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# Assessing translocation of nuisance and rehabilitation of orphan black bears in New Hampshire

Wesley Earl Smith Jr.
*University of New Hampshire, Durham*

# ASSESSING TRANSLOCATION OF NUISANCE AND REHABILITATION OF ORPHAN BLACK BEARS IN NEW HAMPSHIRE

By

WESLEY EARL SMITH, JR.
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This thesis has been examined and approved.

Thesis Director, Dr. Peter J. Pekins
Professor, Wildlife and Conservation Biology
University of New Hampshire

Dr. Mark J. Ducey
Professor, Forest Biometrics and Management
University of New Hampshire

Andrew A. Timmins
Wildlife Biologist, Bear Project Leader
New Hampshire Fish and Game Department

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Date

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ABSTRACT

ASSESSING TRANSLOCATION OF NUISANCE BLACK BEARS AND REHABILITATION OF ORPHAN BLACK BEARS IN NEW HAMPSHIRE

By

Wesley E. Smith, Jr.

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This study evaluated translocation of nuisance and rehabilitation of orphan black bears as management strategies in New Hampshire. Bears were fitted with GPS collars to measure survival, movement, habitat selection, and conflict activity until denning. Survival of nuisance bears was high (73%) the first year, and they exhibited low return rates (28%) with only adults homing; homing declined as distance increased. Bears selected for both natural and human-dominated habitats, and most (55%) were documented in subsequent conflicts indicating that translocation does not eliminate nuisance behavior; some were harvested. Rehabilitated orphan bears had high survival (86%) in 2011 and were not involved in conflicts, but in 2012 none survived and all caused minor conflicts. Conflict rate was believed to be related to availability of natural forage. Translocation of nuisance bears and rehabilitation of orphan bears represent viable management strategies; however, reducing anthropogenic food sources would reduce the need for both.

# INTRODUCTION

Increasing human and black bear (*Ursus americanus*) populations have resulted in greater interactions and conflicts throughout much of black bear range (Beckman and Berger 2003, Hristienko and McDonald 2007, Conover 2008). Bears that obtain food rewards may come to relate humans with food, causing them to forage in human-associated areas, become conditioned to anthropogenic food, and habituated to the presence of humans (McCullough 1982). Such bears can cause property damage in their search for food and may pose a threat to human safety (McCullough 1982, Gunther 1994, Conover 2008). Managers have been compelled to address these conflicts for the protection of both human and bear populations.

One technique used to manage human-bear conflicts is translocation, where an offending bear is relocated to a remote area to prevent the individual from causing further problems or from returning to the original area (Brannon 1987); food-conditioning and the homing ability of bears may compromise these objectives. While translocation is generally recognized as a costly, ineffective, and temporary management solution (Linnell et al. 1997, Annis 2007), public support for it remains high (Fies et al. 1987, Comeau 2012) and may influence agencies to such action (Spencer et al. 2007). From 2003-2010, 56 bears were translocated to remote areas in northern New Hampshire. While most of these bears are tagged, there remains a lack of specific, quantitative information regarding their subsequent survival, movements, and behavior.

Translocations in New Hampshire also include orphaned cubs and malnourished yearlings that are rehabilitated and released in remote northern areas of the state; 37 releases have occurred from 2000-2010, a number of which are the result of lethal action taken by homeowners on females involved in conflict situations. While these animals are tagged after release, information about their survival, movements, and behavior is inadequate to evaluate the efficacy of the procedure. Several studies have indicated the viability of rehabilitation, but concerns regarding survival and habituation remain (Jonkel et al. 1980, Clark et al. 2002, Beecham 2006, Binks 2008). It is important to evaluate the success of such releases in northern New Hampshire that, despite its highly undeveloped nature, has few areas without human activity within a typical bear's home range.

The purpose of this study was to evaluate effectiveness and success of 1) translocation of nuisance bears and 2) rehabilitation of orphan bears as management tools in New Hampshire. Specific objectives were to measure mortality and survival, movement and dispersal patterns, and nuisance behavior and fidelity to anthropogenic food sources.

## STUDY AREA

The primary study area was in northern New Hampshire, where bears were released. Because of their movements, it also included western Maine, northern Vermont, and southern Quebec. Elevations range from 100-1900 m and the area is dominated by northern hardwoods, including sugar maple (*Acer saccharum*), red maple (*A. rubrum*), American beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*); higher elevations are mostly red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) (DeGraaf et al. 1992). Other common species include white pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*). The area is subject to frequent commercial forest harvesting (DeGraaf et al. 1992) that creates numerous openings dominated by early successional species such as raspberry and blackberry (*Rubus* spp.), pin cherry (*Prunus pensylvanica*), and aspen (*Populus* spp). Wetlands, ponds, and lakes are interspersed throughout the region.

Translocated nuisance bears were released at Ingersol Brook in Pittsburg, NH (Fig. 1). It is a sparsely populated area of the state, but with high levels of seasonal recreational use including hunting, fishing, snowmobiling, and wildlife viewing. The release site is ~5 km from the nearest highway and ~10 km from the nearest residential area. Rehabilitated bears were released in Nash Stream Forest, a 160 $km^2$ state-owned property 117 km from the rehabilitation facility (Fig. 1). The area is managed for recreation, wildlife habitat, and sustainable timber harvest and is representative of conditions throughout northern New Hampshire. The release site was located ~10 km from the nearest residential areas and paved roads. Bear population density in both areas was estimated at 0.24 bears/km$^2$ (New Hampshire Fish and Game Department [NHFG] 2012).

