes. We recommend that further modeling be done to determine the range of harvest rates necessary to increase, stabilize, or decrease suburban bear populations.

## LITERATURE CITED

- Alt, G. L. 1977. Home range, annual activity patterns, and movements of black bears in northeastern Pennsylvania. M.S. Thesis, Pennsylvania State University, University Park.
- Alt, G. L. 1980a. Preliminary results of Pennsylvania's 1979 bear harvest. *Pennsylvania Game News* 51:13–20.
- Alt, G. L. 1980b. Hunting vulnerability of bears. *Pennsylvania Game News* 51:7–10
- Alt, G. L. 1980c. Home range and movements of Pennsylvania black bear. *Pennsylvania Game News* 51:10–15.
- Alt, G. L. 1980d. Relocating nuisance bears. *Pennsylvania Game News* 51:20–22.
- Alt, G. L. 1983. Timing of parturition of black bears (*Ursus americanus*) in northeastern Pennsylvania. *Journal of Mammalogy* 64:305–307.
- Alt, G. L. 1989. Reproductive biology of female black bears and early growth and development of cubs in northeastern Pennsylvania. Ph.D. Dissertation, West Virginia University, Morgantown.
- Alt, G. L., F. W. Alt, and J. S. Lindzey. 1976. Home range and activity patterns of black bears in northeastern Pennsylvania. *Proceedings of the Northeast Section of the Wildlife Society* 33:45–56.
- Alt, G. L., G. J. Matula, Jr., F. W. Alt, and J. S. Lindzey. 1980. Dynamics of home range and movements of adult black bears in northeastern Pennsylvania. *Ursus* 4:131–136.
- Beckmann, J. P., and J. Berger. 2003. Rapid ecological behavioural changes in carnivores: the responses of black bears (*Ursus americanus*) to altered food. *Journal of the Zoological Society of London* 261:207–212.
- Beckmann, J. P., and C. W. Lackey. 2008. Carnivores, urban landscapes, and longitudinal studies: a case history of black bears. *Human-Wildlife Conflicts* 2:168–174.
- Brown, W. S. 1980. Black bear movements and activities in Pocahontas and Randolph counties, West Virginia. M.S. Thesis, West Virginia University, Morgantown.
- Conover, M. R. 2001. Effect of hunting and trapping on wildlife damage. *Wildlife Society Bulletin* 29:521–532.
- Costello, C. M. 1992. Black bear habitat ecology in the central Adirondacks as related to food abundance and forest management. Ph.D. Dissertation, State University of New York, College of Environmental Science and Forestry, Syracuse.

Diefenbach, D. R., J. L. Laake, and G. L. Alt. 2004. Spatio-temporal and demographic variation in the harvest of black bears: implications for population estimation. *The Journal of Wildlife Management* 68:947–959.

Elowe, K. D. 1984. Home range, movements, and habitat preferences of black bears (*Ursus americanus*) in western Massachusetts. M.S. Thesis, University of Massachusetts, Amherst.

Eveland, J. F. 1973. Population dynamics, movements, morphology, and habitat characteristics of black bears in Pennsylvania. M.S. Thesis, Pennsylvania State University, University Park.

Fimbel, C. C. 1990. Characteristics of black bears in a residential area of New Jersey. Ph.D. Dissertation, Rutgers University.

Fuller, D. P. 1993. Black bear population dynamics in western Massachusetts. M.S. Thesis, University of Massachusetts, Amhurst.

Garner, N. P. 1986. Seasonal movements, habitat selection, and food habits of black bears (*Ursus americanus*) in Shenandoah National Park, Virginia. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg.

Garshelis, D. L. 1994. Density-dependent population regulation of black bears. Pages 3–14 in M. Taylor, editor. Density-dependent population regulation of black, brown, and polar bears. International Conference on Bear Research and management, Monograph Series Number 3.

Garshelis, D. L. and H. Hristienko. 2006. State and provincial estimates of American Black Bear numbers versus assessments of population trend. *Ursus* 17:1–7.

Giles, J.M., and W.S. Kordek. 1979. Pennsylvania bear hunting. *Pennsylvania Game News* 50:15–17.

Harshyne, W. A., D. R. Diefenbach, G. L. Alt, and G. M. Matson. 1998. Analysis of error from cementum-annuli age estimates of known-age Pennsylvania black bears. *The Journal of Wildlife Management* 62:1281–1291.

Heisey, D. M., and T. K. Fuller. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. *The Journal of Wildlife Management* 49:668–674.

Hellgren, E. C. 1988. Ecology and physiology of a black bear (*Ursus americanus*) population in Great Dismal Swamp and reproductive physiology in the captive female black bear. Ph.D. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg.

Hellgren, E. and M. Vaughan. 1990. Range dynamics of black bears in Great Dismal Swamp, Virginia, North Carolina. *Proceedings Conference of Southeast Association of Fish and Wildlife Agencies* 44:268–278.

