NEW JERSEY BLACK BEAR AVERSIVE CONDITIONING REPORT

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TABLE OF CONTENTS

List of Tables

List of Figures

INTRODUCTION

NJ Black Bear Response Unit

Black bears (*Ursus americanus*) are a unique part of New Jersey's natural heritage. Black bears have a high public profile, largely because conflict often results when bears come into contact with a wide variety of human attractants, especially during seasons of lower natural food availability.

In addition to the New Jersey Division of Fish and Wildlife's (NJDFW) black bear research and monitoring and public education campaign, personnel implement wildlife control measures to manage nuisance black bears. The Bear Response Unit personnel are biologists and technicians trained in wildlife management techniques, who are certified in firearms use and chemical immobilization. They also actively trap and aversively condition bears responsible for recurring nuisance incidents. They will euthanize bears that show unyielding or aggressive behavior and pose a threat to public safety (designated by NJDFW as Category I), or that do not respond to the conditioning process. Division personnel have trained more than 900 police officers and park police in bear response.

An average of 23 Category I black bears have been destroyed in NJ every year since 2001 with totals reaching as high as 37 bears in 2008 (personal communication NJDFW). People unintentionally or otherwise, allow bears to access non-natural food from sources like garbage, pet food, birdseed or grease from barbeques in residential neighborhoods. Once bears gain access to unsecured foods, they often become food-conditioned and/or habituated to humans. Conflict animals may begin causing property damage to access unsecured food or worse, become a risk to human safety. As the behavior associated with food conditioning and human-habituation escalates, few options are available for dealing with these animals.

Complaints associated with nuisance activity by NJ black bears have steadily increased since 1998, demanding intervention. As a result, former New Jersey Department of Environmental Protection (NJDEP) Commissioner Lisa Jackson emphasized more intensive non-lethal management strategies be implemented. This included increased educational programs, enforced regulations regarding proper garbage disposal and research to determine the effectiveness of aversive conditioning on black bears. The breakdown of the number of complaints involving black bears in New Jersey by type of complaint from 1995- 2008 can be found in Appendix A.

Wildlife-Habitat Relationships

The study of wildlife–habitat relationships implicitly assumes an ability to understand habitat suitability by evaluating physical and biological variables for the bear population in NJ. Furthermore, there is an underlying assumption that a subset of important habitat variables can be measured and evaluated to illuminate complex interactions between a bear and its surroundings. Habitat studies have become essential during the twentieth century as the need for scientific management has increased (Morrison et al.1992). The key to developing a successful habitat model lies in the ability to correctly identify, measure, and classify environmental variables in such a way that habitat suitability is revealed from a subset of the actual environmental conditions (Morrison et al. 1992). Established techniques and numerous field studies, particularly on black bears in different regions of the country, have identified measurable environmental variables that may reveal regional habitat patterns. The development and refinement of Geographic Information System (GIS) technology within the past two decades has provided a new venue for habitat models. GIS is designed for the collection, storage, manipulation, and analysis of data that includes geographic location as an important component of the analysis (Aronoff 1993). Implicit in this definition is the spatial analysis of landscape components; various layers of information can be combined to reveal regions of coincidence between multiple environmental variables. Black bears are especially suitable for GIS habitat analysis due to this species' large home range and coarse use of habitat components. Bears seem to respond to gross changes in habitat conditions, and these changes can be identified in a GIS using environmental variables measured by humans. While bears do respond to micro scale habitat conditions, it has been possible to predict bear habitat use by examining only broad scale variables (e.g. Rudis and Tansey 1995, Agee et al. 1989). Many of the common data layers available (i.e. roads, forest cover types, elevation, urban areas) are significant to black bear ecology, and GIS enables wildlife biologists to study complex patterns over large spatial scales (Clark et al. 1993). Using a GIS enables researchers to examine the landscape in different ways; the best habitat model can be developed by selecting a combination of variables that most reliably quantifies habitat conditions in several particular areas of interest.

Space used by a bear is described by its home range as an area with a spatially defined probability of occurrence of the animal during a specific time period (Powell 2000, Kernohan et al. 2001). Home ranges estimated from radio location or GPS data often form a framework for analysis of animal movements and habitat selection, and good estimates of home ranges can thus provide interesting insight into many basic topics in animal ecology and landscape-level habitat assessment for bears.

The action of removing bears from their home range has shown to have a low success rate and is not an effective biological solution for management of conflict bears. Studies reveal that translocated bears often return to their capture sites, continue their conflict behaviors in other locations, disrupt the resident bear social hierarchy in the translocation area, or have difficulty finding adequate seasonal nutrition because of lack of familiarity with local food items or habitats (Treves and Karanth 2003, Howe et al. 2003). Repeated investigations of mortality rates of translocated animals also indicate that transported bears have lower survival rate (Rogers 1986, Stiver 1991, Blanshard and Knight 1995).

Black Bear Rating and Response Criteria

In November 2000, the NJDFW implemented the current ***Black Bear Rating and Response Criteria (BBRRC)***. The BBRRC is the operating policy for response to bears that are a threat to human safety, agricultural crops, property or are a nuisance (NJDFW BWM 2000). The BBRRC defines three categories of black bear behavior and dictates how the New Jersey Department of Environmental Protection and local law enforcement should respond. Category I are bears which are a threat to public safety and property, Category II are nuisance bears which are not a threat to public safety or property, and Category III are bears that exhibit normal behavior and are not a nuisance or threat to public safety.

Non-Lethal Approaches to Bear-Human Conflicts

Non-lethal methods for dealing with conflict bears have been investigated and practiced across North America for all three bear species since the early 1980s, with varying degrees of success (Gillin et al. 1994, McCarthy and Seavoy 1994, Hunt 1984, Schirokauer and Boyd 1998). Recent monitoring programs in Yosemite National Park (Hastings 1980), Lake Tahoe (Beckman et al. 2004), Banff, Yoho and Kootenay National Parks (Morrison 2004), and in Europe (Rauer et al. 2003) have further advanced our understanding of non-lethal approaches to conflict bear management (Howe et al. 2003). Methods utilized in these studies were aversive conditioning and hazing.

Oka et al. (2004) reported that conflict frequency and intensity is directly related to broad scale failures in natural food supplies. Individual bear conflict history and general bear health influence success of non-lethal methods (Gillin et al. 1994). The local bear density and population trends influence the success of non-lethal programs (Clark et al. 2002). The efficacy of non-lethal approaches is directly related to ongoing availability of non-natural attractants (Clark et al. 2002). Some studies suggest that the use of dogs (Laika, Karelian, and black mouth yellow cur) appear to be a plausible management tool (Gillin et al. 1997, Leigh and Chamberlin, 2008). In other studies using hounds, dogs were no more effective at deterring bears over the long-term (Beckmann et al. 2004).

It is easier to reduce conflicts with human-habituated bears than with food- conditioned bears (Greenleaf 2005). Human habituation and food-conditioning are related; there is some evidence that human habituation can lead directly to conflict (Albert and Bowyer 1991).

Studies have investigated how human food-conditioning and habituation influence success rates of behavioral change through hazing or aversive conditioning. These studies have demonstrated that bears at dumps (i.e. landfills and presumably wherever non-natural food is available to bears) may be placed along a gradient of dependence on human foods, from regular use across the entire season to occasional, rare use only during some part of the season, to no use at all; these studies have also demonstrated that age class and sex may strongly influence this (Craighead et al. 1995, Herrero 1985).

Aversive conditioning is a method designed to provide the offending animal with a negative experience using various deterrent measures, such as rubber buckshot, loud noise, and dogs, in hopes that the offender resigns from nuisance behavior (Conover 2002). However, is aversive conditioning or hazing (typically a very labor and time intensive effort) operationally feasible? Early outcomes of LeGrandeur's (1999) research indicated that deterrents can teach bears to avoid sites of conflict if the bear is not food-conditioned. This early work also triggered an on-going collective effort for black bear conservation and management at Whistler, BC (Brabyn et al. 2006, Homstol et al., 2007).

Operational feasibility (LeGrandeur 1999), successful behavior modification, especially on food-conditioned animals (LeGrandeur 1999, Greenleaf 2005), and human safety around food-conditioned animals (Hastings and Gilbert 1984) are examples of outstanding issues regarding non-lethal method operations (Maryland Department of Natural Resources 2004, Virginia Department of Game and Inland Fisheries 2002).

Study Rational

Human–bear conflicts pose significant concern in urban–wild land interfaced communities throughout North America (Beckmann and Lacky 2008, Brown and Conover 2008, Lemelin 2008, Thiemann et al. 2008, Ziegltrum 2008) and the world (Worthy and Foggin 2008). Reports involving nuisance black bears have increased in magnitude and frequency, with an increase of more than 1,500 cases reported in the last decade throughout eastern portions of the United States (Spiker 2007).

New Jersey has a history of black bears living in close proximity to residents (McConnell et al. 1997, Carr and Burguess 2004). As bear and human populations increase and development continues, there is increased potential for human-bear conflict. Interactions between humans and bears are a significant management concern throughout the state of NJ. Conflicts between humans and black bears are commonly centered on the availability of human-provided food and garbage to bears. Similar to other regions, the relationship between bears and humans in some counties in NJ may lead to alterations in the natural behavior, foraging habits, reproductive rates, physical size, and distribution.

One of the objectives outlined by former NJDEP Commissioner Lisa P. Jackson for inclusion into future **Black Bear Management Policy** was to investigate the use of non-lethal aversive conditioning techniques on black bears living in a human-dominated landscape. Ideally, non-lethal behavioral modification techniques would be applied to *prevent* food conditioning thereby minimizing human bear conflict in a non-lethal manner.

The goal of this study was to determine whether aversive conditioning techniques are effective at eliminating nuisance activity in urban landscapes. Of the 6 landscape groups recognized by (NJDEP), only coordinates that were within the urban landscape group were used to determine the distances for "return to urban setting". Power lines are designated as an urban landscape but were excluded for the purpose of this project.
In order to test if aversive conditioning techniques were successful, we evaluated bear movement in and around an urban landscape after the bear was released. Success was

based on whether the individual animal returned to an urban environment after being conditioned.

MATERIALS AND METHODS

Study Area

The study area was determined where nuisance black bear behavior had been reported. It is located in the area known as the Bearfort Mountains. It consists of 175.9 square miles and includes areas of Sussex (Vernon and Hardyston Townships) and Passaic (West Milford Township) counties in New Jersey (Figure 1). Bearfort Mountains is located at latitude - longitude coordinates of N 41.13954 and W -74.39182. Bearfort Mountains is shown in the center of the topographic (topo) map, which is sourced from the United States Geographical Survey map USGS Wawayanda quad. Land use ranges from residential to agricultural and recreational land. The area consists of wetlands, streams and lakes. The vegetation of this part of the state is characteristic of upland forest and lowland swamps and drainages. Most of the area is successional forest as it was harvested for its timber and converted to pasture in the 1700s and 1800s. Forest composition consists of chestnut oak (*Quercus prinus*), pitch pine (*Pinus rigida*) and white oak (*Quercus alba*). Chestnut oaks are most common on the ridge tops while pitch pines and scrub oak (*Quercus ilicifolia)* occur at the highest elevations of the Bearfort Mountains. On the slopes and surrounding low lands of the Bearfort Mountains, there are three major forest types: mixed oaks (deciduous), hemlock-mixed oaks (coniferous-deciduous mix) and wetland associated species (swamps, deciduous or palustrine wetlands, herbaceous wetlands). In the moist valleys and ravines, there are hemlock (*Tsuga canadensis*) forests with mixed oaks. In the fertile lowlands, there are sugar maples (*Acer saccharum*) mixed with oaks and other hardwoods. The mixed oak forests, which dominate much of the study area, are largely composed of red, black and white oaks.

Based on the U.S Census Bureau’s 2000 census of the study area, a total of 57,267 people live within the confines of the study area (Table 1). There are 22,593 homes located within the 175.9 square miles of land incorporated within these three townships.

Table 1. Township demographic information for the study area**.**

Information Based on U.S. Census 2000	Pop	Number of Housing Units	Township Size Square Miles	Density per Square Mile
Vernon	24,686	9,994	68.4	361
Hardyston	6,171	2,690	32.1	192
West Milford	26,410	9,909	75.4	350
Total	**57,267**	**22,593**	**175.9**	

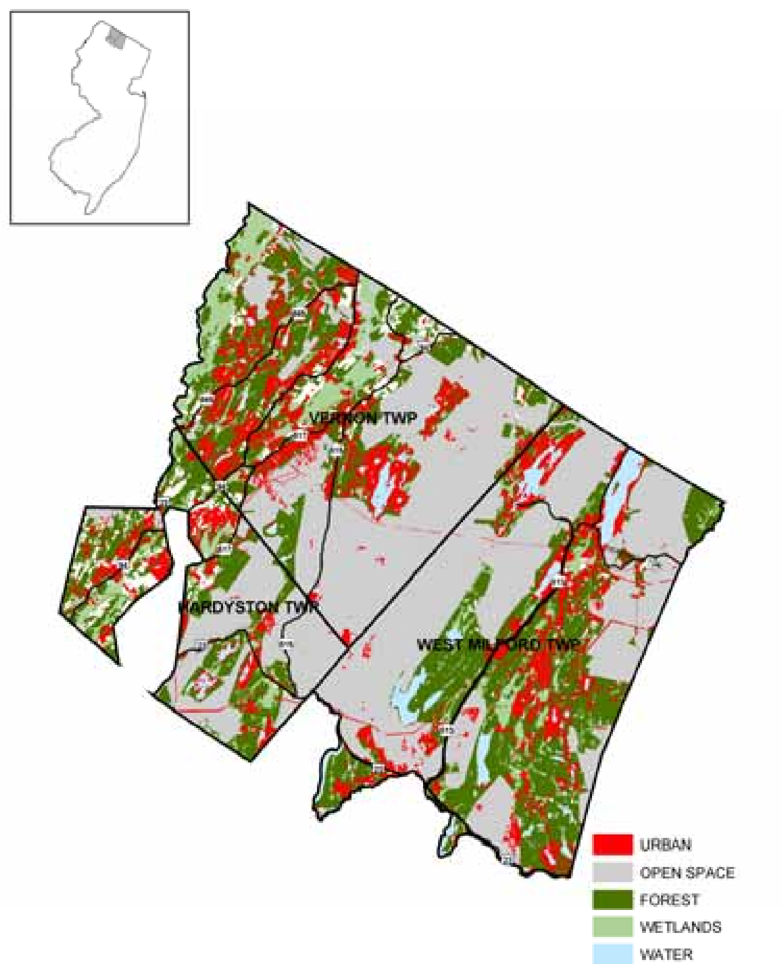

Figure 1. The study area is located in the area known as the Bearfort Mountains. It consists of 175.9 square miles and includes areas of Sussex (Vernon and Hardyston Townships) and Passaic (West Milford Township) counties in New Jersey.