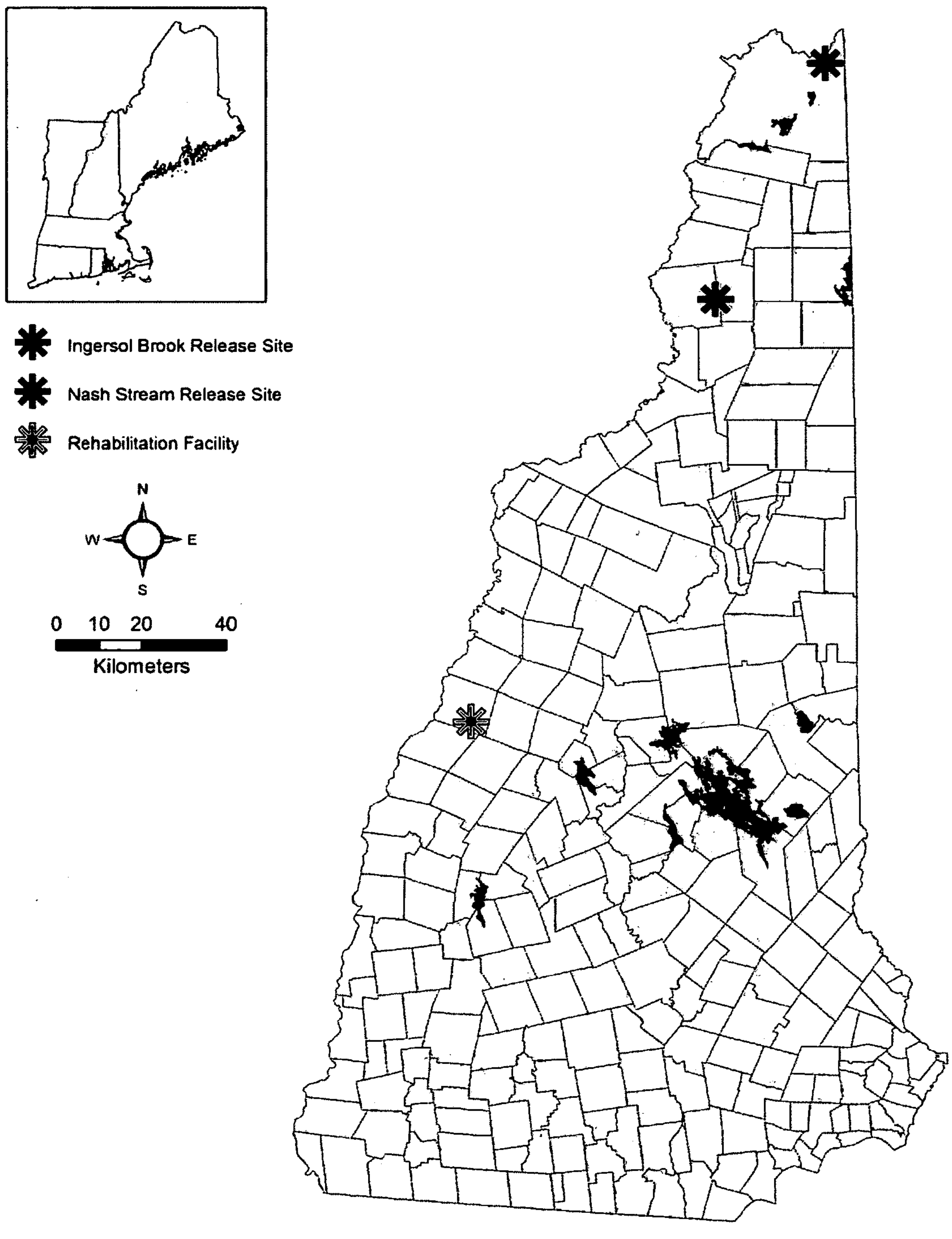


Figure 1. Locations of black bear release sites and rehabilitation facility in New Hampshire. Translocated nuisance bears were released at Ingersol Brook, summer 2011 and 2012; rehabilitated bears were released at Nash Stream, June 2011 and May 2012.

# CHAPTER I

## ASSESSING THE EFFICACY OF TRANSLOCATION AS A NUISANCE BEAR MANAGEMENT TOOL IN NEW HAMPSHIRE

### Introduction

The increase and expansion of both black bear and human populations has led to inevitable encroachment and conflict between the two species. Bears are naturally curious towards people and associated objects (Burghardt and Burghardt 1972, Bacon 1980), and their intelligence and learning capabilities make bears located in, or in close proximity to, human environments susceptible to becoming food-conditioned (Breck et al. 2008). Human foods are typically high in carbohydrates and protein, and bears prefer and will seek out these highly nutritious foods (Bacon and Burghardt 1983, Eagle and Pelton 1983), especially when the availability of natural foods is low (Young and Ruff 1982, Mattson 1990, Blanchard and Knight 1995, Peine 2001). Bears that obtain food rewards may come to relate humans with food, causing them to forage in human-associated areas, become conditioned to anthropogenic food, and habituated to the presence of humans (McCullough 1982), ultimately leading to conflicts and nuisance situations (Peine 2001, Beckman et al. 2004).

An important component of most bear management programs is public education centered on avoiding and preventing conflict with urban bears (McCarthy and Seavoy 1997, Spencer et al. 2007). An initial step to preventing or resolving nuisance bear problems is removing the source of attractant, which is usually food (McCullough 1982, Gillin et al. 1994). Bear-proof garbage containers, electrical fencing, and other barrier devices are used to reduce access to a variety of resources (Breck et al. 2006, Cotton 2008). Although generally effective, they do not necessarily provide a permanent solution due to the innate curiosity and persistence of bears (Bacon 1980, Gunther 1994). In such circumstances, more deliberate methods are employed to eliminate or reduce human-bear conflicts.

Aversive conditioning involves the use of various deterrents that cause pain, avoidance, or irritation to modify bear behavior and reduce nuisance activity (Hopkins et al. 2010). These deterrents include pepper spray, rubber bullets or buckshot, pyrotechnics, chasing with dogs, hard release on-site, and taste-aversion; all have been employed with varying degrees of success (Ternent and Garshelis 1999, Beckman et al. 2004, Leigh and Chamberlain 2008, Mazur 2010). If deterrent attempts fail to alter nuisance behavior, agencies are left with 2 options: move the bear or destroy it. This threshold is usually reached when an individual causes extensive property damage or is perceived as a threat to human safety. Dispatching such an animal is not always an option due to low public support, forcing managers to seek non-lethal solutions (Gillin et al. 1994, Massei et al. 2010, Comeau 2012).

The ultimate objective of translocation is to alter nuisance behavior by permanently removing the bear from the problem area (Brannon 1987). Translocation can delay mortality of nuisance bears until natural foods become available, or until the fall hunting season when they can be utilized as a resource versus wasted (Rogers et al. 1976, Rogers 1986, Fies et al. 1987). Translocated females can possibly augment small populations or serve as reintroductions (Blanchard and Knight 1995, Stiver et al. 1997). However, translocation is generally recognized as an ineffective, temporary management solution (Linnell et al. 1997, Beckman and Lackey 2004, Annis 2007), and may only be suitable to provide time to address the causal agent of the conflict (Riley et al. 1994). Despite its questionable effectiveness and high cost, public support for translocation remains high (Fies et al. 1987) and may influence agencies to such action (Spencer et al. 2007).

A primary reason for the low success rate of translocation is the homing ability of bears. While the exact mechanisms are unknown, black bears have returned from distances up to 389 km (Landriault et al. 2006), though translocations of such extreme distance are rare. Homing from shorter distance is more common, with return rates inversely related to the distance moved (Rogers 1986, Linnell et al. 1997). Physiographic barriers (McArthur 1981, Miller and Ballard 1982) and the number of relocations per bear (Beeman and Pelton 1976, Blanchard and Knight 1995) are important factors in predicting the success of a translocation.

There is conflicting evidence regarding return rates for sex and age classes. Some studies have reported that males homed more often than females (Beeman and Pelton 1976, McLaughlin 1981, Fies et al. 1987), whereas others have documented the opposite (McArthur 1981, Rogers 1986, Annis 2007). Males may have a strong attachment to an area during the mating season, which could encourage them to return after translocation (Landriault et al. 2009). Females are known to be highly philopatric (Rogers 1987, Elowe and Dodge 1989, Lee and Vaughan 2003) and so may also be driven to return to their original range, especially if that range contains highly available and nutritious food sources (Landriault et al. 2009). Many studies indicate that adults exhibit higher return rates than subadults and yearlings (McLaughlin 1981, Rogers 1986, Landriault et al. 2009), although Annis (2007) found no difference. Young bears may have less attachment to an area, underdeveloped homing abilities, or poorer navigational skills than older animals (Harger 1967, Rogers et al. 1987, Landriault et al. 2009).

Nuisance recidivism in translocated bears also contributes to the low success rate of this technique. The negative experience associated with translocation is thought to cause a bear to avoid further contact with humans and therefore cease nuisance behavior. However, some bears continue to cause conflict after dispersal from the release site or upon return to the original range (Brannon 1987, Annis 2007, Landriault et al. 2009). Adult males are most likely to resume nuisance activity (McArthur 1981, Landriault et al. 2009, Annis 2007), which is not unexpected given that most conflicts are caused by this age-sex group (Rogers et al. 1976, Singer and Bratton 1980, Beckman and Berger 2003). Females with cubs also have high recidivism rates, probably due to their higher nutritional requirements (McArthur 1981, Riley et al. 1994). Low availability of natural food in a release area may, in part, predispose translocated bears to seek out and utilize anthropogenic food resources (Piekielek and Burton 1975).

Translocation may decrease survival of relocated bears (Fies et al. 1987, Eastridge and Clark 2001, Clark et al. 2003), though not in all situations (Rogers 1986, Annis 2007). Most mortality is anthropogenic, including vehicular collisions (Comly-Gericke and Vaughan 1997, Beckman and Lackey 2004), hunting (Fies et al. 1987, Landriault et al. 2009), and nuisance behavior (Landriault et al. 2009); mortality via predation or other natural causes is rare (Rogers 1986) excepting cubs accompanying mothers (Miller and

Ballard 1982). The risk of mortality is higher for translocated bears due to increased movement after release (Linnell et al. 1997). Their high harvest rate lends support to the notion that translocation delays mortality until hunting season, effectively providing a used versus wasted resource if dispatched (Rogers 1986, Fies et al. 1987).