- Higgins, J. C. 1997. Survival, home range and spatial relationships of Virginia's exploited black bear population. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg.
- Hristienko, H. and J. E. McDonald, Jr. 2007. Going into the 21st century: a perspective on trends and controversies in the management of the American black bear. *Ursus* 18:72–88.
- Jenks, G. F. 1967. The Data model concept in statistical mapping. *International Yearbook of Cartography* 7:186–190
- Kordek, W. S. 1973. An investigation of the structure, stability, and movements of Pennsylvania black bear with particular emphasis on Pike county. M.S. Thesis, Pennsylvania State University, University Park.
- Kordek, W. S., and J. S. Lindzey. 1980. Preliminary analysis of female reproductive tracts from Pennsylvania black bears. *Ursus* 4:159–161.
- Kraus, J. G. 1990. Home ranges and den site characteristics of female black bears and aspects of bear population structure in West Virginia. M.S. Thesis, West Virginia University, Morgantown.
- Lindzey, J.S., G.L. Alt, C.R. McLaughlin, and W.S. Kordek. 1983. Population response of Pennsylvania black bears to hunting. *Ursus* 5:34–39.
- MacKenzie, K. G. 2003. Nuisance vs. non-nuisance bears: seasonal movement and home range utilization of female New Jersey black bears (*Ursus americanus*). M.S. Thesis, East Stroudsburg State University, East Stroudsburg, Pennsylvania.
- Malcolm, K. D., and T. R. Van Deelen. 2010. Effects of habitat and hunting framework on American black bear harvest structure in Wisconsin. *Ursus* 21:14–22.
- Matson, J. R. 1954. Observations on the dormant phase of a female black bear. *Journal of Mammalogy* 35:28–35.
- McLaughlin, C. R. 1981. Home range, movements, and denning behavior of female black bears in north-central Pennsylvania. M.S. Thesis, Pennsylvania State University, University Park.
- Obbard, M. E., and J. E. Howe. 2008. Demography of black bears in hunted and unhunted areas of the boreal forest of Ontario. *The Journal of Wildlife Management*, 72:869–880.
- Offenbittel, C. 2005. Home range dynamics of black bears in the Alleghany Mountains of western Virginia. M.S. Thesis, Virginia Polytechnic Institute and State University. Blacksburg.
- Pennsylvania State University. 2007. PAMAP Program Land Cover for Pennsylvania, 2005. Penn State University, University Park, PA. <ftp://www.pasda.psu.edu/pub/pasda/orser>. Last accessed 10 October 2013.

- Poelker, R. J. and L. D. Parsons. 1980. Black bear hunting to reduce forest damage. *International Conference on Bear Research and Management* 4:191–193.
- Rainbolt, R. E, M. T. Wegan, C. A. Dobony, and P. D. Curtis. 2011. Black bear project on Fort Drum military installation, final report. [http://fortdrum.isportsman.net/file/Fort\\_Drum\\_Bear\\_Project\\_Report\\_FINAL2011.pdf](http://fortdrum.isportsman.net/file/Fort_Drum_Bear_Project_Report_FINAL2011.pdf). Last Accessed 8 November 2013.
- Responsive Management. 2008. Pennsylvania residents' opinions on and attitudes toward black bears. Harrisonburg, Virginia.
- Rieffenburger, J. C. 1973. Range and movements of West Virginia black bears during summer and autumn 1973. *Proceedings of the Eastern Black Bear Workshop* 2:139–142.
- Rodgers, A. R., and A. P. Carr. 1998. HRE: the home range extension for ArcView. User's manual, Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources.
- Schrage, M. W. 1994. Influence of gypsy moth induced oak mortality on a black bear population. M. S. Thesis, Virginia Polytechnic Institute and State University. Blacksburg.
- Shramko, R. A. 2005. Analysis of home range characteristics of New Jersey black bears pre and post hunting season. M.S. Thesis, East Stroudsburg State University. East Stroudsburg, Pennsylvania.
- Spiker, H. A., and S. Bittner. 2004. Wildlife and Heritage Service, Black Bear Management Plan, 2004–2013. Maryland Department of Natural Resources, Annapolis. DNR-03-0105-0031.
- Ternent, M. A. 2006. Management and biology of black bears in Pennsylvania: Ten Year Plan (2006–2015). Pennsylvania Game Commission, Harrisburg.
- Ternent, M.A. 2008. Effect of lengthening the hunting season in northeastern Pennsylvania on population size and harvest rates of black bears. *Proceedings of the Eastern Black Bear Workshop* 19:90-97.
- Ternent, M. A. 2013a. Black bear harvest and population monitoring. Project Annual Report No. 06230-23001, Pennsylvania Game Commission, Bureau of Wildlife Management, Harrisburg, Pennsylvania.
- Ternent, M. A. 2013b. Annual wildlife food survey. Project Annual Report No. 06230-23000, Pennsylvania Game Commission, Bureau of Wildlife Management, Harrisburg, Pennsylvania.
- Treves, A., K. J. Kapp, and D. MacFarland. 2010. American black bear nuisance complaints and hunter take. *Ursus* 21:30–42.
- Weaver, H. W. 2004. Biometric analysis and aversive conditioning of black bears in southern West Virginia. M.S. Thesis, West Virginia University, Morgantown.

Weaver, H. W. 2004. Biometric analysis and aversive conditioning of black bears in southern West Virginia. M.S. Thesis, West Virginia University, Morgantown.

Webster, T. 1994. Movements and use of habitat of female black bears in western Maryland. M.S. Thesis, Frostburg State University, Frostburg, Maryland.

Wills, G. B. 1980. Black bear-human conflicts and management considerations to minimize and correct these problems. Proceedings of Eastern Workshop on Black Bear Management and Research 5:75–88.

Wolgast, L. J., W. S. Ellis, and J. Vreeland. 2005. New Jersey Fish and Game Council comprehensive black bear (*Ursus americanus*) management policy. New Jersey Fish and Game Council, New Jersey Department of Environmental Protection, Trenton.