Satellite Collars

Satellite collars (Northstar Science and Technology, LLC P.O. 438, King George VA. 22485) using the Global Star Satellite System were fastened to nine bears. The Global star satellite system utilizes 52 satellites as opposed to the Argos system that currently uses 5 satellites. The increased number of satellites increases the success of acquiring GPS coordinates in areas that were in less than ideal locations. Collars were programmed to collect 24 GPS locations per day at a rate of 1 per hour. GPS coordinates were available through a password protected website and offered in real time. Data was provided on Google maps and GPS coordinates were viewable from the website. All collars were equipped with a separate VHF transmitter to monitor movement and to retrieve collars if a malfunction occurred. The collars displayed a reading on the website that indicated if the bear was moving at the time each transmission occurred. After all collars were retrieved, they were sent back to the manufacturer who downloaded the stored on board points and sent the data back to us as a comma-delimited text file. These points were then utilized for the evaluation of bear movement in this study. Collar accuracy was verified to manufacturer's specifications to be within 2.5 meters 66% of the time and within 5 meters 95% of the time.

Cameras

Five Reconyx PC85T Professional Rapid Fire Color IR- Telephoto 3.1 Megapixel color by day monochrome by night with 2.5X telephoto lens (Reconyx, Inc., 3828 Creekside Lane, Holemen WI 54636) were placed at random dumpster sites in July 2008, throughout Great Gorge Village (GGV), Vernon Township, Sussex County to observe bear behavior at dumpster sites. The cameras were taken down December 2008. The cameras were set up initially for a concurrent project monitoring black bear activity at dumpster sites in GGV.

Capture

Trapping began May 1, 2008 at nuisance locations that exhibited the best sign of recent bear activity. Culvert traps baited with bacon, molasses, donuts and "Bear Scent" attractant (Bear Scents, LLC™ , P.O. Box 223 , Lake Mills, WI 53551) and a free-range darting technique were used for capture. Culvert traps were checked and baited daily by Division personnel. All traps were clearly marked with the Division Logo and warned the general public to maintain a safe distance from the trap.

Immobilization

Using Safe Capture International approved methods of immobilization and animal care, professionally trained Division employees chemically immobilized captured bears. Employees used a mixture of Ketamine Hydrochloride and Xylazine Hydrochloride at a ratio of 2:1 at a concentrated dosage (Congaree Veterinary Pharmacy, 1309-B State

Street, Cayce SC 29033). The Ketamine Hydrochloride is concentrated to 200mg/ml and the Xylazine Hydrochloride is concentrated to 450mg/ml. Bears were immobilized using Pneu Dart disposable darts (Pneu-Dart Inc., 15523 Route 87, Williamsport PA 17701) fired from a Pneu Dart hand held pneumatic dart projector or a Dan Inject (Dan Inject of North America, P.O. 7266, Knoxville TN 37921) long range dart projector. Using concentrated drug allows Division employees to use smaller, less traumatic darts.

Each bear's vital signs were monitored throughout the entire handling process. Blood and tissue samples were taken from each bear for analysis. Each bear was tagged with a set of aluminum ear tags, and some were also tagged with plastic cattle tags. An upper pre-molar was extracted for aging using the cementum annuli aging procedure (Matson's Laboratory, P.O. Box 308, Milltown MT 59851). Each bear was tattooed with an identification number, weighed and morphological measurements were taken. Once data was collected, the bear was fitted with a satellite GPS collar. Yohimbine (Zoo Pharmacy, 3131 Grand, Suite B, Laramie WY 82070) was used as a reversal agent at a concentration of 10mg/ml. It was administered 40 minutes after induction.

Release – Aversive Conditioning

All bears were released at the site where the initial capture occurred. Bears were given either a *soft* release (with no pain stimuli) or *hard* release (using pain stimuli and noise deterrents) (Figure 2). Bears were aversively conditioned only at the initial release because we were interested in the effects of the hard release treatment and the resultant subsequent actions by the bear.

The treatment black bears were subjected to a *hard* release that involved an aversive conditioning session utilizing harassment techniques consisting of rubber buckshot, pyrotechnics and Black Mouth Yellow Cur dogs. The control group was considered a *soft* release where the animals were released in a quiet manner and not subject to an aversive conditioning session. Bears were observed during each release as to their stress reaction (primarily vocalizations and jaw-popping), speed of exit from the trap, and whether the bear stopped while seeking cover. All animals retreated into thick brush or forested areas after being released.

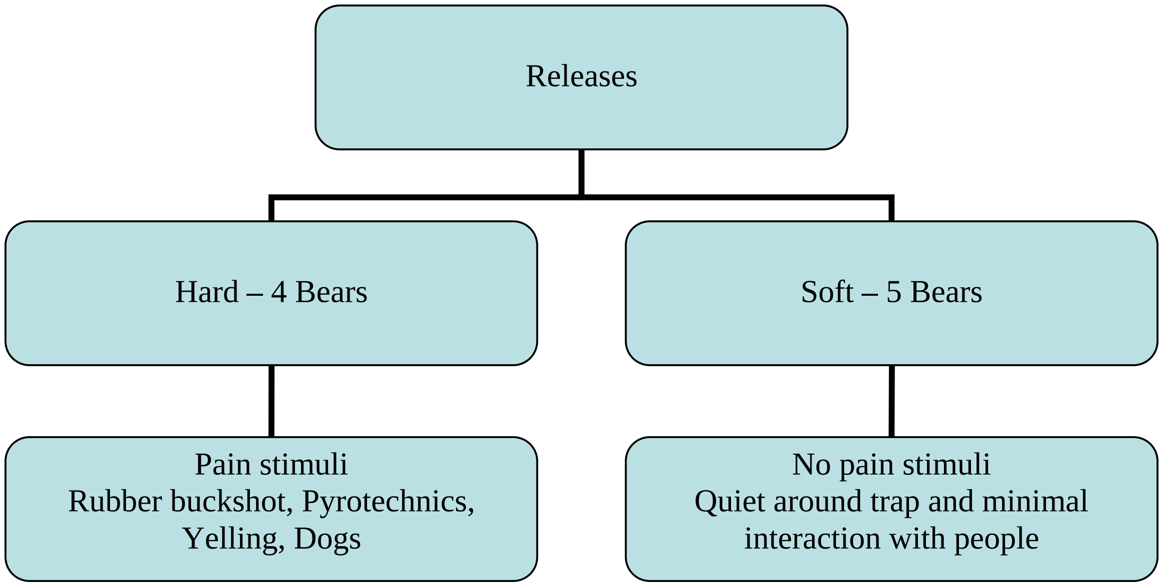

Figure 2. Hard release versus soft release protocols for study animals.

After all biological data was collected, yohimbine was administered as a reversal agent and the bear was placed back into a culvert trap to allow full recovery from anesthesia and to ensure an ideal and effective aversive conditioning. After determining the bear had fully recovered, two NJDFW personnel stood alongside the trap and the bear was released. Five rounds of Def Tech Stinger rubber ball buckshot (Def Tec Technology, 1855 South Loop Avenue, Casper WY 82601) fired from a 12-gauge shotgun were shot at the hindquarters of the bear at a distance of no greater than 15 yards. Three rounds of Shot Tell Pyrotechnics (Reed-Joseph Int., 800 Main Street, Greenville MS 38701) were fired above the bear's head as a noise deterrent. After reaching a distance of 50 yards, two Black Mouth Yellow Cur dogs were released and chased after the animal to further enhance the aversive conditioning session. If the bear treed, the dogs were retrieved and the bear was permitted to descend from the tree. Once on the ground the dogs were released for a second treatment. The conditioning session was terminated if the bear refused to leave the confines of the tree or after 15 minutes had elapsed. Each session was recorded to document behavior and reaction of each individual.

Home Range Analysis

The 95% fixed-kernel home range estimates were calculated as habitat available to individual bears during the study, and the 50% fixed-kernel home range estimates were calculated to define a seasonal core-use area (Thomas and Taylor 1990, Manly et al. 1993). The 50% probability region represents a smaller area with a higher density of telemetry locations while the 95% kernel was treated as habitat area that was locally available for core usage. For each comparison of resource selection and availability, standardized selection ratios described by Manly et al. (1993) were computed. Utilizing the coordinates within the 95% kernel for each bear, home range analysis was determined for both conditioned and non-conditioned bears (Table. 3) Habitat selection was determined at two spatial scales (Johnson 1980), the level of the study area (landscape level or 2nd-order selection) and the level of the home range (home-range-level or 3rd-order selection). In the home-range level analysis, the vegetation type composition of the home range was considered available habitat for a given individual and the specific types used by that individual were considered used habitat. Seasons were determined as follows: spring May 2- June 19; summer June 20- September 21; and fall September 22- October 21.

Dumpster Analysis

A GPS reading was taken for all dumpsters within each township. Bear locations were plotted against the dumpster locations to determine if non-treatment bears utilized these areas more than the conditioned bears.

Soft Mast Analysis

During July 2008 a soft mast evaluation was conducted within home range kernels determined by internet transmitted points for each of the nine black bears that were part of this study. This was performed in order to determine food availability and determine if it contributed to why black bears returned to an urban setting after being aversively conditioned. Using the Animal Movement extension fixed kernel density estimator in ArcView 3.3 at a 50% utilization distribution, a random point was generated within each kernel generated for each animal (Hooge 1997). At the coordinates chosen within each of the 18 kernels, five 3-m radius circular plots were examined. One plot was at the exact coordinates generated by the computer, the others were 100 m away in each of the cardinal directions. In each of the five plots within a kernel, every species capable of bearing ripe soft mast in July was recorded. The percent of the plot covered by each of these species was also recorded. Then, the percentage of each of these species actually bearing ripe fruit was recorded. A soft mast index value was generated for each of the 18 kernels by summing the products of percent cover and percent bearing ripe fruit for each soft mast bearing species. The Bonferroni Pairwise Comparison and the Mann-Whitney Nonparametric tests were used to determine soft mast availability between conditioned and non-conditioned bears.

Landscape Usage Analysis

We refer to ‘‘habitat selection’’ as a difference between observed habitat utilization and expected habitat utilization as determined from a null model (Johnson 1980). We define the habitat that was used most relative to expectation as ‘‘most preferred’’ and the habitat that was used least relative to expectation as ‘‘least preferred.’’

We define any habitat that is used more than expected as a ‘‘preferred habitat’’ and any habitat that is used less than expected as an ‘‘avoided habitat’’. Many habitat selection metrics rely on classifying animal locations by habitat type and determining proportional use of habitats (Johnson 1980, Aebischer et al. 1993), and we define such techniques as ‘‘classification approaches.’’ In contrast, we define methods based on measuring the Euclidean distance from animal locations to habitat features as ‘‘distance-based approaches.’’ Aebischer et al. (1993) argued that a habitat selection metric should: use individual animals as sampling units, be unaffected by the unit-sum constraint, permit tests for differential habitat use among meaningful groups (e.g., sexes or age classes), and allow habitat assessment at multiple spatial scales. They went on to introduce compositional analysis (CA) as a tool for analyzing resource selection data. Since its introduction, CA has become one of the most widely used habitat analysis procedures. Euclidean distances between animal locations and habitat features have been used in studies of animal habitats but for only a restricted set of applications that involved linear (e.g., creeks and roads) or point (e.g., trees and burrows) habitat features (Conner and Plowman 2001, Garrison et al 2007). Use of Euclidean distances for aerial features (e.g., habitat types) has received much less attention. Euclidean distances for habitat types are especially instrumental for detecting differences in bear habitat assessment. For the statistical analyses we selected the Tukey’s multiple comparison test that is the most conservative test among all post-hoc tests when group sizes are unequal.

RESULTS

Capture

Nine adult female black bears were captured from May 2 to June 28, 2008. Seven captures were made using culvert traps; two bears were captured using free-range darting. Seven were captured at dumpster locations and two were captured at residences in a community where a resident was illegally feeding bears.

Immobilization

There were no complications during immobilization. All bears appeared to be in good health. Of the nine bears captured, three had been previously tagged during research trapping. Body weights ranged from 145 pounds to 261 pounds. At the time of capture three of the nine animals had a known age, eight years (Bear ID# 2603), nine years (Bear ID# 4025), three years (Bear ID #4848), teeth went sent out on subsequent study animals for age determination by cementum annuli analysis (Table 2). Four of the nine females had cubs of the year at the time of capture. Bear ID# 4025 and Bear ID# 2603 had four cubs each on the day they were collared. Bear ID# 5109 exhibited signs of lactating but no cubs were observed at the time of capture. Bear ID# 5316 had at least one cub with her at the time of capture. All animals appeared to be in good health with no visible signs of injuries except for Bear ID# 6870 which suffered from an old right hip injury.

Table 2. Initial capture of Bears from May 2nd – June 28th, 2008.

Bear ID	Body weight (lbs)	Age (years)	Cubs	Capture method	Capture site	Conditioned
5538	179	3	0	Culvert	Dumpster	No
5316	160	6	1	Culvert	Dumpster	No
5109	228	10	Lactating	Culvert	Dumpster	No
6822	261	N/A	0	Dart Gun	Residence	No
2603	No Weight Collected	8	4	Dart Gun	Dumpster	No
6870	145	N/A	0	Culvert	Dumpster	Yes
4848	146	3	0	Culvert	Dumpster	Yes
5105	160	2	0	Culvert	Residence	Yes
4025	204	9	4	Culvert	Dumpster	Yes

Releases

All black bears were released at the capture site.

Monitoring

Nine study animals were monitored for 173 days from May 2, 2008 – October 21, 2008. A total of 19,918 points were collected throughout the entire study period. The first bear was collared on May 2, 2008 and the last collar was deployed on June 28, 2008.