Human-bear conflicts in New Hampshire number ~650 annually since 1998 (Comeau 2012). Conflicts involving birdfeeders, garbage, and general property damage comprise the majority of reports, yet human safety represents the most common concern, although most of this category consists of bear sightings, not an actual incident. In New Hampshire conflicts are addressed in accordance with the Nuisance Bear Complaint Protocol (NHFG 2011). Bears demonstrating persistent nuisance behavior are translocated only in the absence or ineffectiveness of other alternatives (e.g., removal of or reducing access to attractants, electric fencing, and/or hazing). From 2003-2010, 56 nuisance bears were translocated to remote areas in northern New Hampshire. While most of these bears are tagged, there remains a lack of specific, quantitative information regarding their subsequent behavior and fate. Of those that have been marked, 39% were harvested, 6% returned to the capture area, and 10% resumed nuisance behavior elsewhere. Recovered bears have dispersed to Maine, Vermont, and southern Quebec.

The purpose of this study was to evaluate the effectiveness of translocation as a nuisance bear management tool in New Hampshire. Specific objectives were to measure 1) mortality and survival, 2) movement and dispersal patterns, 3) nuisance behavior and fidelity to anthropogenic food sources, and 4) to assess the efficacy of trapping and relocating nuisance bears as a conflict abatement tool.

## Methods

*Capture and Translocation*

Human-bear conflicts in New Hampshire are addressed in accordance with the Nuisance Bear Complaint Protocol (NHFG 2011). Bears demonstrating persistent nuisance behavior are translocated only in the absence of, or ineffectiveness of alternatives (e.g., removal of an attractant, electric fencing, hazing). From 1 May-15 August 2011 and 2012, chronic nuisance bears were captured in culvert traps and immobilized with Telazol (6 mg/kg of body weight) by NHFG and USDA Wildlife Services staff. Each animal was sexed, its weight estimated, and a premolar removed for aging via cementum annuli analysis (Matson's Laboratory, Milltown, Montana; Willey 1974); age class (subadult <4 yr old, adult ≥4 yr old; note: yearlings were identified but categorized as subadults for analysis) was estimated if a tooth was not removed. Bears were fitted with a GPS radio-collar and numbered ear tags; collars were either ATS G2110D (Advanced Telemetry Systems, Isanti, Minnesota, USA) or Lotek GPS3300L (Lotek Wireless, Newmarket, Ontario, USA) that were equipped with VHF capabilities and mortality beacons. Collars were programmed to record a GPS fix every 2 h and release in late October-early November. Bears were held in culvert traps until fully recovered, transported by truck, and released at Ingersol Brook in northern Pittsburg, NH (Fig. 1).

*Monitoring and Collar Retrieval*

Ground and aerial telemetry were conducted routinely to monitor bears after release. Mortality signals were investigated to verify mortality or a dropped collar, and collars from harvested or dispatched bears were delivered to NHFG. The hunting method (i.e., bait, hounds, stalking) or reason for dispatch was recorded, and the kill location if available. Dropped collars were collected from the field; those that failed to release were retrieved via den check. Ground and aerial telemetry locations were available and used to meet research objectives for certain bears when a collar was irretrievable.

Location data were downloaded from recovered collars and screened for accuracy by removing locations with high error. GPS radio-collars record both 2-dimensional (2D) and 3-dimensional (3D) locations by communicating with either 3 or ≥4 satellites, respectively; 3D fixes are generally more accurate than 2D fixes (Lewis et al. 2007). Dilution of precision (DOP) values measure the geometry of satellites which can indicate the accuracy of a location; lower values correlate to wider satellite spacing, minimizing error. Locations were screened by keeping all 3D and 2D locations with DOP ≤5 (Lewis et al. 2007). Screened locations were then plotted in ArcMap 10 (Environmental Systems Research Institute, Redlands, California, USA).

*Data Analysis*

<u>Survival</u>

Survival was calculated as the percentage of animals surviving during 3 time periods: 1 month after release, to fall (15 September), and to 1 November. Bears with failed collars or premature drops after 15 September were assumed to survive to denning, as mortality caused by the translocation was unlikely and any anthropogenic mortality (except illegal harvest) would be known via mandatory bear harvest registration and ear tag reports. The cause of mortality was determined in each case, and only included hunter harvest and nuisance dispatch in this study.

Movement

A translocated bear located within 2.4 (female) or 4.6 km (male) from its capture site was defined as a return to the capture area. These distances were based on a previous study of nuisance bears in northern New Hampshire (NHFG 2003) where the mean summer (June-August) home ranges for adult females and males were 18.2 and 66.8 $km^2$, respectively; radii of 2.4 and 4.6 km correspond with circular home ranges of that size. While sample size in that study was relatively small (5 females, 1 male), these nuisance bears were representative of bears in my study. Although the male estimate was based on a single individual, its home range relative to that of the females was consistent with ratios reported elsewhere (Amstrup and Beecham 1976, Alt et al. 1980, Garshelis and Pelton 1981, Koehler and Pierce 2003). Small samples sizes precluded the use of logistic regression to determine what variables influenced return rate. Therefore, t-tests were used to determine if there was a difference in translocation distance for bears that homed and those that did not, and Fisher's exact test was used to test for differences in age and sex class ($P \leq 0.05$).

A bear was considered dispersed from the release area when it was located >2.4 (female) or 4.6 (male) km from the release site for at least 48 h. These distances were based on the estimated home ranges detailed above (NHFG 2003). The straight-line distance between the recovery location and release site was measured for each bear; recovery location included collar drop-off, den, or mortality location. In cases where the final location was unknown, recovery was defined as the last known point the collar was attached to the bear. Average daily movement was calculated for the first week after release and seasonally. Seasons were spring (1 May-15 July), summer (16 July-15

September), and fall (16 September-collar drop-off/den entrance) and corresponded to delineations used in other bear studies in the region (Meddleton and Litvaitis 1989, Samson and Huot 1998, NHFG 2003). All means were reported as mean ± SD. T-tests were performed to test for statistical differences ($P \leq 0.05$) in movement rate between years and age classes.

Habitat Selection

Resource selection functions (RSF) with a used vs. available design fit to a logistic regression function were developed to identify habitat features selected for after release (Manly et al. 2002). Typical models of habitat selection define available habitat as that within a delineated area (e.g., a predefined study area or an individual home range), assuming that this entire area is available to the animal at any given time (Arthur et al. 1996, Compton et al. 2002). This assumption is invalid, however, for animals that lack well-defined home ranges or that exhibit frequent long-distance movements, such as bears in this study; more appropriate is a matched used vs. available sampling design (Duchesne et al. 2010). For each bear, each actual location was matched with 10 locations sampled randomly from a circle centered on the preceding actual location. The radius of the circle was equal to the 95% movement distance for that GPS relocation interval (i.e., 1-2, 3-4, 5-6, 7-12, 13-24, and 25+ h), thus basing the random locations on where the animal could have moved in that time period (Arthur et al. 1996, Johnson and Gillingham 2008, Fortin et al. 2009, van Beest et al. 2012).

Habitat features used in this analysis included land cover, elevation, slope, distance to a road, distance to a highway, distance to a building, distance to a wetland, distance to agriculture, and distance to a regenerating stand. Land cover data were obtained using the 2006 National Land Cover Dataset (NLCD); data for Quebec were obtained from the Canadian Forest Service (CFS) Earth Observation for Sustainable Development (EOSD) project and the National Land and Water Information Service (NLWIS). Land cover types were collapsed into 7 types: water, developed, hardwood-mixed forest, softwood forest, open areas, agriculture, and wetland.

Substantial GPS collar bias caused by low fix rates in habitats restricting satellite reception can be problematic in habitat selection studies (Frair et al. 2004, Hebblewhite et al. 2007); however, data loss <10% does not significantly influence the results of such analyses (D'Eon 2003, Frair et al. 2004, Hebblewhite et al. 2007). I opted not to account for habitat bias as my initial collar tests indicated fix rates of >93% in all major habitat types with canopy (i.e., hardwood forest, softwood forest, mixed forest, and wetlands).