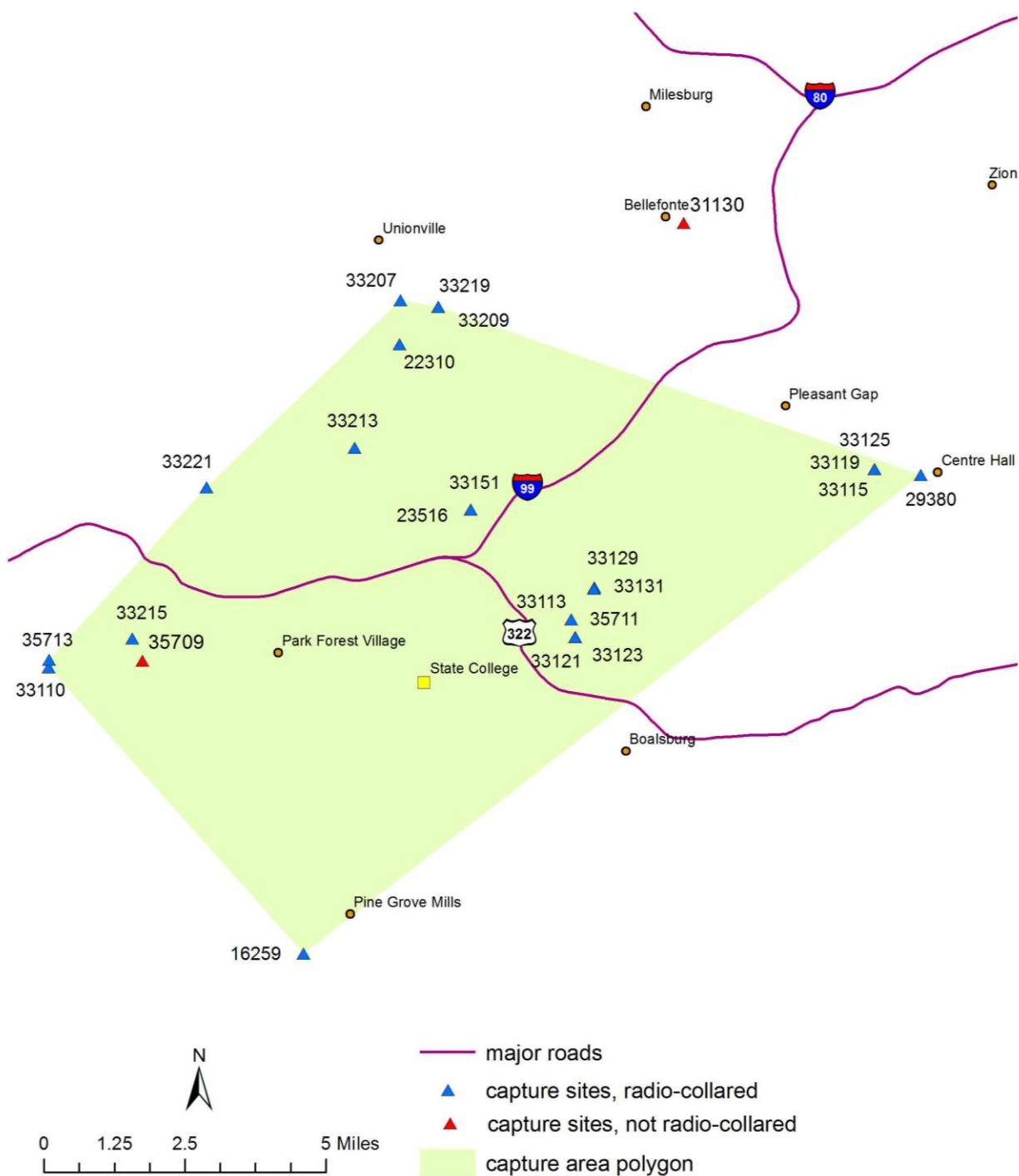
Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.

Ziegltrum, G. J. 2004. Efficacy of black bear supplemental feeding to reduce conifer damage in western Washington. Journal of Wildlife Management 68:470–474.

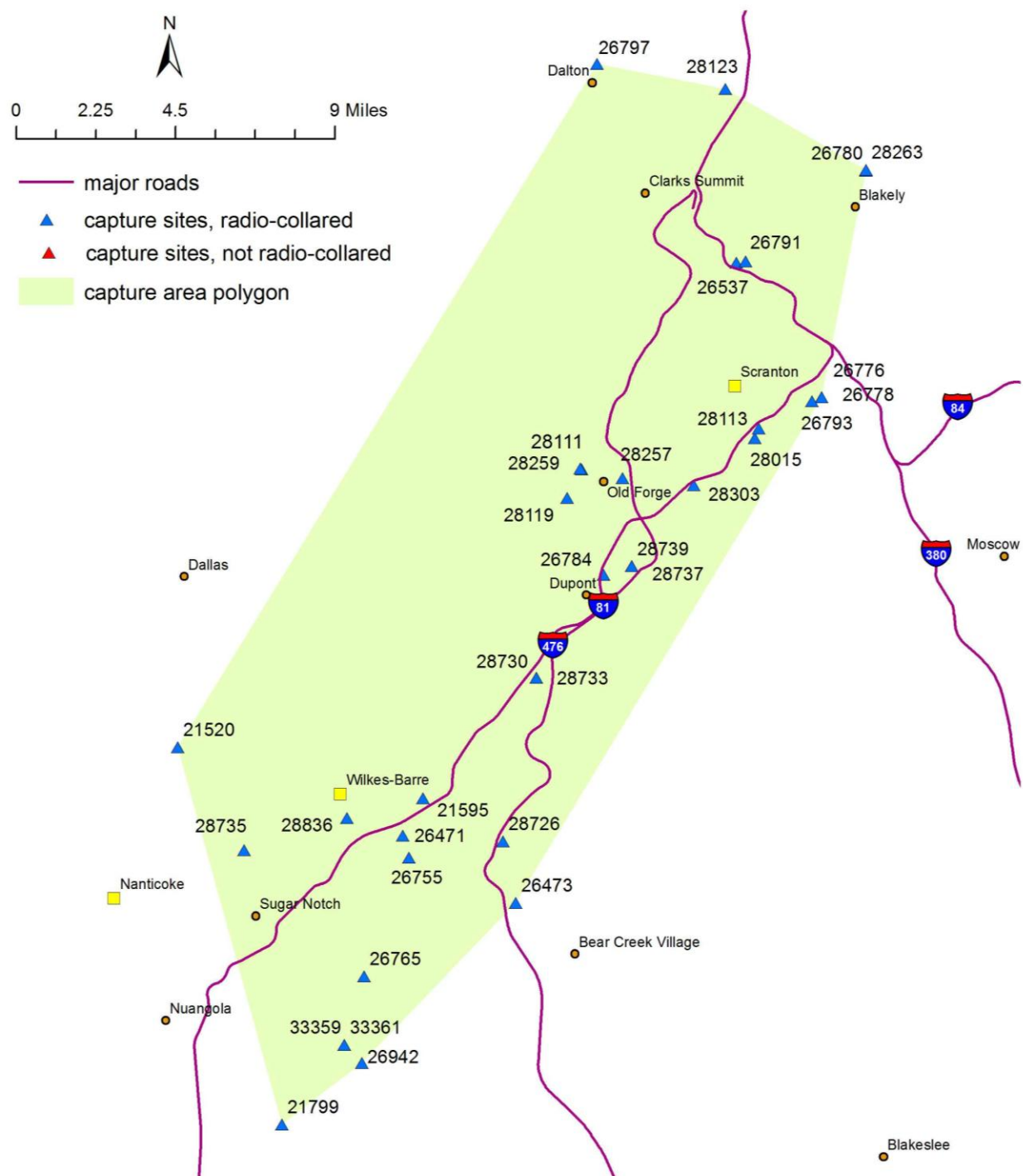
APPENDIX I. Capture locations for 78 black bears handled in 3 urban/suburban study areas. Minimum convex polygons drawn around all capture locations covered 185.7 mi<sup>2</sup> in the Johnstown study area, 88.3 mi<sup>2</sup> in the State college study area, and 278.0 mi<sup>2</sup> in the Scranton study area. All but 2 bears (35709 and 31130, both in the State College area) were fitted with GPS radio-collars.