Bear #5538 is an adult, (3 years-old) previously untagged, 179.0 pound female collared on May 2, 2008 in Great Gorge Village in Vernon Township, Sussex County. The animal was not aversively conditioned but was released at the capture site. The collar failed to log GPS coordinates within the first three days and on May 6, 2008 the collar was replaced after the animal was free range darted, within the village. The same collar remained operable until June 13, 2008 when the bear was captured in a culvert trap and the satellite collar was replaced with a standard VHF collar due to a malfunction of the replacement collar. On June 16, 2008 the same bear was captured in an Aldrich foot snare near Great Gorge Village and released on site after biological data was collected. On July 14, 2008, Bear #5538 was free range darted at the Great Gorge Village garbage disposal facility and had a replacement satellite collar applied. On October 6, 2008 the bear was free range darted from a dumpster within the village and the satellite collar was removed and replaced with a VHF collar. The bear was handled on six occasions during the period May 2, 2008- October 6, 2008 and a total of 2,168 points were compiled for the study period from May 2, 2008-October 6, 2008.

Bear #6870 is an adult, (age not available) previously untagged, 145.0 pound female collared on May 5, 2008 off Route 94 in Vernon Township, Sussex County. The animal was aversively conditioned at the capture site and released. The bear was handled on July 30, 2008 at Great Gorge Village after being free range darted within 10 yards from a

BMX bicycle trail that was being heavily used. A total of 857 GPS coordinates were compiled for the study period from May 5, 2008- July 30, 2008.

Bear #6822 is an adult, (age not available) previously untagged, 261.5 pound female collared on May 12, 2008 in West Milford Township, Passaic County. The animal was not aversively conditioned but was released at the capture site. The bear was handled on May 29, 2008 within 200 yards of the initial capture location. The collar had malfunctioned and was replaced with a second satellite collar. The bear was handled on August 18, 2008 after being free range darted and the collar was removed. A total of 2,225 GPS coordinates were compiled for the study period from May 12, 2008 – August 18, 2008.

Bear #5105 is an adult, (2 years-old) previously untagged, 160.0 pound female collared on May 13, 2008 in West Milford Township, Passaic County. The animal was aversively conditioned and released at the capture location. The animal was handled on October 12, 2008 and the satellite collar was removed and replaced with a VHF collar. A total of 3,402 GPS coordinates were compiled for the study period from May 13, 2008 – October 12, 2008.

Bear #5109 is an adult, (10 years-old) previously untagged, 228.0 pound female collared on May 14, 2008 in West Milford Township, Passaic County. The animal was not aversively conditioned but was released at the capture site. The collar was dropped on June 15, 2008 and retrieved several days later. A total of 722 GPS coordinates were compiled for the study period from May 14, 2008-June 15, 2008.

Bear #4025 is an adult, (9 years-old) previously tagged, 204.0 pound female collared on May 20, 2008 in Hardyston Township, Sussex County. The animal was aversively conditioned and released at the capture site. The animal was handled on October 3, 2008 and the satellite collar was removed and replaced with a VHF collar. A total of 1,495 GPS coordinates were compiled for the study period from May 20, 2008-October 3, 2008.

Bear #2603 is an adult, (8 years-old) previously tagged, 220.0 pound female collared on May 27, 2008 in Hardyston Township, Sussex County. The animal was not aversively conditioned but was released at the capture location. The animal was handled on October 10, 2008 and the satellite collar removed after the bear was euthanized for Category I behavior. A total of 3,117 GPS coordinates were compiled for the study period from May 27, 2008-October 10, 2008.

Bear #5316 is an adult, (6 years-old) previously untagged, 160.0 pound female collared on June 26, 2008 in Vernon Township, Sussex County. The animal was not aversively conditioned but was released at the capture location. The animal was found dead on October 21, 2008 in New York State and the satellite collar was removed. A total of 2,696 GPS coordinates were compiled for the study period from June 26, 2008-October 21, 2008.

Bear #4848 is an adult, (3 years-old) previously tagged, 146.0 pound female collared on June 28, 2008 in Vernon Township, Sussex County. The animal was aversively conditioned and released at the capture location. The animal was handled on October 8, 2008 in Vernon Township and the satellite collar was removed and replaced with a VHF collar. A total of 2, 256 GPS coordinates were compiled for the study period from June 28, 2008-October 8, 2008.

Home Range Size

Home ranges were calculated utilizing the 95% fixed kernel for each animal throughout the duration of the study. Home range size did not differ significantly between conditioned and non-conditioned bears with an average of 3.03 square miles for conditioned bears and 3.19 square miles for unconditioned bears (Table 3). Average annual home range sizes for adult female bears from the Kittattiny Mountain range in Western Sussex and Warren Counties of NJ were found to be 1.72 square miles (MacKenzie 2003) and 1.9 square miles (Shramko 2005).

Table 3. Home ranges of conditioned and non- conditioned bears.

Bear Id	Conditioned	Home Range Square Miles
2603	No	1.47
5109	No	3.02
5316	No	8.09
5538	No	0.87
6822	No	1.72
Average		**3.03**
4025	Yes	1.60
4848	Yes	3.74
5105	Yes	5.83
6870	Yes	1.60
Average		**3.19**

Return to Capture Site

The closest distance in feet to the capture site and the time it took for the bear to return is depicted in Table 4. Bear ID# 5538 was censored for the time of return calculation due to collar malfunction during the first three days of deployment. For the soft releases the range was 17 -528 feet (average 140 feet) and time to return ranged from 2-38 days (average 18 days). For the hard releases the range was 28-321 feet (average 207 feet) from the capture site and the time to return was 45-85 days (average 57 days).

Table 4. The closest distance in feet to capture site and time to return, for soft and hard releases.

Bear ID Number	Closest Distance to Capture Site (Feet)	Time to Return (Days)
Soft Releases		
5538	17	*
5109	528	2
6822	65	13
2603	60	21
5316	29	38
Hard Releases		
6870	306	49
5105	321	45
4025	28	47
4848	175	85

*Collar malfunctioned, no data collected the first three days.

Return to Urban Setting

The length of time that it took for the hard and soft released bears to return to an urban setting is illustrated in Table 5 and Figures 12 - 20. Bear ID# 5538 was censored for the time of return calculation due to collar malfunction during the first three days of deployment. The time to return for the soft releases ranged from 3-7 days (average 5 days). The time to return for the hard releases ranged from 3-17 days (average 9 days). Appendix D illustrates photos of conditioned bears that returned to a dumpster site.

Table 5. The time to return to an urban setting after either a hard or soft release.

Bear ID Number	Time to Return to an Urban Setting (Days)
Soft Releases	
5538	*
5109	4
6822	3
2603	7
5316	6
Hard Releases	
6870	3
5105	17
4025	6
4848	8

*Collar malfunctioned, no data collected the first three days.

Figures of Home Range Analysis and Activity Maps

See Appendix D

Cameras

While monitoring dumpsters in GGV for black bear activity, cameras recorded three of the bears in the study group. The bears were positively identified by unique ear tags and morphological markings. Bears # 4848, #5538, #6870 were each photographed in a dumpster in GGV. These three animals were all initially captured for exhibiting this same behavior. Bears # 4848 and # 6870 were conditioned animals while # 5538 was unconditioned.

Habitat Use

Telemetry locations (19,918) were collected and used to determine habitat use of the nine black bears in NJ during the 2008 spring, summer, and fall seasons. A resulting ranking matrix of pairwise comparisons was used to rank relative habitat preferences. The ranking matrix ordered habitat types in order of use from "most preferred" to "least preferred" in the following sequence: forest > wetlands > urban > water > barren lands > agriculture. Pairwise comparisons indicated that FOREST was preferred ($P < 0.05$) over all other habitats (see Tables 6- 25). Forest was used significantly more than the other top-ranking habitats and significantly more than the two bottom-ranking habitats. There was a detectable difference in use of the second and third top-ranking habitats for two bears, #5538 and #6870, which preferred urban areas to wetlands in the spring and summer seasons, and bear #5538 which preferred urban areas more often than the other animals, 20% of the time, also in the fall season. Each of the top-ranking habitats was used significantly more than the remaining habitat types. There was no detectable difference in use of the bottom-ranking habitats. Overall, use of the six habitat types based on satellite location compositions differed significantly from the habitat compositions within the kernel. Seasonal variations in urban habitat use differ for several bears: bear # 5538 used it more often than the third-ranking habitat in the spring, summer and fall seasons. Bear #2603 and #4848 used it in the summer season, and bear #6870 in the spring and summer. Barren habitat and agriculture covers were used significantly less than the four top-ranking habitats.

Seasonal and Spatial Variation In Landscape Use

Tables 6-25, listed below by bear ID number, are individual seasonal landscape cover selections for each of the nine bears. These results compare the frequency of revisiting six landscape covers for each season, spring, summer, and fall, using a general randomized block design with individual collared animals as a blocking factor to control for individual variation across seasonal periods. For the analyses, the GIS-obtained vegetation covers (Cover Variable) were classified into six groups: 1 – agriculture, 2 – forest, 3 – urban, 4 – water, 5 – barren lands, 6 – wetlands. Seasons were determined as follows: spring May 2- June 19; summer June 20- September 21; and fall September 22- October 21.

Table 6. Seasonal and spatial variation in landscape use, Bear #2603, Spring 2008
Vegetation covers (Cover Variable) were forest, urban, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	223	40.5	40.5	40.5
urban	25	4.5	4.5	45.0
wetlands	303	55.0	55.0	100.0
Total	**551**	**100.0**	**100.0**	

Table 7. Seasonal and spatial variation in landscape use, Bear #2603, Summer 2008
Vegetation covers (Cover Variable) were forest, urban, water, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	1134	52.8	52.8	52.8
urban	318	14.8	14.8	67.7
water	2	0.1	0.1	67.8
wetlands	692	32.2	32.2	100.0
Total	**2146**	**100.0**	**100.0**	

Table 8. Seasonal and spatial variation in landscape use, Bear #2603, Fall 2008
Vegetation covers (Cover Variable) were forest, urban, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	292	73.4	73.4	73.4
urban	27	6.8	6.8	80.2
barren lands	2	0.5	0.5	80.7
wetlands	77	19.3	19.3	100.0
Total	**398**	**100.0**	**10.0**	

Table 9. Seasonal and spatial variation in landscape use, Bear #5109, Spring 2008. Vegetation covers (Cover Variable) were forest, urban, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	558	77.3	77.3	77.3
urban	48	6.6	6.6	83.9
barren lands	1	0.1	0.1	84.1
wetlands	115	15.9	15.9	100.0
Total	**722**	**100.0**	**100.0**	

Table 10. Seasonal and spatial variation in landscape use, Bear #5316, Summer 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, barren lands, wetlands**.**

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	18	8.3	8.3	8.3
forest	1229	61.0	61.0	69.4
urban	161	8.0	8.0	77.4
barren lands	3	0.1	0.1	77.5
wetlands	453	22.5	22.5	100.0
Total	**2014**	**100.0**	**100.0**	

Table 11. Seasonal and spatial variation in landscape use, Bear #5316, Fall 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	6	0.9	1.6	1.6
forest	314	46	81.6	83.1
urban	11	1.6	2.9	86.0
barren lands	1	0.1	0.3	86.2
wetlands	53	7.8	13.8	100.0
Total	**385**	**56.5**	**100.0**	
Missing- habitat data-time bear spent in NY	**297**	**43.5**		
Total	**682**	**100.0**		

Table 12. Seasonal and spatial variation in landscape use, Bear #5538, Spring 2008. Vegetation covers (Cover Variable) were forest, urban, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	195	78.9	78.9	78.9
urban	48	19.4	19.4	98.4
wetlands	4	1.6	1.6	100.0
Total	**247**	**100.0**	**100.0**	

Table 13. Seasonal and spatial variation in landscape use, Bear #5538, Summer 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, water, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	3	0.2	0.2	0.2
forest	1149	74.8	74.8	75.0
urban	314	20.4	20.4	95.4
water	4	0.3	0.3	95.7
wetlands	66	4.3	4.3	100.0
Total	**1536**	**100.0**	**100.0**	

Table 14. Seasonal and spatial variation in landscape use, Bear #5538, Fall 2008. Vegetation covers (Cover Variable) were forest, urban, water, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	279	72.5	72.5	72.5
urban	77	20.0	20.0	92.5
water	3	0.8	0.8	93.2
wetlands	26	6.8	6.8	100.0
Total	**385**	**100.0**	**100.0**	

Table 15. Seasonal and spatial variation in landscape use, Bear #6822, Spring 2008. Vegetation covers (Cover Variable) were forest, urban, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	774	84.4	84.4	84.4
urban	40	4.4	4.4	88.8
wetlands	103	11.2	11.2	100.0
Total	**917**	**100.0**	**100.0**	

Table 16. Seasonal and spatial variation in landscape use, Bear #4025, Spring 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	2	0.5	0.5	0.5
forest	218	51.4	51.4	51.9
urban	23	5.4	5.4	57.3
wetlands	181	42.7	42.7	100.0
Total	**424**	**100.0**	**100.0**	

Table 17. Seasonal and spatial variation in landscape use, Bear #4025, Summer 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	13	1.3	1.3	1.3
forest	809	81.5	81.5	82.8
urban	105	10.6	10.6	93.4
barren lands	1	0.1	0.1	93.5
wetlands	65	6.5	6.5	100.0
Total	**993**	**100.0**	**100.0**	

Table 18. Seasonal and spatial variation in landscape use, Bear #4025, Fall 2008. Vegetation covers (Cover Variable) were forest, urban, wetlands**.**

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	63	80.8	80.8	80.8
urban	2	2.6	2.6	83.3
wetlands	13	16.7	16.7	100.0
Total	**78**	**100.0**	**100.0**	

Table 19. Seasonal and spatial variation in landscape use, Bear #4848, Summer 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, water, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	40	2.2	2.2	2.2
forest	1032	56.2	56.2	58.4
urban	334	18.2	18.2	76.6
water	3	0.2	0.2	76.8
barren lands	3	0.2	0.2	76.9
wetlands	423	23.1	23.1	100.0
Total	**1835**	**100.0**	**100.0**	

Table 20. Seasonal and spatial variation in landscape use, Bear #4848, Fall 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, water, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	3	0.7	0.7	0.7
forest	326	78.0	78.0	78.7
urban	34	8.1	8.1	86.8
water	9	2.2	2.2	89.0
barren lands	2	0.5	0.5	89.5
wetlands	44	10.5	10.5	100.0
Total	**418**	**100.0**	**100.0**	

Table 21. Seasonal and spatial variation in landscape use, Bear #5105, Spring 2008. Vegetation covers (Cover Variable) were forest, urban, water, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	530	65.8	65.8	65.8
urban	50	6.2	6.2	72.0
water	1	0.1	0.1	72.2
wetlands	224	27.8	27.8	100.0
Total	**805**	**100.0**	**100.0**	

Table 22. Seasonal and spatial variation in landscape use, Bear #5105, Summer 2008.Vegetation covers (Cover Variable) were agriculture, forest, urban, water, barren lands, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	1	0.0	0.0	0.0
forest	1487	69.7	69.7	69.8
urban	178	8.3	8.3	78.1
water	3	0.1	0.1	78.3
barren lands	1	0.0	0.0	78.3
wetlands	462	21.7	21.7	100.0
Total	**2132**	**100.0**	**100.0**	

Table 23. Seasonal and spatial variation in landscape use, Bear #5105, Fall 2008. Vegetation covers (Cover Variable) were forest, urban, wetlands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	363	78.1	78.1	78.1
urban	4	9	0.9	78.9
wetlands	98	21.1	21.1	100.0
Total	**465**	**100.0**	**100.0**	

Table 24. Seasonal and spatial variation in landscape use, Bear #6870, Spring 2008. Vegetation covers (Cover Variable) were agriculture, forest, urban, barren lands, wetlands

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
agriculture	2	.3	.3	.3
forest	441	75.8	75.8	76.1
urban	102	17.5	17.5	93.6
barren lands	4	.7	.7	94.5
wetlands	33	5.7	5.7	100.0
Total	**582**	**100.0**	**100.0**	

Table 25. Seasonal and spatial variation in landscape use Bear #6870, Summer 2008. Vegetation covers (Cover Variable) were forest, urban, barren lands.