Because GPS collars are capable of gathering high amounts of data in short intervals, the locations often show high spatial and temporal autocorrelation (Boyce 2006). This lack of independence can result in models with biased parameter estimates, but incorporating each individual as a random effect in a mixed effects model can address this autocorrelation (Gillies et al. 2006). It can also be used to control for different numbers of observations among individuals (Gillies et al. 2006) and to account for variability in selection among individuals (Duchesne et al. 2010). Models were solved in the program R (R Development Core Team 2012) using the lmer function within the lme4 package (Bates et al. 2012). Models were selected based on AIC value, and the model with fewer variables was selected when $\Delta AIC \leq 2.0$ (Burnham and Anderson 2002).

Nuisance Recidivism

Reports of nuisance behavior by tagged or collared bears were investigated to identify the specific bear involved and the extent of the behavior. Tag numbers were often provided in reports, but in the absence of such information, telemetry and current bear locations were used to identify the animal. Sightings of collared bears unrelated to any nuisance activity were not considered a nuisance incident. Recidivism was calculated for all bears as well as by sex-age class. Bears requiring further management action (e.g., hazing, translocation, or dispatch) were noted. Those translocated a second time (in New Hampshire or elsewhere) or dispatched were considered an unsuccessful translocation.

Fidelity to anthropogenic food sources and the subsequent potential for nuisance behavior was estimated by calculating the percentage of locations within 100 and 500 m of a building for each bear's used and available locations (method for selecting available locations follows that used for habitat selection analysis, detailed above) after dispersal from the release site. Buildings in the study area were digitized in ArcGIS 10 using aerial images from the 2011 and 2012 National Agriculture Imagery Program (NAIP). Aerial images for Quebec were not available, so Google Earth was used at a scale approximate to that used in ArcGIS. All means were reported as mean ± SD. Kruskal-Wallis tests were used to test for statistical differences ($P \leq 0.05$) between years, between used and available locations, and between age classes.

## Results

Twenty-two bears (17M, 4F, 1U) were captured and translocated to northern New Hampshire: 8 (6M, 1F, 1U) in 2011 and 14 (11M, 3F) in 2012 (Fig. 1.1, Appendix B), including 11 adults, 5 subadults, 5 yearlings, 1 unknown, and 2 cubs of the year with female N16 in 2011. Twenty (16M, 4F) were ear tagged and 18 (14M, 4F) were collared (Table 1.1); all collared bears in 2011 were subadults (n = 5), with 8 adults and 5 subadults collared in 2012. The mean translocation distance for collared bears was 127.7 ± 41.3 km. Collars were recovered from 16 bears (12M, 4F), with 1 collar a presumed VHF signal malfunction and 1 unretrievable in the den after a drop-off malfunction (Appendix B). After screening, 38-1258 locations were available per bear; 15 ground and aerial telemetry locations were collected for the 2 bears with unrecovered collars (Appendix E). Two adult females relocated in 2012 gave birth after translocation; N49 was found with 4 cubs during the den check to retrieve her collar, and N39 was reported lactating when captured in Wales, Maine (2 cubs were reported in a nearby tree). Maps of GPS locations for individual bears are in Appendix C.

Table 1.1. Summary of nuisance black bears translocated to northern New Hampshire, summer 2011 and 2012. Numbers in parentheses indicate number by sex (male, female).

| | # Bears Translocated | | # Tagged Translocated Bears | | # Collared Translocated Bears | |
|---|---|---|---|---|---|---|
| **Year** | **Adults** | **Subadults** | **Adults** | **Subadults** | **Adults** | **Subadults** |
| 2011 | 2 (2,0) | 5 (4, 1) | 2 (2, 0) | 5 (4, 1) | 0 | 5 (4, 1) |
| 2012 | 9 (7, 2) | 5 (4, 1) | 8 (6, 2) | 5 (4, 1) | 8 (6, 2) | 5 (4, 1) |
| Total | 11 (9, 2) | 10 (8, 2) | 10 (8, 2) | 10 (8, 2) | 8 (6, 2) | 10 (8, 2) |
| Grand Total | 21 (17, 4)* | | 20 (16, 4) | | 18 (14, 4) | |

* Does not include 1 bear that was translocated, but not handled, in 2011 (sex and age unknown)

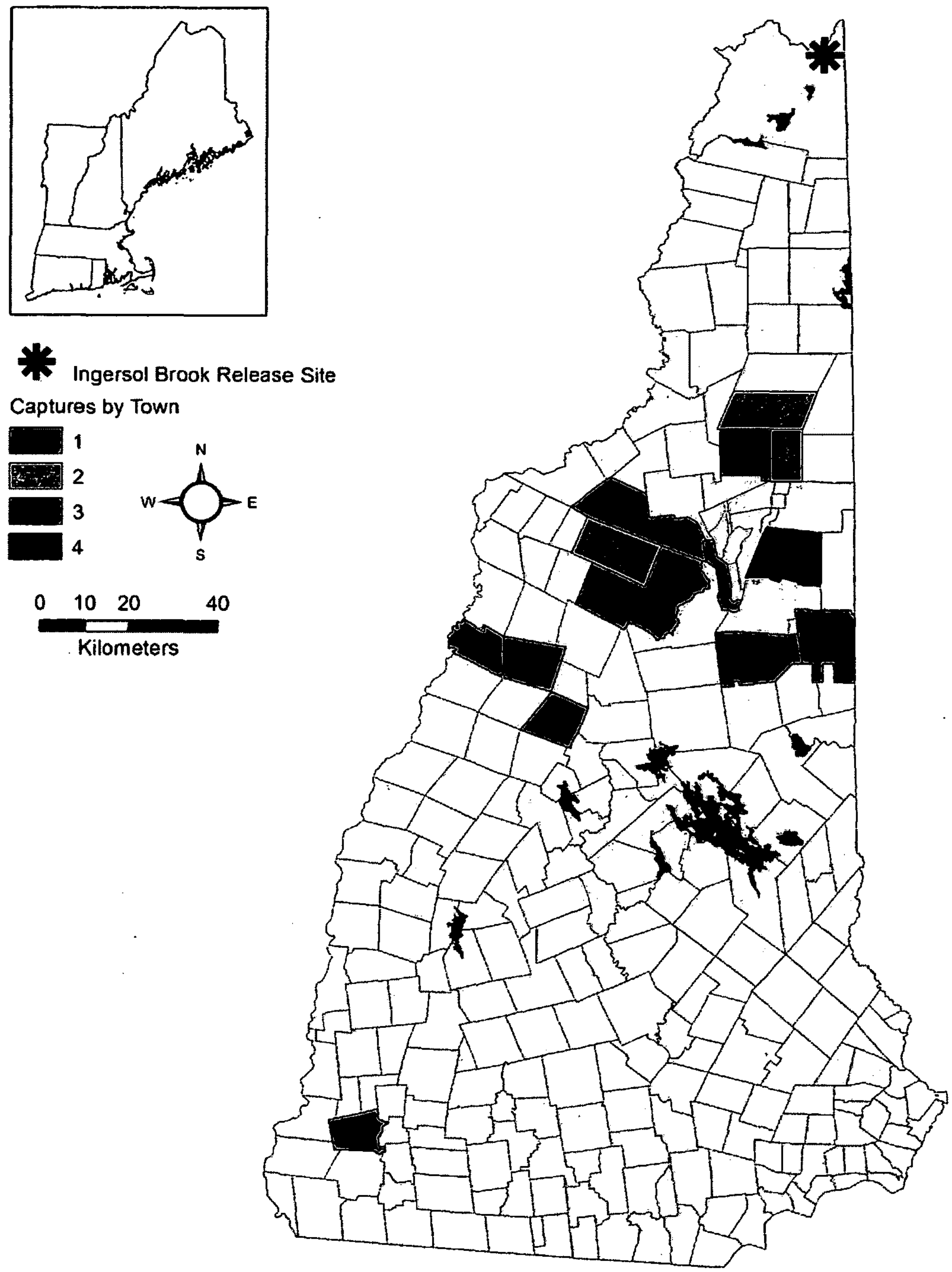


Figure 1.1. Towns where nuisance black bears were captured for translocation to northern New Hampshire, summer 2011 and 2012. The mean translocation distance for collared bears was 127.7 ± 41.3 km.