JOHNSTOWN STUDY AREA



STATE COLLEGE STUDY AREA



SCRANTON STUDY AREA

## APPENDIX II. Black bears radio-collared in 3 urban/suburban study areas.

| SCRNATON STUDY AREA |     |              |         |                  |                   |                                                                                                                                                                       |
|---------------------|-----|--------------|---------|------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Capture Date        | Sex | Weight (lbs) | Bear ID | Collar ID        | Collar Status     | Notes                                                                                                                                                                 |
| 6 May 2010          | M   | 109          | 26776   | 8321             | Killed by vehicle | killed by vehicle 6/3/10                                                                                                                                              |
| 7 May 2010          | F   | 211          | 26778   | 8335; 8337; 8327 | Malfunctioning    | visited den 3/28/11, with 3 cubs, given new collar 8337; recaptured 8/30/11; visited den 2/23/12, with 3 yrls, given new collar 8327, collar stopped working 5/29/12  |
| 8 May 2010          | M   | 208          | 26471   | 8342             | Harvested         | recaptured 6/5/10; harvested 11/20/10                                                                                                                                 |
| 10 May 2010         | F   | 140          | 26780   | 8327; 8346       | Dropped           | collar stopped working 6/28/10; recaptured 5/22/11 and given new collar 8346; visited den 2/23/12 with unkn number of yrls, dropped collar 10/15/12                   |
| 12 May 2010         | F   | 191          | 26537   | 8332             | Killed by vehicle | killed by vehicle 6/20/10                                                                                                                                             |
| 12 May 2010         | F   | 259          | 26755   | 8333; 8369       | Dropped           | visited den 3/14/11, with 4 cubs, given new collar 8369; dropped collar 7/13/11                                                                                       |
| 13 May 2010         | M   | 575          | 26473   | 8339; 8368; 8351 | Malfunctioning    | dropped collar 5/14/10, recaptured 7/21/10 & given new collar 8368, visited den 2/15/11 & given new collar 8351, collar stopped working 5/12/11                       |
| 14 May 2010         | F   | 210          | 21520   | 8329             | Dropped           | dropped collar 6/21/10                                                                                                                                                |
| 14 May 2010         | M   | 300          | 26765   | 8334             | Dropped           | dropped collar 5/15/10                                                                                                                                                |
| 15 May 2010         | M   | 355          | 28726   | 8340             | Harvested         | dropped collar 7/5/10; harvested 11/21/11                                                                                                                             |
| 22 May 2010         | M   | 127          | 26784   | 8328; 8346       | Harvested         | recaptured 11/2/10 and given new collar 8346; harvested 11/20/10                                                                                                      |
| 3 June 2010         | F   | 152          | 21595   | 8341             | Harvested         | harvested 11/23/10                                                                                                                                                    |
| 3 June 2010         | M   | 420          | 21799   | 8339             | Dropped           | dropped collar 6/3/10                                                                                                                                                 |
| 7 June 2010         | M   | 345          | 28015   | 8368             | Dropped           | dropped collar 6/20/10                                                                                                                                                |
| 8 June 2010         | F   | 220          | 28730   | 8326; 8369       | Collar removed    | observed with cubs in 2010; collar stopped working 10/5/10; den discovered 3/15/12, with 4 cubs, given new collar 8369, visited den 2/25/13, removed collar 8369      |
| 10 June 2010        | M   | 145          | 28733   | 8331             | Harvested         | harvested 11/15/10                                                                                                                                                    |
| 11 June 2010        | M   | 374          | 26791   | 8339; 8348       | Dropped           | visited den 2/11/11 and given new collar 8348; collar stopped working 9/18/11, dropped collar 7/20/12                                                                 |
| 11 June 2010        | M   | 213          | 26793   | 8384             | Dropped           | collar stopped working 10/23/10, recaptured 3/23/12 without collar                                                                                                    |
| 18 June 2010        | M   | 146          | 28735   | 8361; 8334; 8333 | Killed illegally  | visited den 2/15/11 and given new collar 8334; recaptured 5/11/11 and given new collar 8333; killed illegally by homeowner 6/9/11                                     |
| 22 July 2010        | M   | 114          | 28737   | 8343             | Harvested         | harvested 11/23/10                                                                                                                                                    |
| 24 July 2010        | M   | 141          | 28739   | 8359             | Harvested         | collar stopped working 7/30/10; harvested 11/23/10                                                                                                                    |
| 4 Oct 2010          | F   | 120          | 26797   | 8356; 8354; 8359 | Euthanized        | visited den 3/14/11 and given new collar 8354; dropped collar 4/22/11; recaptured 5/18/11 and given new collar 8359; dropped collar 8/9/11, killed as nuisance 7/2/12 |
| 9 May 2011          | M   | 213          | 28836   | 8328             | Harvested         | harvested 11/14/11                                                                                                                                                    |
| 14 May 2011         | M   | 280          | 26942   | 8367             | Malfunctioning    | collar stopped working 8/24/11                                                                                                                                        |