Cover	Frequency	Percent	Valid Percent	Cumulative Percent
forest	186	67.6	67.6	67.6
urban	78	28.4	28.4	96.0
barren lands	11	4.0	4.0	100.0
Total	**275**	**100**	**100**	

The following tables, Tables 26 - 28, are organized by bear ID to show the animal's seasonal selection for the three top-ranking covers: forest, wetlands, and urban areas, respectively.

Table 26. Landscape use of forest for conditioned and unconditioned black bears. Soft release #s 5538, 5109, 6822, 2603, and 5316. Hard release #s, 6870, 5105, 4025, 4848.

Bear ID	Conditioned?	Frequency/ Percent, Spring	Frequency/ Percent, Summer	Frequency/ Percent, Fall
2603	No	223 (40.5%)	1134 (52.8%)	292 (73.4%)
5109	No	558 (77.3%)	dropped collar	dropped collar
5316	No	no spring data	1229 (61%)	314 (46%)
5538	No	195 (78.9%)	1149 (74.8%)	279 (72.5%)
6822	No	774 (84.4%)	989 (75.6%)	no fall data
4025	Yes	218 (51.4)	809 (81.5%)	63 (80.8%)
4848	Yes	no spring data	1032 (56.2%)	326 (78%)
5105	Yes	530 (65.8%)	1487 (69.7%)	363 (78.1%)
6870	Yes	441 (75.8%)	186 (67.6%)	no fall data

Table 27. Landscape use of wetlands for conditioned and unconditioned black bears. Soft release #s 5538, 5109, 6822, 2603, and 5316. Hard release #s, 6870, 5105, 4025, 4848.

Bear ID	Conditioned?	Frequency/ Percent, Spring	Frequency/ Percent, Summer	Frequency/ Percent, Fall
2603	No	303 (55%)	692 (32.2%)	77 (19.3%)
5109	No	115 (15.9%)	dropped collar	dropped collar
5316	No	no spring data	453 (22.5%)	53 (7.8%)
5538	No	4 (1.6%)	66 (4.3%)	26 (6.8%)
6822	No	198(15.1%)	33 (5.7%)	no fall data
4025	Yes	181 (42.7)	65 (6.5%)	13 (16.7%)
4848	Yes	no spring data	423 (23.1%)	44 (10.5 %)
5105	Yes	224 (27.8%)	462 (21.7%)	98 (21.1%)
6870	Yes	33 (5.7%)	0(0%)	no fall data

Table 28. Landscape use of urban areas for conditioned and unconditioned black bears. Soft release #s 5538, 5109, 6822, 2603, and 5316. Hard release #s, 6870, 5105, 4025, 4848.

Bear ID	Conditioned?	Frequency/ Percent, Spring	Frequency/ Percent, Summer	Frequency/ Percent, Fall
2603	No	25 (4.5%)	318 (14.8%)	27 (6.8%)
5109	No	48 (6.6%)	dropped collar	dropped collar
5316	No	no spring data	161 (8%)	11 (1.6%)
5538	No	48 (19.4%)	314 (20.4%)	77 (20%)
6822	No	0 (0%)	120 (9.2%)	no fall data
4025	Yes	23 (5.4%)	105 (10.6%)	2 (2.6%)
4848	Yes	no spring data	334 (18.2%)	34 (8.1 %)
5105	Yes	50 (6.2%)	178 (8.3%)	4 (0.9%)
6870	Yes	102 (17.5%)	78 (28.4%)	no fall data

Results of statistical analyses at two spatial scales were evaluated. Selection of the home range from the landscape (home-range selection) and selection of habitat types within the home range (habitat selection within the home range) for spring, summer, and fall home ranges were determined. The F value and significance level p for the Mast index within the home range are reported below. A significant p value ($p < 0.05$) will indicate that bears exhibited habitat selection.

Comparative Soft Mast Index Analysis for Conditioned and Unconditioned Bears

A Total Soft Mast Index was calculated for the unconditioned and conditioned group of bears. The F-statistic, F=0.281, means that there is no difference for the dependent variable between the two groups with the p-value of 0.613.

Bonferroni Pairwise Comparisons Between Two Groups

The Bonferroni test demonstrated a pairwise comparison between the two groups exists. This test produced the mean difference in the soft mast indices that equals 263.441 that is not statistically significant. We also calculated a contrast matrix that enables us to test the null hypothesis that there is no difference in both mean indices between the two groups.

Mann-Whitney Nonparametric Test for Two Groups

From the Mann-Whitney U test (U = 10.00), we find that, on average, unconditioned bears and conditioned bears do not differ significantly in soft mast availability within their respective home ranges.

Distances from Release Site

The descriptive statistics output compares the mean distances from the release site and their standard deviations for the nine bears. Conditioned bear #5105 has the largest mean distance from its release site but 2 non-conditioned bears (#6822, #5109) had the 2nd and 3rd greatest distances.

To evaluate the effectiveness of aversive conditioning treatments, we calculated the cumulative distances for the first fifteen days after the release for the two groups, unconditioned and conditioned bears. The calculated mean distances from the release site was 36,361 feet for the conditioned bears and 28,909 feet for the unconditioned bears**.**

A side-by-side box plot for the total distance traveled by each of the two groups of bears had demonstrated that the conditioned bears as a group walked further from the release site than the unconditioned bears for the first fifteen days and the median distance from the release site for the unconditioned group is greater than the median distance for the conditioned group. No outliers are shown with this analysis with the MANOVA (multiple analysis of variance) F statistic, F=672.81.

Three conditioned bears, #4025, #4848, and #6870 traveled farther from the release site compared to the other animals and show a number of outliers in that direction (particularly, bear # 4025 and bear #4848). Bear #5105 (conditioned bear) walked the longest distance from the release site among all the animals. This bear moved back to the release site but not as close as most of the unconditioned bears did. The mean distance from the release site for the conditioned bears as a group is greater than the mean distance for the unconditioned bears but some individual behavioral patterns exist.

Total Distance Traveled by Individual Bears for Different Cover Types

The total distance from release sites was calculated for several bears that demonstrate their preferences for different habitat types. Frequency distributions were used for comparison purposes that displayed different habitat patterns of individual bear movement. The frequency distribution of total distance traveled by bear #5105 (conditioned bear) was determined by cover type. The preferred habitat for this particular animal was forest and next, wetlands. This particular bear tended to avoid most urban areas. Bear #5538 visited urban areas more frequently than bear #5105. Conditioned bear #4848 chose each of the six cover types: agriculture, forest, urban, water, barren lands, and wetlands. Its frequency at urban sites is also significantly lower than was demonstrated by bear #5538.

Nonparametric Tests

Since our GIS collected data does not always represent randomly collected data sets in sense that they are observational data with mostly unknown probability distributions, we have to check our results with various parametric methods by comparing them with nonparametric methods.

The Kruskal-Wallis test takes advantage of the known variance of the ranks. We decided to use the Kruskal-Wallis procedure because the test requires no assumptions about the actual form of the probability distribution of a random variable and is analogous to the parametric analysis of variance procedure (Kutner et al. 2005).

Regression Analysis for Distance from Release Site

A scatter plot of the distance from release site of bear #4848 after its release date as a function of time for the first 15 days of bear movement was analyzed. The explanatory variable is a serial date (from the beginning of the year) that was calculated in Excel from the GIS-obtained standard time format, month-day-year and hour-min.

The initial scatter plot for this particular animal shows a very weak correlation between the two variables. This response variable has a non-constant variance. The latter can sometimes be corrected by a transformation of the response but in many situations it cannot. Neither a logarithmic transformation nor a square-root transformation could help us to analyze this particular data set and make prediction about this bear movement.

We used the method *weighted least squares* that proved to be valuable in three different practical situations and one for this case. When the response values are measurements whose estimated standard deviations (*SEs*) are available, we can calculate their weights, $w = 1/(SE(Y))$ ^2 for each observation on the data set; that is, the responses with smaller standard errors should receive more weight, or in other words, larger weights have smaller variances and should be weighted more in the analysis.

The weighted regression model can be estimated by *weighted least squares* within the standard regression procedure in SPSS or SAS. The estimated regression coefficients then are chosen to minimize the weighted sum of squared residuals.

We plotted the response variable against the unstandardized residuals that suggests that the error variance is not constant. Next, we estimated the standard deviation function by regressing the absolute residual values against the explanatory variable and saved the unstandardized predicted values for computing the weights. Finally, we performed a weighted least-squares regression by regressing the distance from release on time using the weights calculated as a weight variable. We also obtained the 95% confidence interval for the regression coefficient. The F-statistic for this regression model is $F = 3.339$ with $p = 0.068$, thus the model is statistically significant at $\alpha \leq 0.1$.

DISCUSSION

Bear complaints continue to rise in New Jersey, requiring a demand to help decrease the number of negative bear and human interactions that occur annually. In 2008, the New Jersey Division of Fish and Wildlife reported 2844 phone calls regarding nuisance bear complaints and sightings. Category I incidents increased over 149% in 2008 in comparison to 2007. In response to an escalation in complaints, non-lethal management strategies were implemented. Increased bear training has been provided to municipal and state law enforcement officers on how to respond to nuisance bear incidents. In 2008, a toll free hotline (1-877-927-6337) was established for residents to report nuisance bear activity and sightings. In addition, a wildlife biologist was hired to increase public awareness of black bear behavior through education and literature distribution. With these new measures in place, however, bear complaints and sightings have exceeded 3000 phone calls for the year 2009. Many states have addressed human–bear conflicts by implementing nonlethal deterrent measures in addition to adjusting hunting season regulations (i.e., length of season, baiting, and bag limits).

The purpose of this project was to determine the efficacy of aversive conditioning on bears exhibiting nuisance behavior in local communities. We applied the aversive conditioning techniques only once, as this is the most reasonable means of application. For the purpose of this project, aversive conditioning is simply creating a negative experience for a bear in the act of nuisance behavior; the desired effect being the negative experience will outweigh the positive rewards offered by the nuisance activity. The end result of this experience is whether the animal alters its behavior and does not return to the nuisance location and repeat the negative behavior.

We used a combination of rubber buckshot, pyrotechnics and specially trained dogs to aversively condition four treatment bears. We used five additional bears captured at nuisance locations as the control group. All bears returned to an urban setting within 3-17 days after being released. Unconditioned bears returned within an average distance of 140 feet (17-528 feet) to the capture site and conditioned bears returned within an average of 207 feet (28-321 feet) to the original capture site. It is important to note that the distances for return to capture site may have been much closer than what was indicated as a result of the satellite transmission occurring once per hour. The location of the animal in between these one hour intervals is not logged by the collar therefore, it does not display locations that may have been closer than what was recorded at the time of satellite transmission. The findings of this study suggest that conditioned bears resulted in slightly further movement away from sites where nuisance activity occurred compared to unconditioned bears. The cumulative distances traveled for every bear within a group was calculated for the first fifteen days post treatment. This showed conditioned bears had a larger cumulative distance traveled from each study animal's respective treatment site, 36,361 feet. Unconditioned bears had a smaller cumulative distance traveled from each study animal's respective treatment site, 28,909 feet. Despite the difference between treatment and control groups, all bears returned to urban settings within 17 days and exhibited nuisance behavior. Beckmann et al. (2004) reported that 92% (*n* = 57) of bears returned to nuisance behavior, with 70% (*n* = 44) returning within

40 days. Additionally, they observed behavioral trends similar to those we observed in our study. Conditioned bears remained farther away (mean distance) for slightly longer periods of time than unconditioned bears. The results of this study show that aversive conditioning techniques to deter bears from returning to the location of nuisance activity have limited short-term effectiveness. All the bears in this study returned within close proximity to the capture site and to an urban setting regardless of the treatment used.

We analyzed vegetation composition, available habitat and home ranges of individual bears using the Geographic Information System data along with field observations. Home-range estimates for female bears were reported in different geographic regions: in the central Sierra, California (40.4 km^2, Sitton 1982), the San Bernardino 65 Mountains, California (17.1 km^2, Novick and Stewart 1982), Arizona (17.9 km^2, LeCount 1980), Idaho (16.6 – 130.3 km^2, Amstrup and Beecham 1976), and Prince William Sound, Alaska (10 - 30 km^2, Modafferi 1978). Home-range estimates for female bears in Yosemite were larger than those reported for female bears in Washington (5.3 km^2, Poelker and Hartwell 1973) and smaller than those reported along the Susitna River, Alaska (200 km^2, Miller and McAllister 1982). Home range estimates for female bears in NJ are comparable with those estimates reported in Washington and are quite small. Field measurements produced a total mast index for 50% kernel home range for each of the nine bears which were used for the statistical analyses.