*Survival*

Survival was high in all 3 periods: 0.82 in the first month, 0.76 to 15 September, and 0.73 to 1 November (Table 1.3, Fig. 1.2). Adult survival was 1.0 in the first month and 0.88 to 15 September and 1 November, and higher than subadult survival (0.67 in all time periods) but not statistically significant ($P = 0.21$, 0.58, and 0.58, respectively); survival was similar both years, though sample size was larger in 2012. All mortalities were attributable to harvest (n = 2) or conflict situations (n = 2) outside of New Hampshire (Table 1.3). One tagged male (N91) was harvested in 2011 after returning to the capture area, and 1 censored female (N24) was destroyed due to conflict in Quebec in 2012 after it was translocated out of the study area by Maine wildlife officials.

Three bears were harvested the year after translocation (Table 1.3). In Maine, male N26 with a field-dressed weight of 82 kg was harvested (29 August) 81.1 km from the release site and 6.9 km from where the collar was recovered, and male N17 with a field-dressed weight of 100 kg was harvested (13 September) 12.6 km from the release site and 60.1 km from where the collar was recovered. Male N48 with a field-dressed weight of 132 kg was harvested (7 June) in Quebec, 55.6 km from the release site.

Table 1.2. The number of bears surviving to 3 time periods for translocated nuisance black bears released in northern New Hampshire, 2011-2012. Statistical differences (*P* ≤0.05) were not present between years or age classes.

| | **1 Month after Release (n)** | **15 September (n)** | **1 November (n)** |
|---|---|---|---|
| 2011 | 4 (5) | 4 (5) | 4 (5) |
| 2012 | 10 (12) | 9 (12) | 7 (10) |
| Adult | 8 (8) | 7 (8) | 6 (7) |
| Subadult | 6 (9) | 6 (9) | 5 (8) |
| Total | 14 (17) | 13 (17) | 11 (15) |

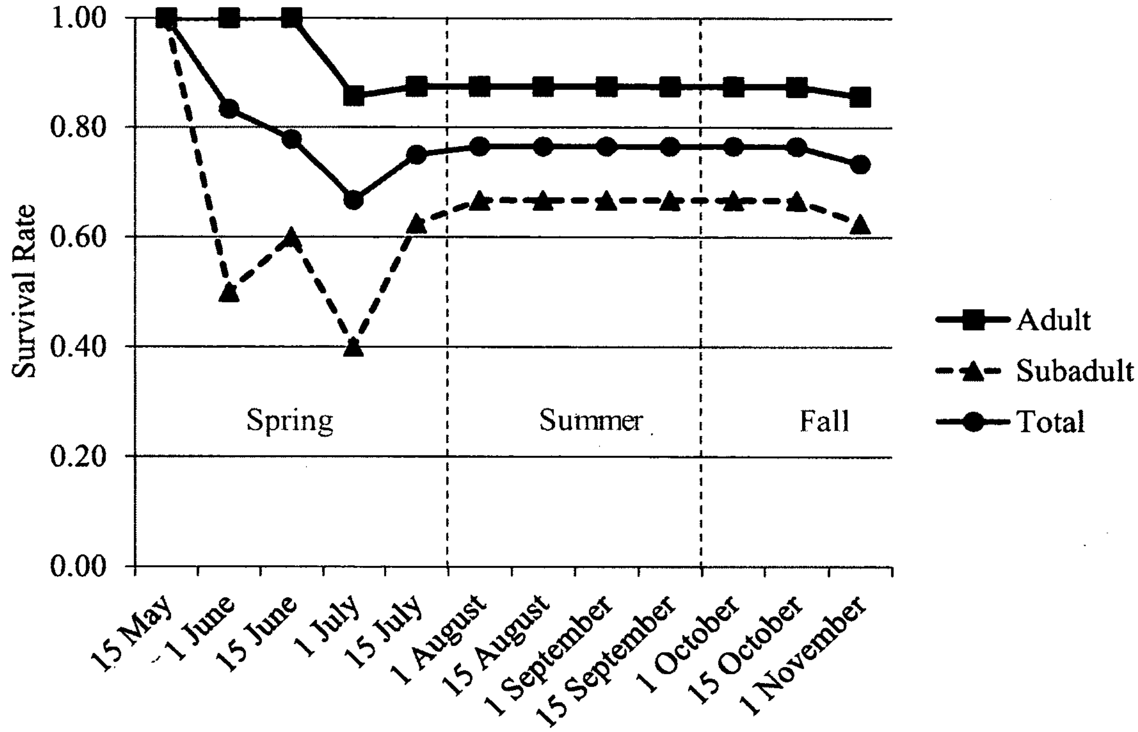


Figure 1.2. Survival rates of translocated nuisance black bears released in northern New Hampshire, 2011-2012. The drop in survival rate after 15 October was due to reduced sample size after 2 collars dropped off before 1 November.

Table 1.3. Causes of mortality for translocated nuisance black bears released in northern New Hampshire, 2011-2012.

| Bear ID | Sex | Date | Cause | Location | Distance from Release Site (km) |
|---|---|---|---|---|---|
| N16 | F | 6/7/2011 | Harvest | Woburn, QC | 27.1 |
| N91[a] | M | 9/8/2011 | Harvest | Gorham, NH | 72.1 |
| N35 | M | 5/28/2012 | Conflict | Phillips. ME | 73.0 |
| N47 | F | 6/18/2012 | Harvest | Scotstown, QC | 30.8 |
| N37 | M | 6/28/2012 | Conflict | Avon, ME | 82.0 |
| N26[b] | M | 8/29/2012 | Harvest | Rumford, ME | 81.1 |
| N17[b] | M | 9/13/2012 | Harvest | Lynchtown, ME | 12.6 |
| N24[c] | F | 10/3/2012 | Conflict | Saint-Zacharie, QC | 26.0[d] |
| N48[b] | M | 6/7/2013 | Harvest | Stornoway, QC | 55.6 |

[a] Not collared; harvested in capture area
[b] Harvested year after translocation
[c] Censored after removal from study area (translocated by Maine wildlife officials)
[d] Distance from second release site in Maine

*Movement*

Five adults relocated in 2012 (4M, 1F) returned to the capture area; male N91 also homed in 2011, but was not included in analysis because it was not collared (Table 1.4). Adults (62.5%) homed more than subadults (0%; $P$ <0.01), and there was no statistical difference between males and females ($P$ = 1.0). Bears that returned were translocated shorter distances (106.8 ± 16.7 km vs. 135.7 ± 45.5 km), but the difference was not significant ($P$ = 0.19).

Bears were recovered 84.0 ± 74.6 km from the capture site and 80.0 ± 33.5 km from the release site; annual differences were not statistically significant ($P$ = 0.3; Table 1.5). Adults were recovered ~75 km closer to the capture site (34.8 ± 42.9 km) than subadults (113.6 ± 75.3 km), but this distance was not significant ($P$ = 0.06); adults were recovered farther from the release site (114.2 ± 23.1 km) than subadults (59.4 ± 75.3 km; $P$ <0.01). The mean dispersal time for all bears was 1.7 ± 1.1 days and was similar between years and age classes (Table 1.6). Bears moved faster during the first week after release in 2012 (11.5 ± 3.9 km/d) than in 2011 (7.5 ± 1.8 km/d; $P$ = 0.05; Table 1.6); adults (14.1 ± 2.3 km/d) moved faster than subadults (7.9 ± 2.5 km/d) during the first week ($P$ <0.001). For all bears combined, movement rate decreased seasonally, from a high of 9.3 ± 4.2 km/d in spring to a low of 3.6 ± 1.8 km/d in fall (Fig. 1.3). The spring movement rate was higher than both summer and fall movement rates ($P$ <0.001) with no statistical difference between summer and fall movement rates ($P$ = 0.35).