## SCRANTON STUDY AREA continued

| Capture Date | Sex | Weight (lbs) | Bear ID | Collar ID  | Collar Status     | Notes                                                                                                     |
|--------------|-----|--------------|---------|------------|-------------------|-----------------------------------------------------------------------------------------------------------|
| 14 May 2011  | F   | 176          | 33359   | 8335       | Harvested         | harvested 11/19/11                                                                                        |
| 17 May 2011  | F   | 206          | 33361   | 8356       | Killed by vehicle | killed by vehicle 4 hours after being radio-collared                                                      |
| 18 May 2011  | M   | 247          | 28111   | 8336       | Dropped           | recaptured 7/30/11; dropped collar 2/28/12                                                                |
| 19 May 2011  | F   | 110          | 28113   | 8349; 8347 | Malfunctioning    | visited den 3/15/12, without young, given new collar 8347, collar stopped working 11/30/12                |
| 8 June 2011  | M   | 269          | 28119   | 8350       | Malfunctioning    | collar stopped working 10/2/11                                                                            |
| 16 Aug 2011  | M   | 173          | 28303   | 8356       | Dropped           | collar stopped working 12/12/11, recaptured 10/26/12 and 5/16/13 and released both times without a collar |
| 27 Aug 2011  | M   | 290          | 28123   | 8333       | Malfunctioning    | collar stopped working 12/3/11                                                                            |
| 24 Mar 2012  | M   | 200          | 28257   | 8357       | Harvested         | collar stopped working 5/12/12, harvested 11/19/12                                                        |
| 28 Apr 2012  | M   | 350          | 28259   | 8339       | Malfunctioning    | collar stopped working 8/29/12                                                                            |
| 11 May 2012  | F   | 180          | 28263   | 8382       | Collar Removed    | with 3 yrs in May 2012, visited den 3/18/13, removed collar 8382                                          |

## STATE COLLEGE STUDY AREA

| Capture Date | Sex | Weight (lbs) | Bear ID | Collar ID  | Collar Status          | Notes                                                                                                                                |
|--------------|-----|--------------|---------|------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| 25 May 2010  | F   | 210          | 33110   | 8366       | Dropped                | dropped collar 6/13/10                                                                                                               |
| 29 May 2010  | F   | 125          | 33113   | 8337       | Dropped                | dropped collar 7/15/10                                                                                                               |
| 23 June 2010 | M   | 219          | 33115   | 8371       | Harvested              | harvested 11/22/10                                                                                                                   |
| 29 June 2010 | M   | 388          | 33119   | 8348       | Harvested              | dropped collar 7/27/10; harvested 11/21/11                                                                                           |
| 8 July 2010  | F   | 115          | 33121   | 8370       | Unknown cause of death | unknown cause of death 10/25/10                                                                                                      |
| 9 July 2010  | M   | 232          | 33123   | 8390; 8330 | Malfunctioning         | visited den 1/30/11 and given new collar 8330; collar stopped working 6/29/11                                                        |
| 9 July 2010  | F   | 106          | 33125   | 8389       | Killed by vehicle      | killed by vehicle 10/26/10                                                                                                           |
| 15 July 2010 | F   | 167          | 22310   | 8349       | Killed by vehicle      | observed with cubs in 2010, killed by vehicle 10/28/10                                                                               |
| 17 July 2010 | M   | 168          | 33131   | 8386; 8357 | Euthanized             | collar stopped working 12/9/10; recaptured 6/25/11 and given new collar 8357; euthanized at den 2/1/12 for chronic nuisance activity |
| 21 July 2010 | M   | 209          | 29380   | 8382       | Harvested              | harvested 11/16/10                                                                                                                   |
| 26 Aug 2010  | M   | 320          | 12392   | 8369       | Killed by vehicle      | killed by vehicle 11/22/10                                                                                                           |
| 26 Apr 2011  | F   | 222          | 33151   | 8361; 8390 | Harvested              | visited den 3/10/12, with 3 cubs, given new collar 8390, harvested 11/19/12                                                          |
| 14 May 2011  | M   | 289          | 23516   | 8344       | Killed by vehicle      | killed by vehicle 6/9/11                                                                                                             |
| 20 May 2011  | M   | 205          | 33209   | 8368       | Malfunctioning         | recaptured 5/29/11; collar stopped working 7/30/11                                                                                   |
| 23 May 2011  | M   | 250          | 33213   | 8382       | Harvested              | harvested 11/21/11                                                                                                                   |
| 29 May 2011  | M   | 250          | 33129   | 8345       | Malfunctioning         | Collar stopped working 6/14/11                                                                                                       |

## STATE COLLEGE STUDY AREA continued

| Capture Date | Sex | Weight (lbs) | Bear ID | Collar ID        | Collar Status  | Notes                                                                                                                                          |
|--------------|-----|--------------|---------|------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 June 2011  | M   | 267          | 33215   | 8347; 8321; 8355 | Malfunctioning | recaptured 6/8/11 and given new collar 8321; dropped collar 6/21/11; recaptured 5/10/12, given new collar 8355; collar stopped working 5/17/12 |
| 21 June 2011 | M   | 351          | 33219   | 8339; 8337       | Malfunctioning | visited den 2/3/12; recaptured 4/24/12, given new collar 8337; collar stopped working 4/28/12                                                  |
| 16 July 2011 | M   | 208          | 33221   | 8341; 8365       | Malfunctioning | collar stopped working 8/7/11; recaptured 1/30/12, given new collar 8365, collar stopped working 11/9/12                                       |
| 26 Apr 2012  | F   | 134          | 33207   | 8389             | Active         | solitaire in April 2012, visited den 3/4/13, abandoned den, 3 cubs placed in other litters                                                     |
| 25 May 2012  | F   | 176          | 35711   | 8370             | Collar removed | with 3 cubs in May 2012, visited den 2/23/13, collar removed                                                                                   |
| 7 June 2012  | M   | 346          | 35713   | 8341             | Harvested      | no breakaway device on collar, dropped collar 8/7/12, harvested 11/21/12                                                                       |
| 12 June 2012 | M   | 173          | 16259   | 8386             | Malfunctioning | no breakaway device on collar, collar stopped working 1/29/13                                                                                  |