We looked at the soft mast availability within each bears home range to determine if it differed between conditioned and unconditioned bears. The Soft Mast Index for unconditioned and conditioned bears did not differ significantly. Our parametric and nonparametric tests on the Soft-Mast Index indicate that the areas frequented by unconditioned and conditioned bears did not differ significantly in soft mast availability.

Habitat selection was evaluated for the bears after the hard or soft release. Studies by Leban et al. (2001) and Girard et al. (2006) evaluated habitat selection using GPS. The kernel method with cross validation produced the most accurate estimates of simulated home ranges. When performing density estimates on data that are multimodal and non-normal, the cross-validated fixed kernel appears to be the best method to use. This corroborates Worton's (1995) conclusion that the fixed kernel gives the least biased results, and that proper selection of the smoothing parameter is very important. We investigated seasonal patterns of landscape and home range use to provide the most complete description of spatial use patterns useful for management and ecological interpretation. Pairwise comparisons indicated that FOREST was preferred ($P < 0.05$) over all other habitats. There was a detectable difference in the use of the second and third top-ranking habitats (urban and wetlands) for two bears, #5538 and #6870. These animals preferred urban areas to wetlands in the spring and summer seasons. Bear #5538 preferred urban areas, in the fall, 20% more often than the other animals.

Only adult females were used in the study and it would be important to examine the effects of aversive conditioning on males as well as yearlings. The sample size for this study was statistically valid; however, an increased sample size may provide additional insight into the efficacy of aversive conditioning techniques.

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APPENDIX

A. Complaint Table

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Nuisance	46	39	100	126	468	483	357	525	357	229	387	271	331	692
Garbage	86	103	153	183	496	290	269	379	503	282	358	288	319	632
Birdfeeder	66	45	51	125	274	202	137	137	89	59	87	71	45	77
Protected Hive	2	0	2	8	4	7	0	2	3	5	2	6	3	6
Unprotected Hive	15	7	12	11	19	16	13	24	9	5	9	10	5	16
Livestock Kill	3	11	20	15	25	22	36	27	17	24	24	13	13	49
Rabbit Kill	18	10	16	30	28	38	57	34	38	27	15	7	2	24
Unprovoked Dog Attack	6	3	9	5	12	17	6	15	11	5	8	2	9	1
Provoked Dog Attack	***	***	***	***	***	***	***	***	22	4	4	3	3	13
Home Entry	3	4	5	16	29	29	29	55	53	24	29	40	32	69
Aggressive	2	33	9	17	34	51	37	28	19	7	21	13	10	28
Campsite / Park	5	9	1	12	28	22	5	10	1	3	0	2	4	2
Urban Removal					10	7	12	19	11	12	38	15	17	27
Property Damage	33	17	72	111	232	191	123	111	132	44	83	61	75	160
Human Attack	*	*	*	*	*	*	1	1	2	1	1	1	0	1
Attempted Home Entry	*	*	*	*	*	*	5	25	23	10	23	17	16	32
Agricultural Damage	*	*	*	*	*	*	5	9	5	10	8	9	12	29
Tent Entry	*	*	*	*	*	*	2	5	4	2	3	0	1	2
Vehicle Entry	*	*	*	*	*	*	2	6	9	3	4	4	3	9
Total	**285**	**281**	**450**	**659**	**1,659**	**1,375**	**1,096**	**1,412**	**1,308**	**756**	**1,104**	**833**	**900**	**1869**

B. Data points for 50 and 95% kernels for land use classification

Bear 2603		
Soft Release	COUNT	ACRES
50 %		Total points 1268
FOREST	7	75.690
URBAN	14	29.327
WATER	1	1.862
WETLANDS	5	32.805
95 %		Total points 2921
BARREN LAND	1	0.838
FOREST	46	805.695
URBAN	70	214.197
WATER	2	35.040
WETLANDS	50	199.494

Bear 4025		
Hard Release	COUNT	ACRES
50%		Total points 737
AGRICULTURE	2	2.094
FOREST	35	142.715
URBAN	29	38.601
WETLANDS	14	11.796
95 %		Total points 1384
AGRICULTURE	2	6.905
BARREN LAND	2	1.785
FOREST	101	641.565
URBAN	95	301.936
WATER	2	4.598
WETLANDS	52	64.127

Bear 5105		
Hard Release	COUNT	ACRES
50 %		Total points 889
FOREST	28	232.954
URBAN	3	4.240
WETLANDS	10	31.137
95 %		Total points 3304
AGRICULTURE	7	10.960
BARREN LAND	7	8.261
FOREST	190	2935.498
URBAN	105	307.399
WATER	12	59.019
WETLANDS	159	407.383

Bear 5109		
Soft Release	COUNT	ACRES
50 %		Total points 356
BARREN LAND	3	2.597
FOREST	52	294.522
URBAN	19	31.932
WATER	1	0.269
WETLANDS	18	17.413
95 %		Total points 705
AGRICULTURE	8	15.324
BARREN LAND	6	5.966
FOREST	183	1285.455
URBAN	135	389.461
WATER	8	52.284
WETLANDS	110	181.930

Bear 5316		
Soft Release	COUNT	ACRES
50 %		Total points 1755
AGRICULTURE	8	67.359
BARREN LAND	17	57.350
FOREST	81	761.336
URBAN	108	211.419
WATER	7	4.523
WETLANDS	82	101.088
95 %		Total points 2242
AGRICULTURE	37	202.565
BARREN LAND	64	138.931
FOREST	297	2987.765
URBAN	400	1010.272
WATER	34	88.661
WETLANDS	245	450.808

Bear 5538		
Soft Release	COUNT	ACRES
50 %		Total points 760
FOREST	21	40.390
URBAN	7	12.599
WATER	1	0.071
95 %		Total points 2000
AGRICULTURE	3	4.509
FOREST	82	363.510
URBAN	38	146.273
WATER	5	18.089
WETLANDS	25	25.072

Bear 6822		
Soft Release	COUNT	ACRES
50 %		Total points 707
FOREST	9	102.989
URBAN	2	9.742
WETLANDS	5	4.691
95 %		Total points 2195
AGRICULTURE	2	4.171
FOREST	49	835.442
URBAN	44	130.923
WATER	3	15.584
WETLANDS	34	117.015

Bear 6870		
Hard Release	COUNT	ACRES
50 %		Total points 296
FOREST	16	65.037
URBAN	9	26.324
WATER	2	1.509
WETLANDS	4	2.449
95 %		Total points 832
AGRICULTURE	3	2.404
BARREN LAND	8	11.320
FOREST	92	621.797
URBAN	71	316.100
WATER	10	18.095
WETLANDS	39	54.928

Bear 4848		
Hard Release	COUNT	ACRES
50 %		Total points 1367
AGRICULTURE	4	6.341
BARREN LAND	4	10.973
FOREST	60	311.961
URBAN	57	160.734
WATER	2	1.741
WETLANDS	30	63.344
95 %		Total points 2220
AGRICULTURE	18	80.015
BARREN LAND	12	17.318
FOREST	207	1367.976
URBAN	174	608.378
WATER	21	65.961
WETLANDS	130	251.354

C. Study Animals at Vernon Valley Dumpster Locations

Bear ID #4848 (Hard release) Repeat nuisance behavior post aversive conditioning treatment. Picture taken 7/30/2008. Bear # 4848 was collared on June 28, 2008. The bear was aversively conditioned at the capture site and released. The animal was handled on October 8, 2008 in Vernon Township and the satellite collar was replaced with a VHF collar. A total of 2,256 points were collected for the period from June 28, 2008-October 8, 2008.

Bear ID #5538 (Soft release) Repeat nuisance behavior post handling. Picture taken 7/28/2008.

Bear #5538 was collared on May 2, 2008. The collar failed to log GPS coordinates within the first three days and on May 6, 2008 the collar was replaced after the animal was free range darted within the village. The same collar remained operable until June 13, 2008 when the bear was captured in a culvert trap and the satellite collar was replaced with a standard VHF collar due to a malfunction of the replacement collar. On June 16, 2008 the same bear was captured in an Aldrich foot snare near Great Gorge Village and released on site after biological data was collected. On July 14, 2008, Bear #5538 was free range darted at the Great Gorge Village garbage disposal facility and had a replacement satellite collar applied. On October 6, 2008 the bear was free range darted from a dumpster within the village and the satellite collar was removed and replaced with a VHF collar. The bear was handled on six occasions during the period May 2, 2008-October 6, 2008 and a total of 2,168 points were collected for the period from May 2, 2008-October 6, 2008.

Bear ID #6870 (Hard release) Repeat nuisance behavior post aversive conditioning treatment. Picture taken 8/14/2008.

Bear #6870 was collared on May 5, 2008. The animal was aversively conditioned at the capture site and released.

D. Activity Maps – Capture site and return to Urban Setting

Figures 3- 11 are the activity maps for all bears (soft and hard releases). Appendix D

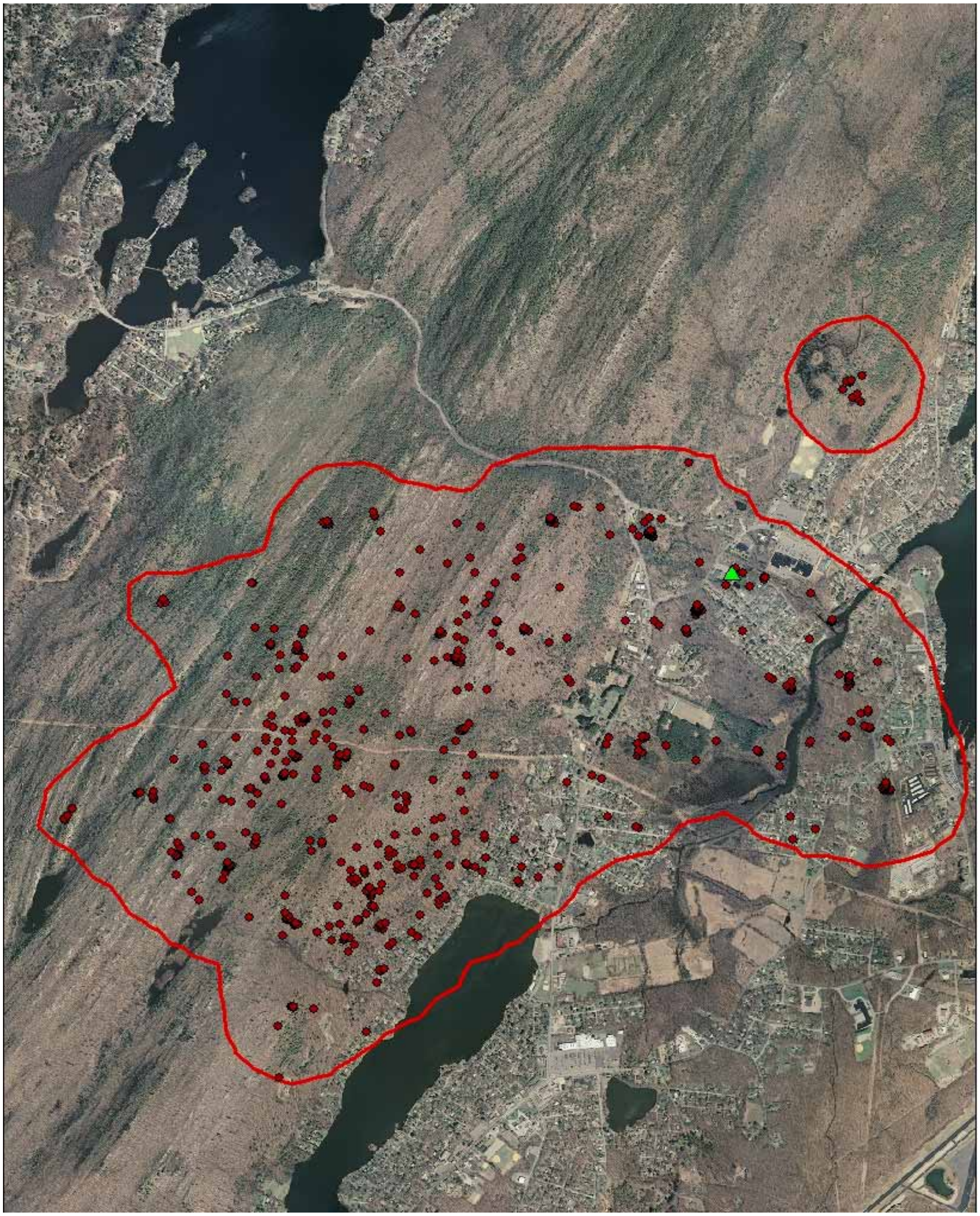

Figure 3. Activity map for Bear ID #5109 (soft release).