Table 1.4. Summary of translocated nuisance black bears that returned to the capture area after release in northern New Hampshire, 2011-2012.

| Bear ID | Release Date | Sex | Age Class | Town of Capture | Distance Translocated (km) | Time to Return (d) |
|---|---|---|---|---|---|---|
| N91[a] | 5/17/2011 | M | Adult | Gorham | 71.0[b] | - |
| N41 | 5/11/2012 | M | Adult | Jackson | 120.6 | 27[c] |
| N43 | 6/1/2012 | M | Adult | Randolph | 95.5 | 17 |
| N49 | 6/18/2012 | F | Adult | Jackson | 121.3 | 74 |
| N03 | 6/19/2012 | M | Adult | Berlin | 83.4 | 42[c] |
| N05 | 7/2/2012 | M | Adult | Bethlehem | 113.3 | 48 |

[a] Bear tagged, but not collared; censored from analysis

[b] Released 27 km south of Ingersol Brook release site due to road conditions

[c] Collars not retrieved, so exact date of return unknown (estimated based on telemetry)

Table 1.5. Mean recovery distance from capture and release sites for translocated nuisance black bears released in northern New Hampshire, 2011-2012. Sample sizes given in parentheses. All means reported as mean ± SD. Statistical differences ($P \leq 0.05$) in each column within each group denoted by *.

| Group (n) | Recovery Distance from Capture Site (km) | Recovery Distance from Release Site (km) |
|---|---|---|
| 2011 (5) | 116.3 ± 104.3 | 63.7 ± 20.6 |
| 2012 (12) | 69.4 ± 56.9 | 87.4 ± 36.4 |
| Adult (7) | 34.8 ± 42.9 | 114.2 ± 23.1* |
| Subadult (10) | 113.6 ± 75.3 | 59.4 ± 75.3 |
| Total (17) | 84.0 ± 74.6 | 80.0 ± 33.5 |

Table 1.6. Mean dispersal time and movement rate during the first week after release for translocated nuisance black bears released in northern New Hampshire, 2011-2012. All means reported as mean ± SD. Statistical differences ($P \leq 0.05$) in each column within each group denoted by *.

| Group (n) | Days to Dispersal | Movement Rate during 1st Week (km/d) |
|---|---|---|
| 2011 (5) | 1.7 ± 1.9 | 7.5 ± 1.8* |
| 2012 (12) | 1.7 ± 0.6 | 11.5 ± 3.9 |
| Adult (7) | 1.6 ± 0.5 | 14.1 ± 2.3* |
| Subadult (10) | 1.8 ± 1.3 | 7.9 ± 2.5 |
| Total (17) | 1.7 ± 1.1 | 10.2 ± 3.9 |

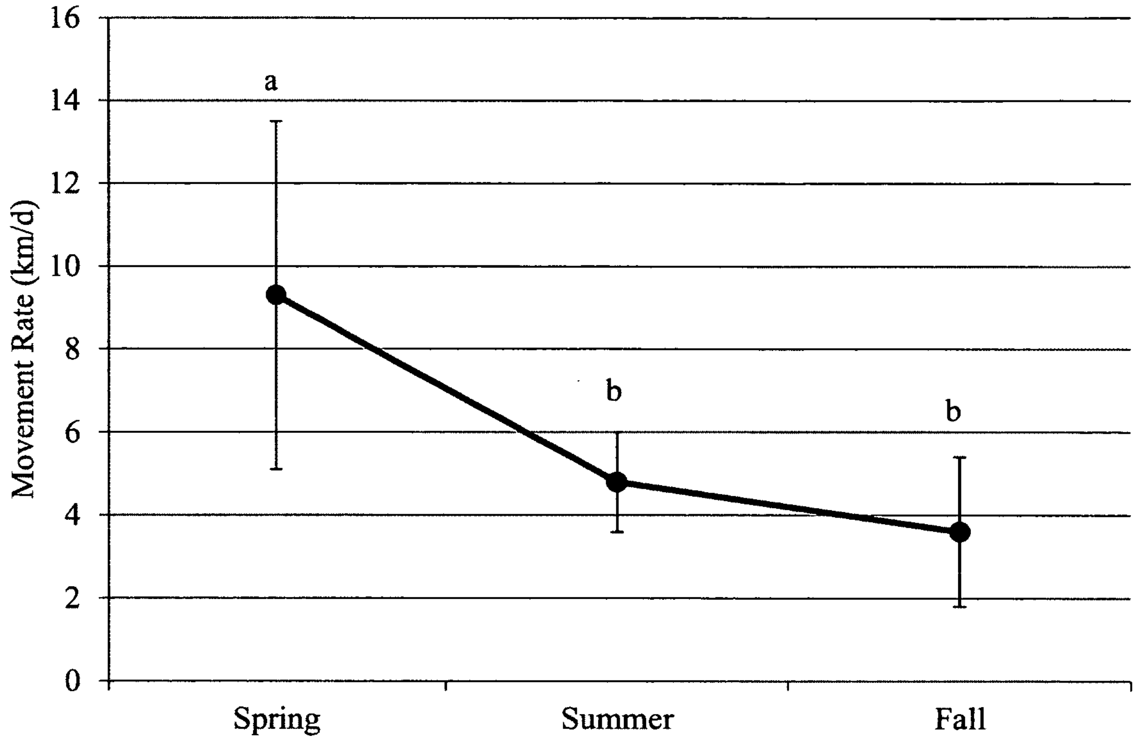


Figure 1.3. Seasonal mean movement rate for translocated nuisance black bears released in northern New Hampshire, 2011-2012. Error bars indicate standard deviation. Statistical differences ($P \leq 0.05$) among seasons denoted by different letters.

*Habitat Selection*

The top model for habitat selection was the full model (Appendix G) which indicated selection for areas close to the release site, buildings, and roads (Table 1.7). Bears also selected for regenerating areas, softwood, wetlands, low elevation, and high slopes, but against agriculture, developed areas, and open water. Finally, the model indicated selection for areas close to streams, but away from agriculture and regenerating areas.

Models were also developed for each age class, but small sample sizes preclude making strong conclusions. Selection was similar to the overall model for both age classes, with a few differences (Table 1.8). Subadults selected for areas close to the release site and for high elevations and away from wetlands, whereas adults selected for wetlands and streams and against developed areas.

Table 1.7. Variables, coefficients, standard errors, and z values of the top model for habitat selection by translocated nuisance black bears released in northern New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| Covariate | β | SE | z value |
|---|---|---|---|
| (Intercept) | -2.377 | 0.016 | -144.800 |
| Distance to Release Site | -0.133 | 0.018 | -7.220 |
| Agriculture | -0.483 | 0.062 | -7.850 |
| Developed | -0.232 | 0.062 | -3.720 |
| Regeneration | 0.552 | 0.042 | 13.010 |
| Softwood | 0.340 | 0.030 | 11.510 |
| Water | -2.178 | 0.151 | -14.400 |
| Wetland | 0.564 | 0.049 | 11.470 |
| Distance to Building | -0.146 | 0.019 | -7.850 |
| Distance to Road | -0.059 | 0.018 | -3.340 |
| Distance to Highway | 0.015 | 0.014 | 1.140 |
| Distance to Agriculture | 0.074 | 0.015 | 4.940 |
| Distance to Regeneration | 0.068 | 0.012 | 5.600 |
| Distance to Stream | -0.043 | 0.012 | -3.570 |
| Distance to Wetland | 0.008 | 0.014 | 0.590 |
| Slope | 0.066 | 0.013 | 5.100 |
| Elevation | -0.147 | 0.022 | -6.760 |