## JOHNSTOWN STUDY AREA

| Capture Date | Sex | Weight (lbs) | Bear ID | Collar ID        | Collar Status          | Notes                                                                                                                                       |
|--------------|-----|--------------|---------|------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 26 May 2010  | F   | 156          | 27961   | 8354; 8389       | Dropped                | collar dropped 6/17/10; recaptured 5/10/11, given new collar 8389; harvested 11/21/11                                                       |
| 27 May 2010  | M   | 360          | 25163   | 8401             | Malfunctioning         | collar stopped working 6/30/10                                                                                                              |
| 17 June 2010 | M   | 188          | 27340   | 8320             | Dropped                | Captured outside study area; collar dropped 7/1/10                                                                                          |
| 18 June 2010 | F   | 249          | 27170   | 8350             | Dropped                | collar dropped 7/27/10                                                                                                                      |
| 9 July 2010  | M   | 118          | 33127   | 8347             | Killed by vehicle      | killed by vehicle 8/5/10                                                                                                                    |
| 16 July 2010 | F   | 184          | 33836   | 8367; 8343       | Harvested              | visited den 3/17/11, with 3 cubs, given new collar 8343; collar stopped working 8/12/11; harvested 11/19/11                                 |
| 24 July 2010 | M   | 185          | 27466   | 8320             | Harvested              | collar stopped working 9/9/10; harvested 11/19/11                                                                                           |
| 25 Aug 2010  | M   | 106          | 33838   | 8322; 8331; 8369 | Unknown cause of death | visited den 2/23/11, given new collar 8331; recaptured 10/13/11, given new collar 8369; died of unknown causes 11/12/11                     |
| 20 Sept 2010 | M   | 153          | 32781   | 8355; 8342       | Harvested              | collar stopped working 11/1/10; recaptured 5/7/11, given new collar 8342; collar stopped working 5/28/11; harvested 11/19/11                |
| 12 Oct 2010  | M   | 205          | 33148   | 8391             | Collar removed         | visited den 2/23/11; collar stopped working 7/5/11; recaptured 5/21/12 and collar removed because outside study area                        |
| 29 Mar 2011  | M   | 290          | 32726   | 8341             | Harvested              | dropped collar 5/22/11; harvested 11/19/11                                                                                                  |
| 10 Apr 2011  | M   | 262          | 33201   | 8372; 8343       | Collar removed         | collar stopped working 1/7/12, recaptured 10/4/12, given new collar 8343, visited den 2/12/13, removed collar                               |
| 3 May 2011   | M   | 187          | 33153   | 8344; 8370       | Harvested              | dropped collar 5/4/11; recaptured 6/3/11, given new collar 8370; collar stopped working 10/4/11; harvested 11/19/11                         |
| 21 May 2011  | M   | 195          | 33211   | 8371; 8342       | Collar removed         | collar stopped working 8/1/11, recaptured 7/31/12, given new collar 8342, collar stopped working 8/5/12, recaptured 5/30/12, collar removed |

## JOHNSTOWN STUDY AREA continued

| Capture Date | Sex | Weight (lbs) | Bear ID | Collar ID     | Collar Status     | Notes                                                                                                                                                  |
|--------------|-----|--------------|---------|---------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3 May 2011   | M   | 187          | 33153   | 8344;<br>8370 | Harvested         | dropped collar 5/4/11; recaptured 6/3/11, given new collar 8370; collar stopped working 10/4/11; harvested 11/19/11                                    |
| 21 May 2011  | M   | 195          | 33211   | 8371;<br>8342 | Collar removed    | collar stopped working 8/1/11, recaptured 7/31/12, given new collar 8342, collar stopped working 8/5/12, recaptured 5/30/12, collar removed            |
| 1 July 2011  | M   | 129          | 33366   | 8366;<br>8335 | Killed by vehicle | collar stopped working 7/14/11; recaptured 4/13/12, given new collar 8335; recaptured 5/7/12, collar stopped working 7/5/12, killed by vehicle 8/18/12 |
| 18 July 2011 | F   | 108          | 33369   | 8344          | Malfunctioning    | collar stopped working 9/15/11                                                                                                                         |
| 3 Aug 2011   | M   | 117          | 31530   | 8354;<br>8334 | Harvested         | collar stopped working 11/13/11; recaptured 3/15/12, given new collar 8334, collar stopped working 10/23/12, harvested 11/20/12                        |
| 2 June 2012  | F   | 115          | 31716   | 8329          | Collar removed    | suspected yearling, recaptured 7/21/12, visited den 3/13/13, removed collar 8329                                                                       |
| 14 Oct 2012  | F   | 202          | 27910   | 8390          | Dropped           | visited den 2/23/13, ran and not handled, with 2 untagged yearlings, collar dropped 6/29/13                                                            |