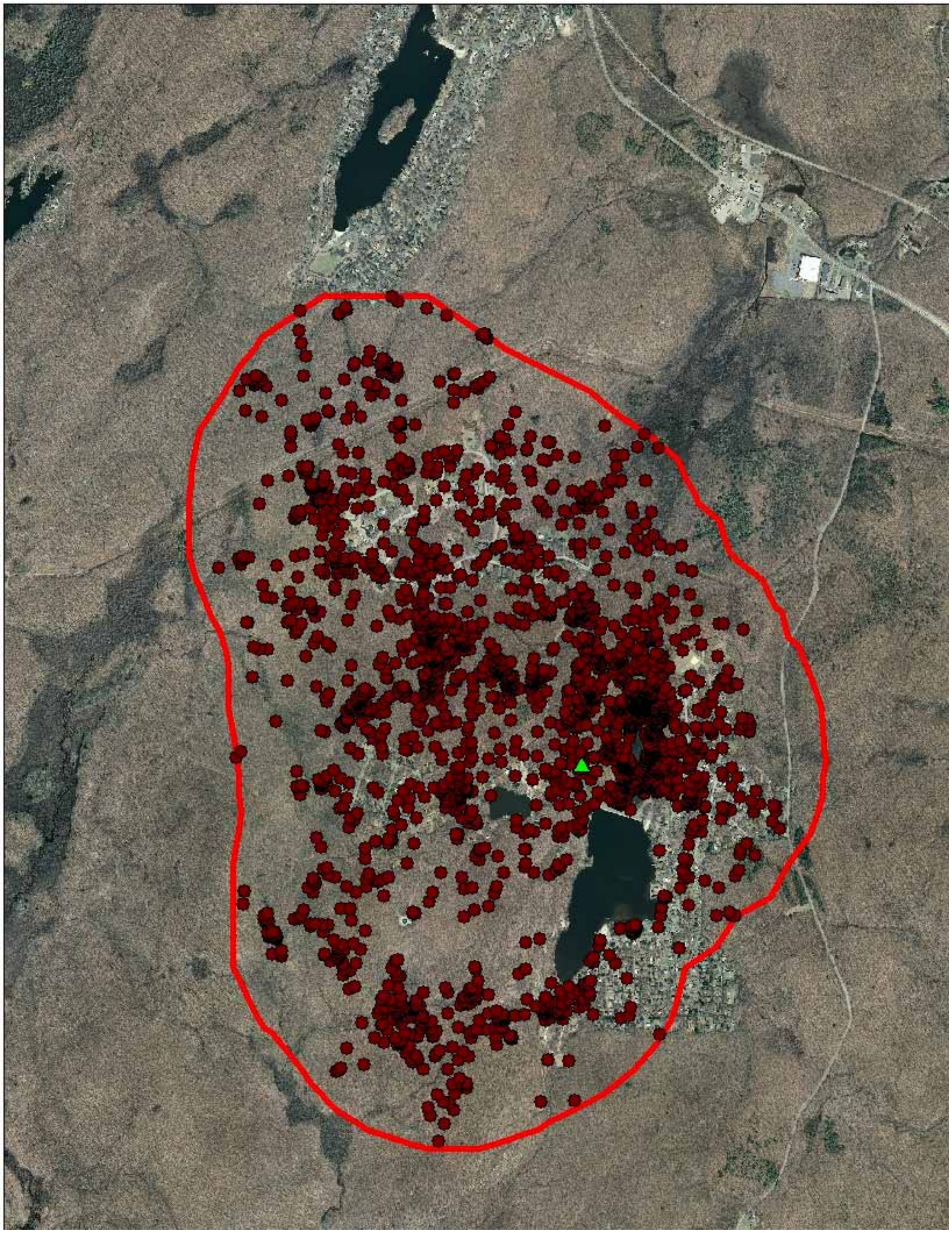

Figure 4. Activity map for Bear ID #2603 (soft release).

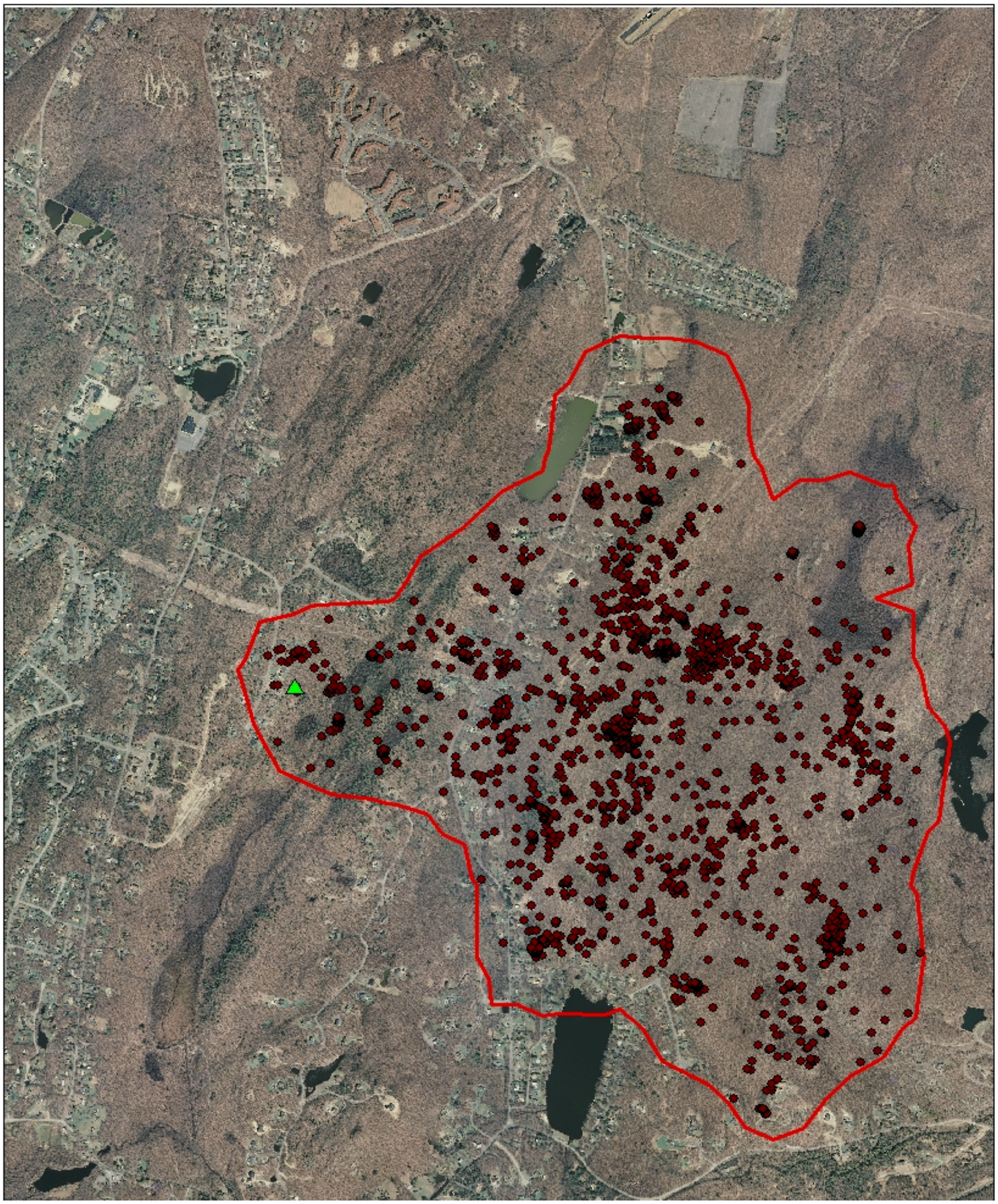

Figure 5. Activity map for Bear ID #6822 (soft release).

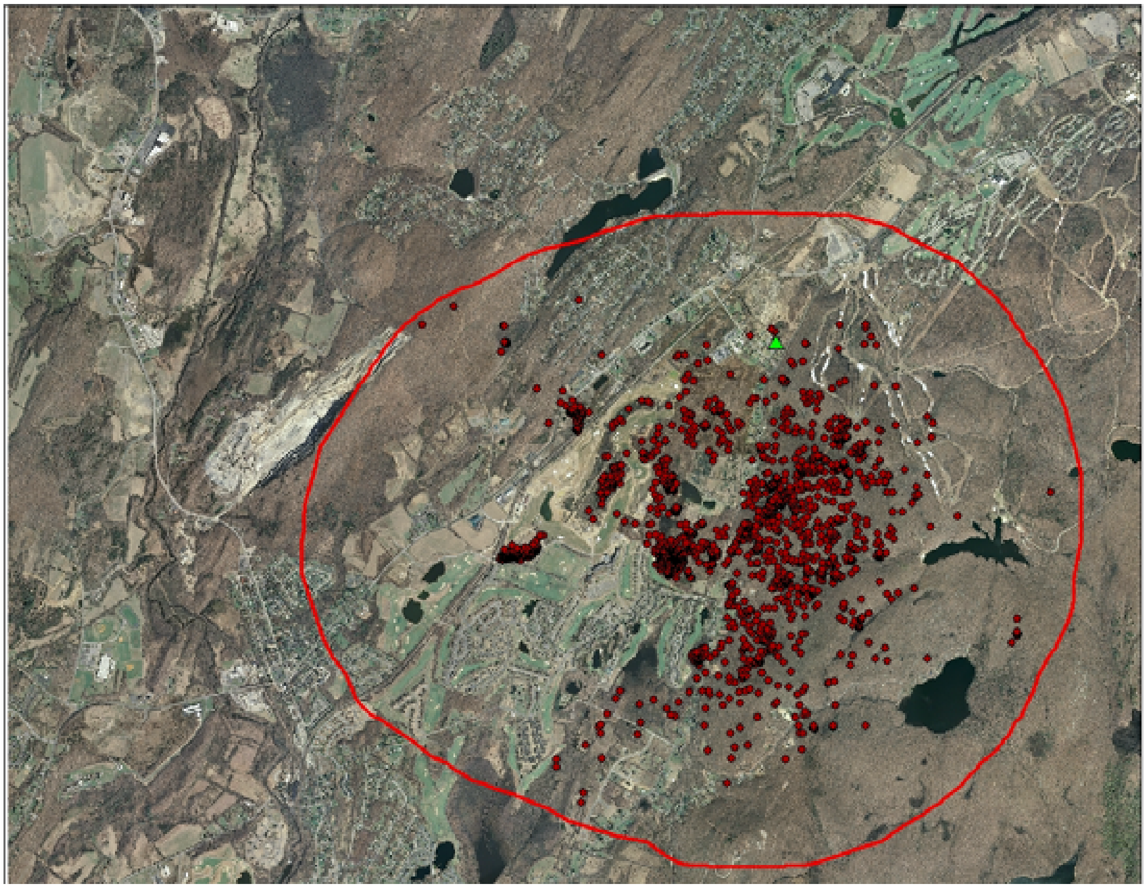

Figure 6. Activity map for Bear ID #5316 (soft release).

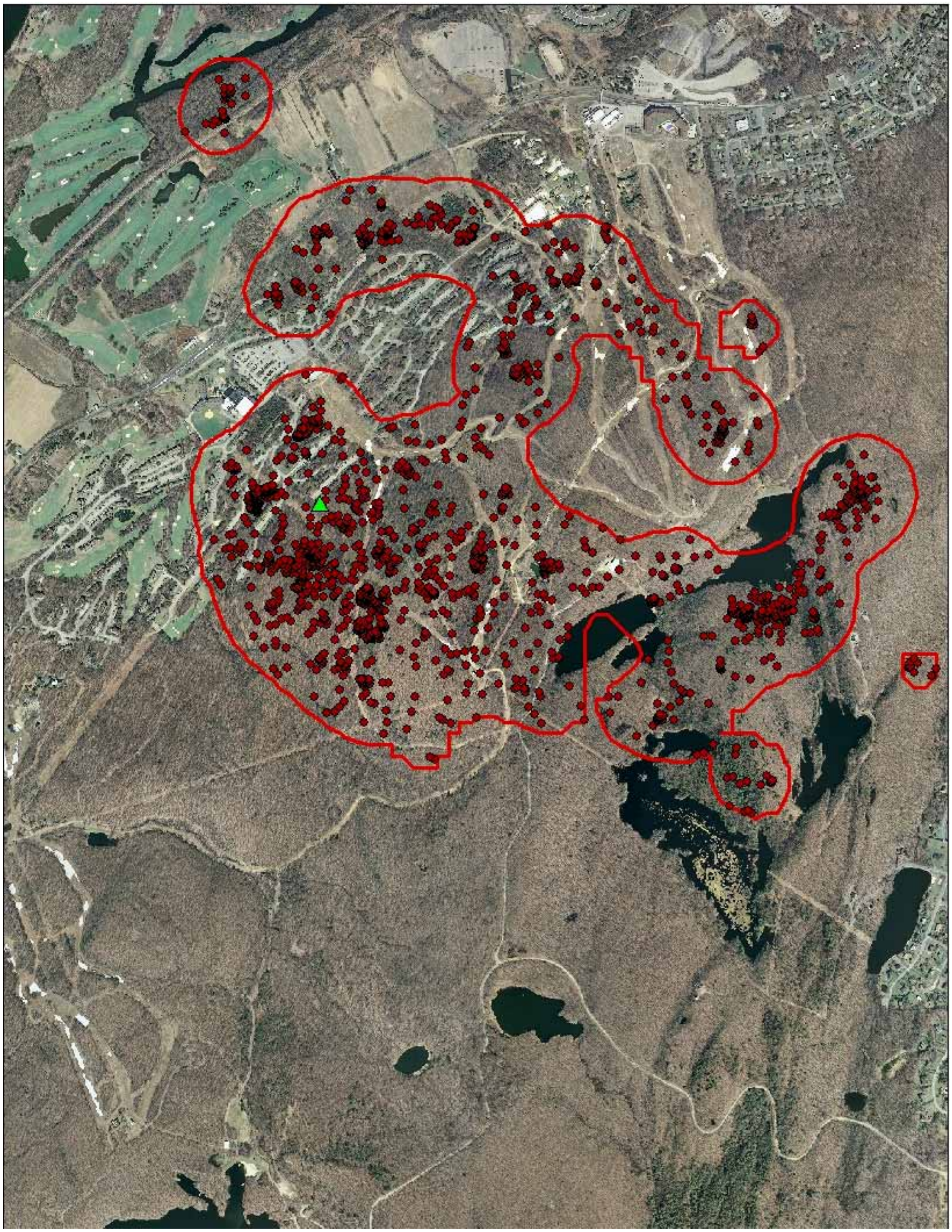

Figure 7. Activity map for Bear ID #5538 (soft release).