Table 1.8. Variables, coefficients, standard errors, and z values of the top models by age class for habitat selection by translocated nuisance black bears released in northern New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| | Adult | | | Subadult | | |
|---|---|---|---|---|---|---|
| **Covariate** | **β** | **SE** | **z value** | **β** | **SE** | **z value** |
| (Intercept) | -2.589 | 0.042 | -61.700 | -2.359 | 0.031 | -75.390 |
| Distance to Release Site | -0.051 | 0.035 | -1.460 | -0.092 | 0.038 | -2.440 |
| Agriculture | -0.583 | 0.115 | -5.070 | -0.419 | 0.074 | -5.630 |
| Developed | -0.244 | 0.079 | -3.100 | -0.190 | 0.102 | -1.850 |
| Regeneration | 0.439 | 0.068 | 6.410 | 0.609 | 0.055 | 11.070 |
| Softwood | 0.398 | 0.040 | 9.950 | 0.253 | 0.044 | 5.740 |
| Water | -2.690 | 0.255 | -10.570 | -1.616 | 0.189 | -8.540 |
| Wetland | 0.650 | 0.058 | 11.120 | 0.047 | 0.103 | 0.460 |
| Distance to Building | -0.141 | 0.032 | -4.430 | -0.145 | 0.025 | -5.920 |
| Distance to Road | -0.052 | 0.027 | -1.960 | -0.076 | 0.026 | -2.960 |
| Distance to Highway | 0.001 | 0.022 | 0.050 | 0.027 | 0.018 | 1.510 |
| Distance to Agriculture | 0.068 | 0.025 | 2.670 | 0.092 | 0.024 | 3.930 |
| Distance to Regeneration | 0.079 | 0.017 | 4.730 | 0.062 | 0.019 | 3.310 |
| Distance to Stream | -0.087 | 0.018 | -4.820 | -0.003 | 0.016 | -0.190 |
| Distance to Wetland | -0.544 | 0.070 | -7.740 | 0.030 | 0.015 | 2.020 |
| Slope | 0.087 | 0.019 | 4.630 | -0.127 | 0.036 | -3.580 |
| Elevation | -0.014 | 0.037 | -0.370 | 0.074 | 0.018 | 4.040 |

*Nuisance Recidivism*

Ten bears (55%) were documented in conflict situations after release, 3 in 2011 and 7 in 2012; 50% of adults and 60% of subadults resumed nuisance behavior. Most reports involved unsecured attractants, primarily garbage and birdfeeders. In 2011, <1 week after release female N16 was harvested at a birdfeeder in Woburn, Quebec, and male N29 was hazed by Maine wildlife officials <1 month after release at a campground 35 km from the release site. In 2012, males N35 and N37 were shot by landowners in Maine while engaging in conflict activity 19 and 49 days after release, respectively. Female N24 was translocated from the study area by Maine wildlife officials <2 weeks after release; it was censored after this period, but was subsequently dispatched by Quebec wildlife officials after dispersal from the Maine release site. Male N48 was translocated twice by Maine officials, returning both times to the capture area in Oquossoc, Maine.

Bears in 2012 were located within 100 m (13.9 ± 7.7%) and 500 m (60.5 ± 14.6%) of a building more often than bears in 2011 (4.5 ± 4.1% and 18.2 ± 9.1%, respectively; $P$ <0.05; Table 1.8). There was no statistical difference at either 100 or 500 m for used and available locations in 2011 ($P$ = 0.68 for both), whereas in 2012 bears were located within 500 m of a building (60.5 ± 14.6%) more than what was available to them (46.8 ± 18.1%; $P$ = 0.04); there was no statistical difference at 100 m ($P$ = 0.26). Adults were located within 100 m of a building (16.9 ± 7.1%) more often than subadults (7.4 ± 6.5%; $P$ = 0.02); the same trend occurred at 500 m, but was not statistically significant ($P$ = 0.12). Neither adults nor subadults were located within 100 or 500 m at frequencies statistically different to what was available to them.

Table 1.9. Mean percent of used and available locations within 100 m and 500 m of a building by year and age class for translocated nuisance black bears released in northern New Hampshire, 2011-2012. Available locations were derived on a 10:1 sampling design based on movement distance between points for each animal. All means reported as mean ± SD. Statistical differences ($P \leq 0.05$) in each column within each group denoted by different letters.

| Group (n) | Used or Available | Locations/bear | Locations within 100m (%) | Locations within 500m (%) |
|---|---|---|---|---|
| 2011 (5) | Used | 423.8 ± 230.0 | 4.5 ± 4.1[a] | 18.2 ± 9.1[a] |
| | Available | 4238.0 ± 2230.0 | 3.5 ± 3.9[a] | 19.6 ± 10.5[a] |
| 2012 (11) | Used | 663.6 ± 438.8 | 13.9 ± 7.7[b] | 60.5 ± 14.6[b] |
| | Available | 6635.5 ± 4387.9 | 10.3 ± 7.0[b] | 46.8 ± 18.1[c] |
| Adult (6) | Used | 809.8 ± 304.4 | 16.9 ± 7.1[a] | 62.8 ± 17.9[a] |
| | Available | 8098.3 ± 3043.8 | 13.2 ± 8.4[a] | 50.2 ± 19.8[a] |
| Subadult (10) | Used | 455.9 ± 394.6 | 7.4 ± 6.5[b] | 37.9 ± 22.7[a] |
| | Available | 4559.0 ± 3946.3 | 5.1 ± 3.5[b] | 31.2 ± 18.1[a] |

## Discussion

The higher number of bears translocated in 2011 than 2012 reflects the annual difference in human-bear conflicts reported statewide (Fig. 1.4; NHFG 2013). The increased conflict rate in 2012 (117% increase from 2011) was likely attributed to lower availability of natural forage. Annual surveys indicated high abundance of mast species in 2011 and low abundance in 2012 (Fig. 1.5; NHFG 2013). Bears typically seek alternate food sources (i.e., anthropogenic food) during years of poor natural food production, often leading to increased conflict in spring/early summer (Rogers 1976, Knight et al. 1988, Baruch-Mordo et al. 2008); most translocations occurred in May-June 2012 (Table 1.1).

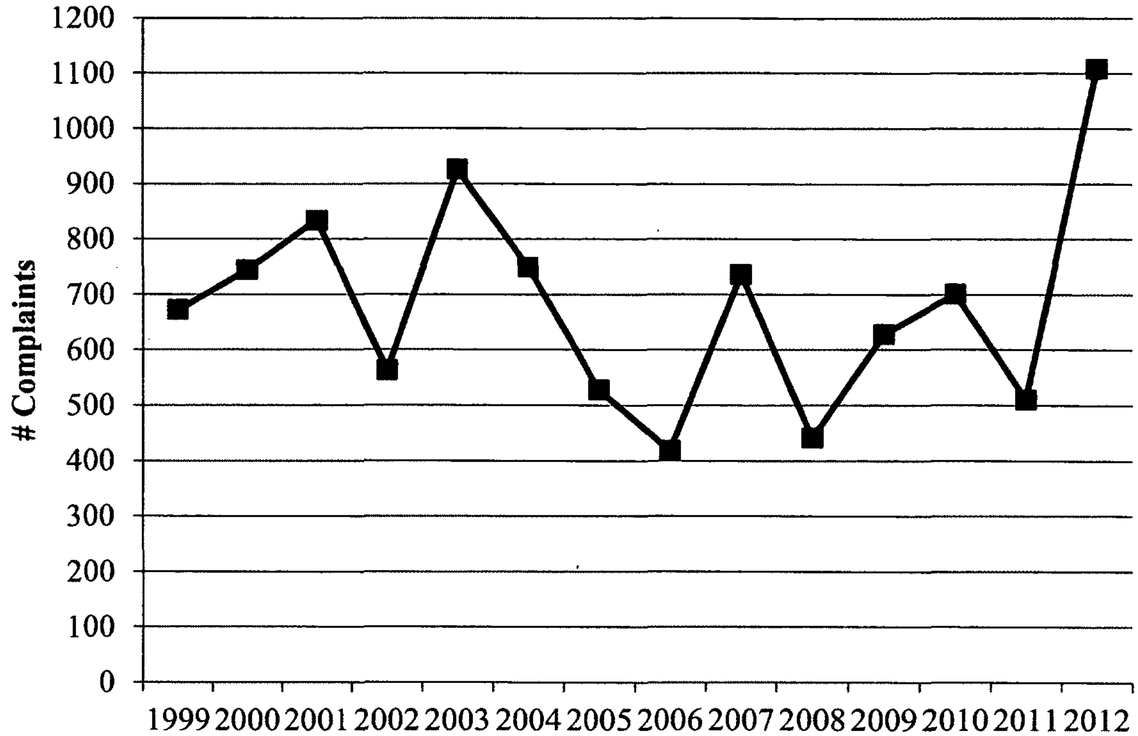

Figure 1.4. Annual reported human-bear conflicts in New Hampshire, 1999-2012 (NHFG 2013). Human-bear conflicts during 2012 (1,108) more than doubled the 510 complaints logged in 2011.