## APPENDIX III. Number of GPS locations collected from 76 radio-collared black bears.

| Study Area       | Bear ID | Monitoring Period         | Number of Location Attempts | Number of Locations Received | Success Rate<br>1 September –<br>15 December | Remainder<br>of Year |
|------------------|---------|---------------------------|-----------------------------|------------------------------|----------------------------------------------|----------------------|
| State<br>College | 12392   | 26 Aug 2010 - 22 Nov 2010 | 1367                        | 1,267                        | 94%                                          | 36%                  |
|                  | 16259   | 12 Jun 2012 - 29 Jan 2013 | 2953                        | 2,777                        | 97%                                          | 87%                  |
|                  | 22310   | 15 Jul 2010 - 28 Oct 2010 | 1668                        | 1,486                        | 96%                                          | 69%                  |
|                  | 23516   | 14 May 2011 - 9 Jun 2011  | 193                         | 159                          |                                              | 82%                  |
|                  | 29380   | 21 Jul 2010 - 16 Nov 2010 | 2024                        | 1,860                        | 93%                                          | 87%                  |
|                  | 33110   | 25 May 2010 - 13 Jun 2010 | 76                          | 31                           |                                              | 41%                  |
|                  | 33113   | 29 May 2010 - 15 Jul 2010 | 318                         | 206                          |                                              | 65%                  |
|                  | 33115   | 23 Jun 2010 - 22 Nov 2010 | 1166                        | 875                          | 83%                                          | 65%                  |
|                  | 33119   | 29 Jun 2010 - 27 Jul 2010 | 109                         | 42                           |                                              | 39%                  |
|                  | 33121   | 8 Jul 2010 - 25 Oct 2010  | 1640                        | 1,234                        | 81%                                          | 59%                  |
|                  | 33123   | 9 Jul 2010 - 29 Jun 2011  | 2353                        | 1,837                        | 84%                                          | 75%                  |
|                  | 33125   | 9 Jul 2010 - 26 Oct 2010  | 1669                        | 1,327                        | 85%                                          | 65%                  |
|                  | 33129   | 16 Jul 2010 - 14 Jun 2011 | 117                         | 81                           |                                              | 69%                  |
|                  | 33131   | 17 Jul 2010 - 9 Dec 2010  |                             |                              |                                              |                      |
|                  |         | 25 Jun 2011 - 1 Feb 2012  |                             |                              |                                              |                      |
|                  |         | Total for bear 33131      | 5169                        | 4,326                        | 91%                                          | 61%                  |
|                  | 33151   | 26 Apr 2011 - 18 May 2012 | 5058                        | 4,740                        | 98%                                          | 90%                  |
|                  | 33207   | 26 Apr 2012 - 30 Jun 2013 | 3881                        | 3,263                        | 93%                                          | 74%                  |
|                  | 33209   | 20 May 2011 - 30 Jul 2011 | 699                         | 284                          |                                              | 41%                  |
|                  | 33213   | 23 May 2011 - 21 Nov 2011 | 2326                        | 2,023                        | 91%                                          | 77%                  |
|                  | 33215   | 1 Jun 2011 - 21 Jun 2011  |                             |                              |                                              |                      |
|                  |         | 10 May 2012 - 17 Ma 2012  |                             |                              |                                              |                      |
|                  |         | Total for bear 33215      | 178                         | 105                          |                                              | 59%                  |
|                  | 33219   | 21 Jun 2011 - 28 Apr 2012 | 3575                        | 3,092                        | 93%                                          | 78%                  |
|                  | 33221   | 16 Jul 2011 - 7 Aug 2011  |                             |                              |                                              |                      |
|                  |         | 30 Jan 2012 - 9 Nov 2012  |                             |                              |                                              |                      |
|                  |         | Total for bear 33221      | 2367                        | 2055                         | 92%                                          | 85%                  |
|                  | 35711   | 25 May 2012 - 23 Feb 2013 | 3327                        | 2,479                        | 83%                                          | 60%                  |
|                  | 35713   | 7 Jun 2012 - 7 Aug 2012   | 732                         | 672                          |                                              | 92%                  |
|                  | Total   |                           | 42965                       | 36221                        |                                              |                      |
|                  | Mean    |                           |                             |                              | 90%                                          | 68%                  |
| Scranton         | 21520   | 14 May 2010 - 21 Jun 2011 | 4891                        | 2,333                        | 52%                                          | 44%                  |
|                  | 21595   | 3 Jun 2010 - 23 Nov 2010  | 1911                        | 1,683                        | 92%                                          | 74%                  |
|                  | 21799   | 3 Jun 2010 - 3 Jun 2010   | 2                           | 2                            |                                              | 100%                 |
|                  | 26471   | 8 May 2010 - 20 Nov 2010  | 2307                        | 1,911                        | 88%                                          | 73%                  |
|                  | 26473   | 13 May 2010 - 14 May 2010 |                             |                              |                                              |                      |
|                  |         | 21 Jul 2010 - 12 May 2011 |                             |                              |                                              |                      |
|                  |         | Total for bear 26473      | 3918                        | 3472                         | 92%                                          | 83%                  |
|                  | 26537   | 12 May 2010 - 20 Jun 2010 | 276                         | 177                          |                                              | 64%                  |
|                  | 26755   | 12 May 2010 - 13 Jul 2011 | 4876                        | 2,364                        | 52%                                          | 45%                  |
|                  | 26765   | 14 May 2010 - 15 May 2010 | 4                           | 2                            |                                              | 50%                  |
|                  | 26776   | 6 May 2010 - 3 Jun 2010   | 104                         | 44                           |                                              | 42%                  |
|                  | 26778   | 7 May 2010 - 29 May 2012  | 8393                        | 4,515                        | 68%                                          | 38%                  |
|                  | 26780   | 10 May 2010 - 28 Jun 2010 |                             |                              |                                              |                      |
|                  |         | 22 May 2011 - 15 Oct 2012 |                             |                              |                                              |                      |
|                  |         | Total for bear 26780      | 5899                        | 4434                         | 87%                                          | 64%                  |
|                  | 26784   | 22 May 2010 - 20 Nov 2010 | 2430                        | 1,908                        | 86%                                          | 61%                  |
|                  | 26791   | 11 Jun 2010 - 18 Sep 2011 | 3784                        | 3,195                        | 91%                                          | 79%                  |
|                  | 26793   | 11 Jun 2010 - 23 Oct 2010 | 1144                        | 886                          | 86%                                          | 68%                  |
|                  | 26797   | 4 Oct 2010 - 9 Aug 2011   | 2393                        | 1,254                        | 64%                                          | 42%                  |
|                  | 26942   | 14 May 2011 - 24 Aug 2011 | 347                         | 226                          |                                              | 65%                  |
|                  | 28015   | 7 Jun 2010 - 20 Jun 2010  | 123                         | 83                           |                                              | 67%                  |
|                  | 28111   | 18 May 2011 - 28 Feb 2012 | 3383                        | 2,984                        | 93%                                          | 81%                  |
|                  | 28113   | 19 May 2011 - 30 Nov 2012 | 5620                        | 3,405                        | 74%                                          | 46%                  |
|                  | 28119   | 8 Jun 2011 - 2 Oct 2011   | 964                         | 245                          | 17%                                          | 30%                  |