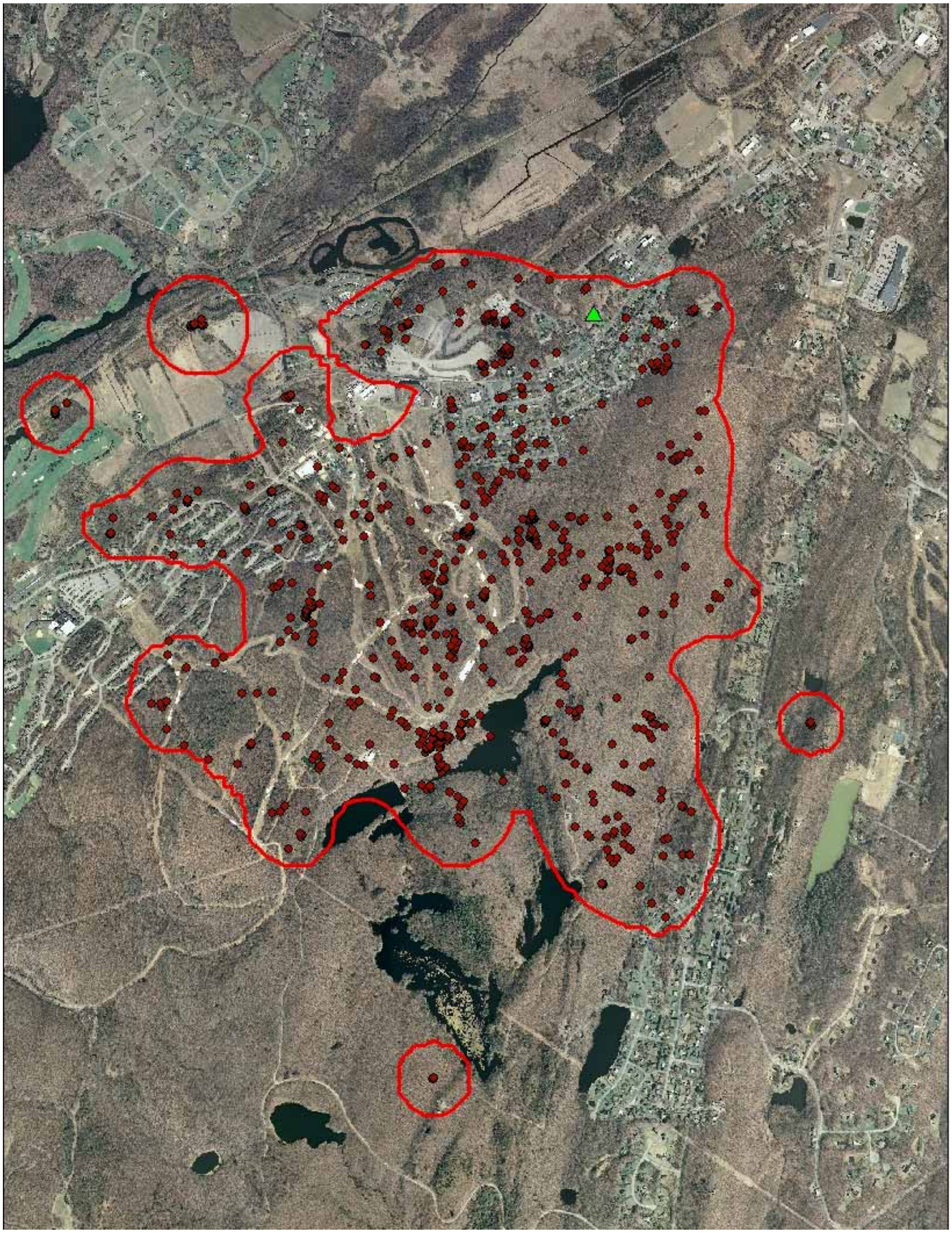

Figure 8. Activity map for Bear ID #6870 (hard release).

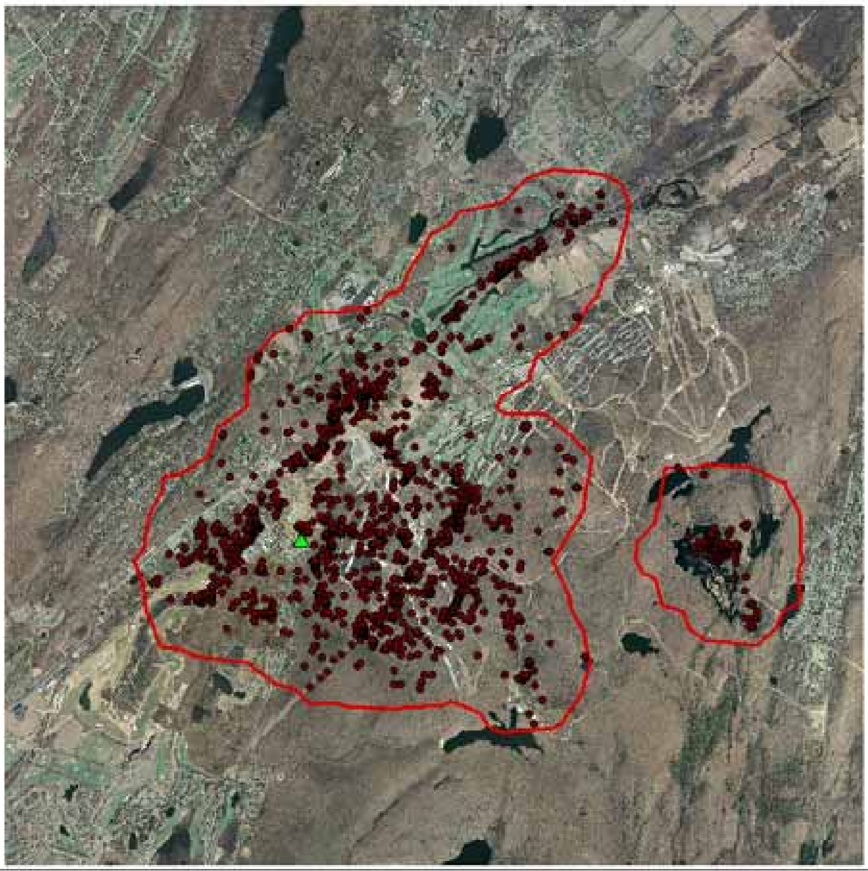

Figure 9. Activity map for Bear ID #4848 (hard release).

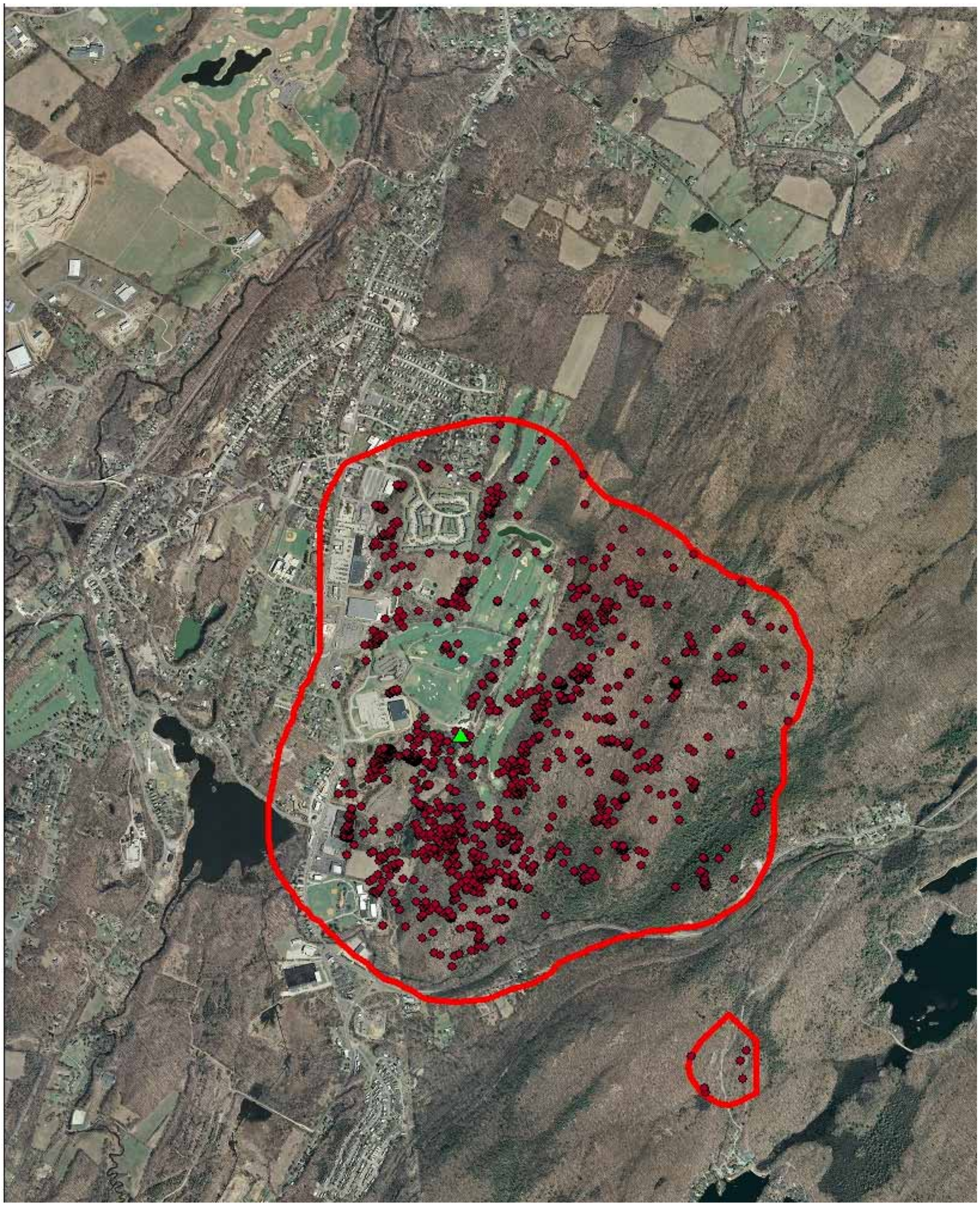

Figure 10. Activity map for Bear ID #4025 (hard release).

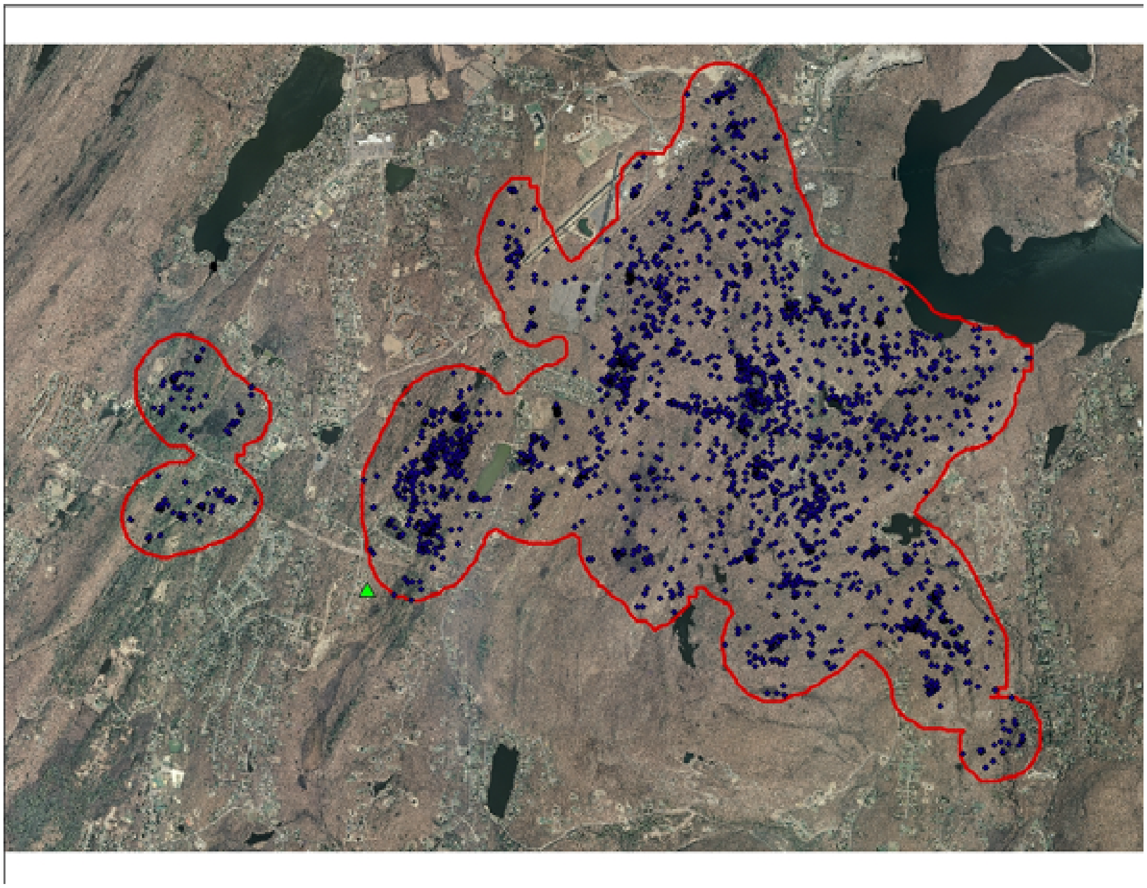

Figure 11. Activity map for Bear ID #5105 (hard release).

Figures 12 - 20 are bear activity maps for time spent in urban settings, after hard or soft release.

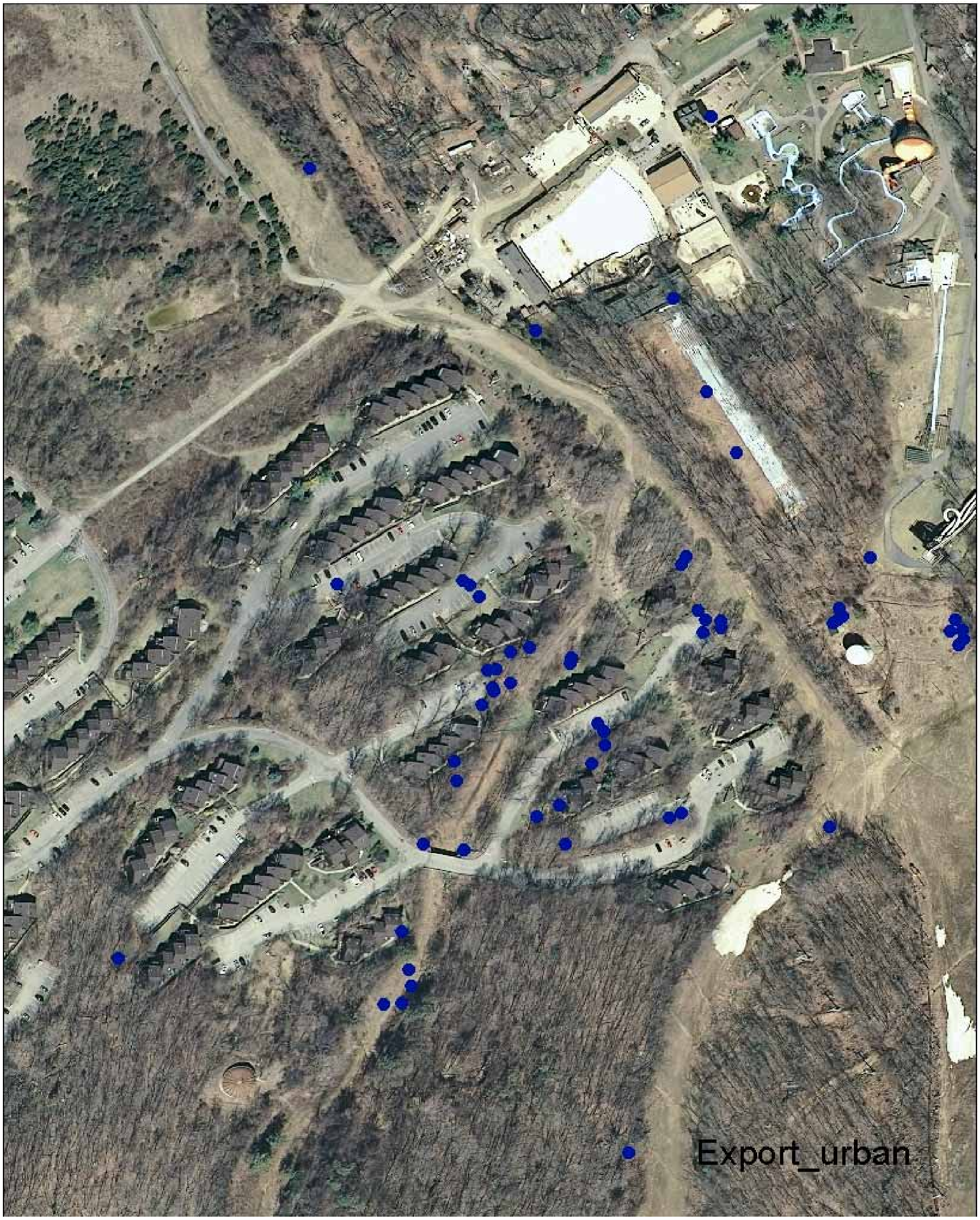

Figure 12. Activity map for the time Bear ID #5538 (soft release) spent in an urban area.

Figure 13. Activity map for the time Bear ID #5109 (soft release) spent in an urban area.

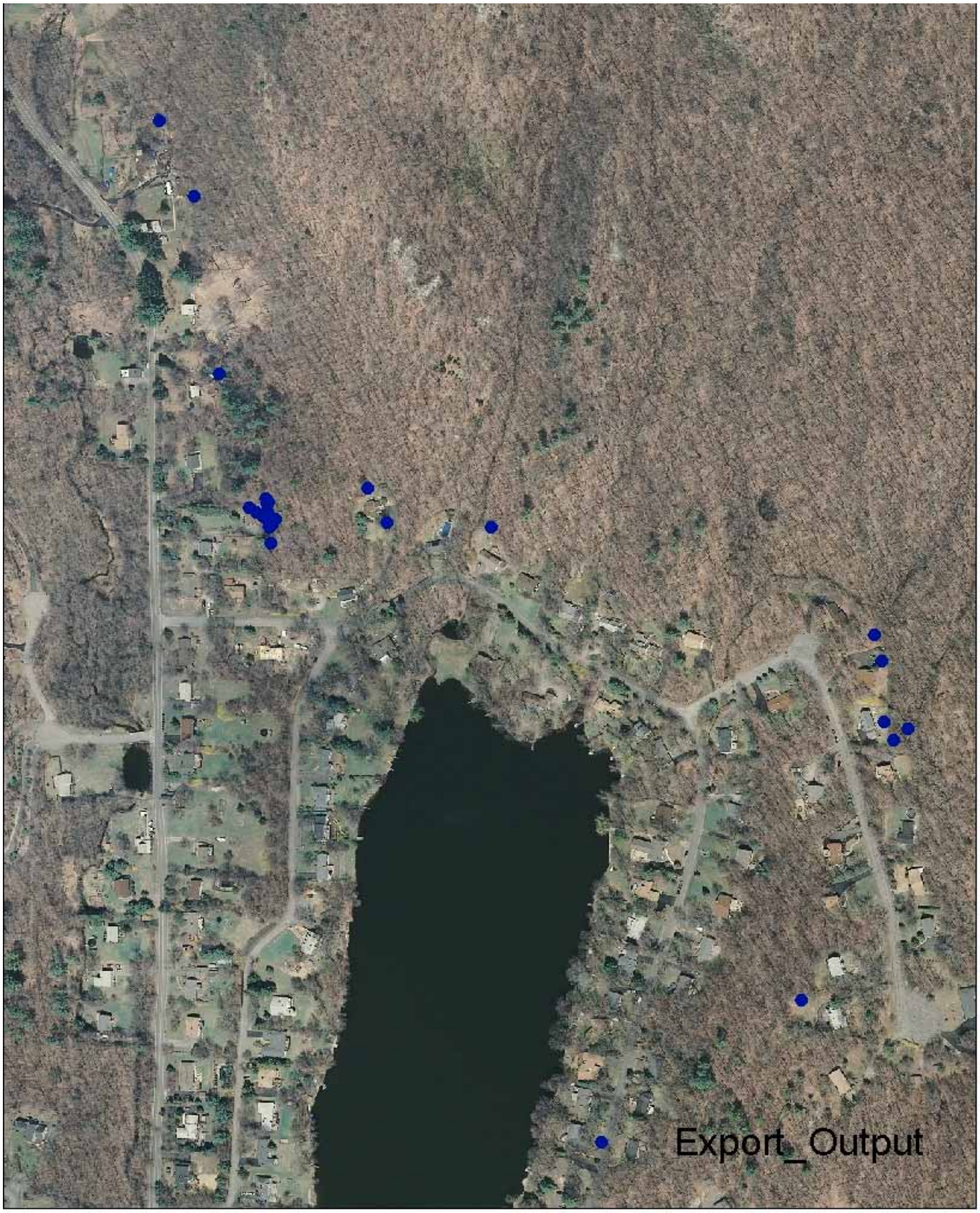

Figure 14. Activity map for the time Bear ID #6822 (soft release) spent in an urban area.

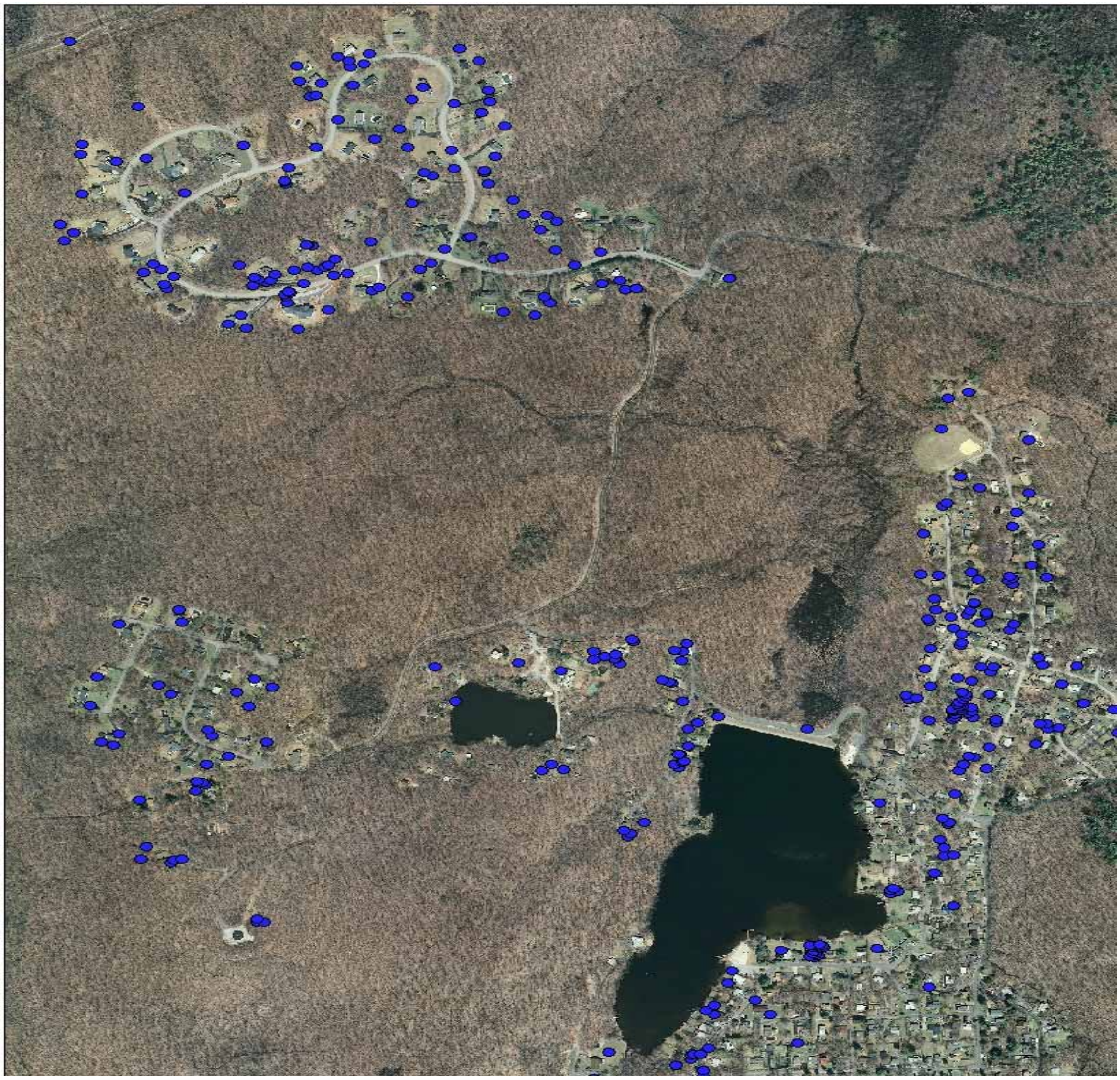

Figure 15. Activity map for the time Bear ID #2603 (soft release) spent in an urban area.

Figure 16. Activity map for the time Bear ID #5316 (soft release) spent in an urban area.

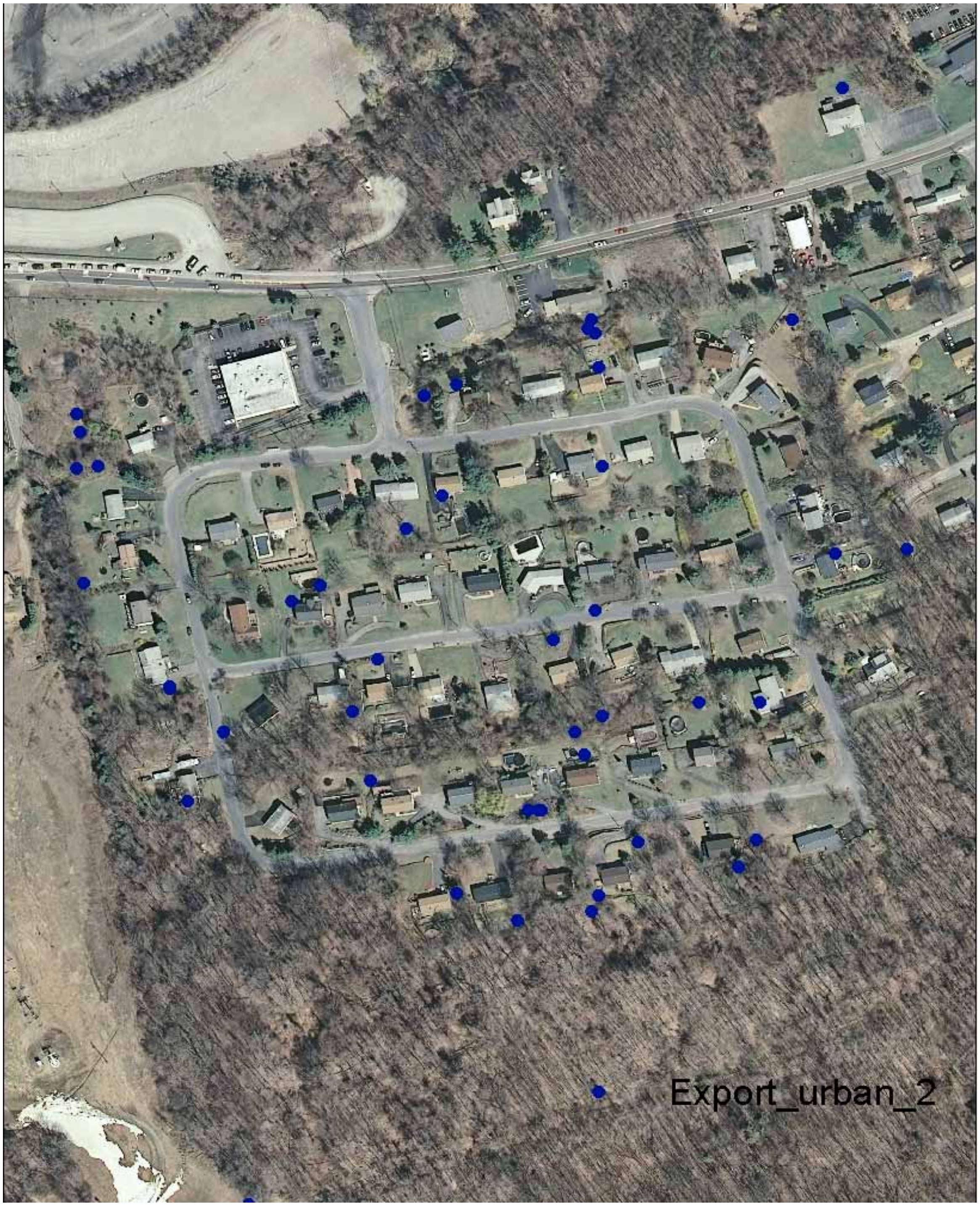

Figure 17. Activity map for the time Bear ID #6870 (hard release) spent in an urban area.

Figure 18. Activity map for the time Bear ID #5105 (hard release) spent in an urban area.

Figure 19. Activity map for the time Bear ID #4025 (hard release) spent in an urban area.

Figure 20. Activity map for the time Bear ID #4848 (hard release) spent in an urban area.