## APPENDIX III. continued.

| Study Area          | Bear ID | Monitoring Period         | Number of Location Attempts | Number of Locations Received | Success Rate 1 September – 15 December | Remainder of Year |
|---------------------|---------|---------------------------|-----------------------------|------------------------------|----------------------------------------|-------------------|
| Scranton, continued | 28123   | 27 Aug 2011 - 3 Dec 2011  | 1685                        | 1,534                        | 91%                                    | 85%               |
|                     | 28257   | 24 Mar 2012 - 12 May 2012 | 210                         | 81                           |                                        | 39%               |
|                     | 28259   | 28 Apr 2012 - 29 Aug 2012 | 873                         | 583                          |                                        | 67%               |
|                     | 28263   | 11 May 2012 - 18 Mar 2013 | 3525                        | 1,920                        | 62%                                    | 45%               |
|                     | 28303   | 16 Aug 2011 - 16 May 2013 | 1791                        | 1,250                        | 71%                                    | 56%               |
|                     | 28726   | 15 May 2010 - 5 Jul 2010  | 333                         | 228                          |                                        | 68%               |
|                     | 28730   | 8 Jun 2010 - 5 Oct 2010   |                             |                              |                                        |                   |
|                     |         | 15 Mar 2012 - 25 Feb 2013 |                             |                              |                                        |                   |
|                     |         | Total for bear 28730      | 4426                        | 2927                         | 79%                                    | 51%               |
|                     | 28733   | 10 Jun 2010 - 15 Nov 2010 | 2284                        | 1,938                        | 90%                                    | 71%               |
|                     | 28735   | 18 Jun 2010 - 9 Jun 2011  | 4077                        | 3,002                        | 91%                                    | 51%               |
|                     | 28737   | 22 Jul 2010 - 23 Nov 2010 | 2220                        | 1,530                        | 72%                                    | 53%               |
|                     | 28739   | 24 Jul 2010 - 30 Jul 2010 | 34                          | 24                           |                                        | 71%               |
|                     | 28836   | 9 May 2011 - 14 Nov 2011  | 2296                        | 1,816                        | 90%                                    | 60%               |
|                     | 33359   | 14 May 2011 - 19 Nov 2011 | 2347                        | 2,145                        | 95%                                    | 85%               |
|                     | 33361   | 17 May 2011 - 17 May 2011 | 2                           | 1                            |                                        | 50%               |
|                     | Total   |                           | 78872                       | 54102                        |                                        |                   |
|                     | Mean    |                           |                             |                              | 78%                                    | 61%               |
| Johnstown           | 25163   | 27 May 2010 - 30 Jun 2010 | 269                         | 185                          |                                        | 69%               |
|                     | 27170   | 18 Jun 2010 - 27 Jul 2010 | 149                         | 17                           |                                        | 11%               |
|                     | 27340   | 17 Jun 2010 - 1 Jul 2010  | 56                          | 17                           |                                        | 30%               |
|                     | 27466   | 24 Jul 2010 - 9 Sep 2010  | 290                         | 199                          | 79%                                    | 68%               |
|                     | 27910   | 14 Oct 2012 - 29 Jun 2013 | 2102                        | 1,965                        | 96%                                    | 90%               |
|                     | 27961   | 26 May 2010 - 17 Jun 2010 |                             |                              |                                        |                   |
|                     |         | 10 May 2011 - 21 Nov 2011 |                             |                              |                                        |                   |
|                     |         | Total for bear 27961      | 2558                        | 2060                         | 91%                                    | 63%               |
|                     | 31530   | 3 Aug 2011 - 23 Oct 2012  |                             |                              |                                        |                   |
|                     |         | 15 Mar 2012 - 20 Nov 2012 |                             |                              |                                        |                   |
|                     |         | Total for bear 31530      | 2464                        | 1862                         | 86%                                    | 65%               |
|                     | 31716   | 2 Jun 2012 - 13 Mar 2013  | 3371                        | 2,949                        | 94%                                    | 77%               |
|                     | 32726   | 29 Mar 2011 - 22 May 2011 | 247                         | 193                          |                                        | 78%               |
|                     | 32781   | 20 Sep 2010 - 1 Nov 2010  |                             |                              |                                        |                   |
|                     |         | 7 May 2011 - 28 May 2011  |                             |                              |                                        |                   |
|                     |         | Total for bear 32781      | 791                         | 631                          | 84%                                    | 52%               |
|                     | 33127   | 9 Jul 2010 - 5 Aug 2010   | 162                         | 88                           |                                        | 54%               |
|                     | 33148   | 12 Oct 2010 - 5 Jul 2011  | 2009                        | 1,484                        | 89%                                    | 57%               |
|                     | 33153   | 3 May 2011 - 4 May 2011   |                             |                              |                                        |                   |
|                     |         | 3 Jun 2011 - 4 Oct 2011   |                             |                              |                                        |                   |
|                     |         | Total for bear 33153      | 513                         | 184                          | 2%                                     | 39%               |
|                     | 33201   | 10 Apr 2011 - 7 Jan 2012  |                             |                              |                                        |                   |
|                     |         | 4 Oct 2012 - 12 Feb 2013  |                             |                              |                                        |                   |
|                     |         | Total for bear 33201      | 5015                        | 4,125                        | 93%                                    | 59%               |
|                     | 33211   | 21 May 2011 - 5 Aug 2012  | 554                         | 356                          |                                        | 64%               |
|                     | 33366   | 1 Jul 2011 - 14 Jul 2011  |                             |                              |                                        |                   |
|                     |         | 13 Apr 2012 - 5 Jul 2012  |                             |                              |                                        |                   |
|                     |         | Total for bear 33366      | 602                         | 345                          |                                        | 57%               |
|                     | 33369   | 18 Jul 2011 - 15 Sep 2011 | 260                         | 184                          | 93%                                    | 60%               |
|                     | 33836   | 16 Jul 2010 - 12 Aug 2011 | 2693                        | 1,816                        | 72%                                    | 59%               |
|                     | 33838   | 25 Aug 2010 - 12 Nov 2011 | 2527                        | 1,811                        | 86%                                    | 51%               |
|                     | Total   |                           | 26632                       | 20471                        |                                        |                   |
|                     | Mean    |                           |                             |                              | 81%                                    | 58%               |
| All Areas Pooled    | Total   |                           | 148469                      | 110794                       |                                        |                   |
|                     | Mean    |                           |                             |                              | 82%                                    | 62%               |