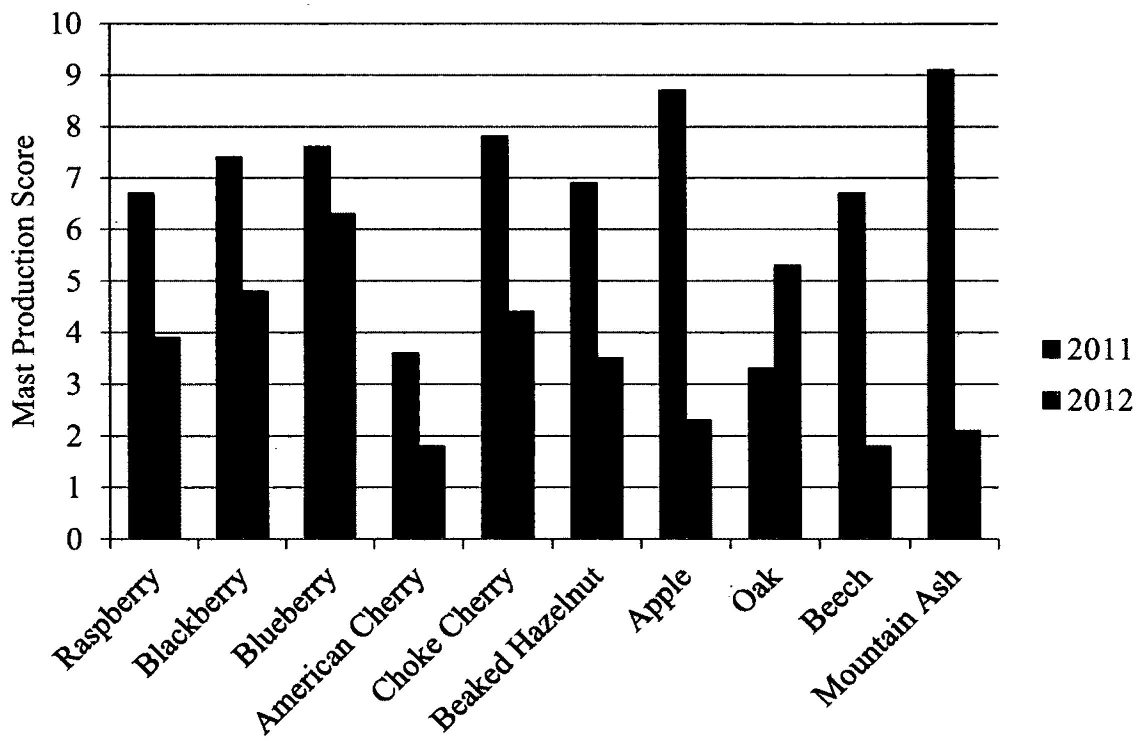


Figure 1.5. Mast production scores for 10 hard and soft mast species in New Hampshire, 2011-2012 (1 = not abundant, 10 = very abundant) (NHFG 2013).

The majority (77%) of translocated bears were males, which corresponds with the overall trend (59%) from 2003-2010 in New Hampshire (NHFG, unpublished data). Males were also the majority of bears involved in conflicts in British Columbia (Rutherglen and Herbison 1977), Great Smoky Mountains National Park (Beeman and Pelton 1976, Singer and Bratton 1980), Montana (McArthur 1981), Pennsylvania (McLaughlin 1981), and Florida (Annis 2007). The larger home range size of males and/or their dominant nature might increase their opportunity to encounter sources of human food (Rogers et al. 1976, Mattson 1990). Dominant animals often utilize the best food sources on the landscape (Jonkel and Cowan 1971, Rogers 1987, Mattson 1990) which could be anthropogenic foods in certain years, such as the poor food year in 2012 when most males (64%) were adults. Conversely, adult males may use human food sources distant from human development where risk is reduced (Tietje and Ruff 1983, Mattson 1990, NHFG 2003), excluding subadult males from these areas and forcing them to take greater risk utilizing resources closer to people (Young and Ruff 1982, Tietje and Ruff 1983, Mattson 1990). Interestingly, the majority (67%) of translocations involved subadults in 2011, when mast crop production was higher.

Translocation probably has minimal effect on reproduction as both adult females reproduced the following year. Reduced reproduction following translocation in black (Comly-Gericke and Vaughan 1997) and brown bears (*Ursus arctos*) (Miller and Ballard 1982, Brannon 1987) has been documented and could relate to stress from the procedure or subsequent movement. Blanchard and Knight (1995) documented that the majority of female grizzly bears reproduced after translocation, but were likely bred prior to capture. Female N39 was moved well before the breeding season and was probably bred after she established a new home range in southern Maine, and N49 was translocated in mid-June, so could have been bred before or after translocation.

*Survival*

Survival was high for collared bears throughout the first year, with only 1 mortality occurring after the first month; conversely, most mortality occurred after 30 days in Ontario (Landriault 1998). All mortality was human-induced, consisting of harvest and management action; anthropogenic causes are typically responsible for mortality of translocated bears (Riley et al. 1994, Comly-Gericke and Vaughan 1997, Landriault 1998, Annis 2007). Vehicle collisions did not occur despite the fact that all bears crossed major highways, many with numerous crossings (5 bears made >40 highway crossings). Vehicle collision was the major source of mortality in Virginia (Comly-Gericke and Vaughan 1997) and less so in Florida (Annis 2007) and Ontario (Landriault 1998). The absence of vehicle mortality is likely due to the lack of busy highways and interstates in the study area.

It is difficult to accurately compare the survival rate of the translocated bears to that of the general bear population in New Hampshire because survival is only calculated for females in the state, which is 0.79 (NHFG 2012), slightly higher than that in this study (0.73). Males likely have higher mortality rates than females in New Hampshire, as documented elsewhere (Bunnell and Tait 1985), especially considering that the estimated annual harvest rate of males (0.25) is twice that of females (0.12; NHFG 2012). Therefore, the survival rate of translocated bears is probably similar to that of the general bear population, and perhaps slightly higher.

An argument supporting translocation is that it delays mortality until the subsequent fall hunting season (Rogers et al. 1976, Rogers 1986, Fies et al. 1987), but the harvest rate (0.11) was lower than that of the general population (0.19; NHFG 2012). The low harvest rate could be attributed to small sample size and study duration or to hunter bias against harvest caused by collaring these animals (Kasworm and Thier 1994, Jacques et al. 2011). However, bears were harvested the year after translocation, consistent with data from 2003-2010 (NHFG unpublished data), indicating translocated bears are utilized by hunters but not necessarily immediately after release.

*Movement*

The return rate in this study (28%) was higher than in 2003-2010 in New Hampshire (6%; NHFG unpublished data), based on reports of ear-tagged bears; however, identifying ear tags is problematic and probably yields conservative return rates. Although it is difficult to compare homing rates among studies because of variations in study design, translocation distance, topography, and sex-age class, the return rate was lower than that reported in British Columbia (69%; Rutherglen and Herbison 1977), Glacier National Park (51%; McArthur 1981), Wisconsin (71%; Massopust and Anderson 1984), and Ontario (49%; Landriault et al. 2009). The mean translocation distance in this study (127.7 ± 41.3 km) exceeded that in these studies which averaged <100 km. Rogers (1986) recommended moving bears >64 km to achieve a return rate of <50%, and all bears were translocated >83 km (Appendix B). While not different statistically, bears that did not home were translocated farther than those that returned, a trend documented elsewhere (Sauer et al. 1969, Harms 1980, Beeman and Pelton 1976, Fies et al. 1987, Annis 2007, Landriault et al. 2009).

Two subsequent translocations of male N48 conducted by Maine wildlife officials corroborate the effect of distance on homing ability. This bear was relocated distances of 28 and 33 km from Oquossoc, Maine and returned in <3 days on both occasions (Appendix C). The bear was released >25 km from any of its previous locations during the first translocation, yet still managed to return quickly. In the second translocation, it was released <1 km from its dispersal route from the Ingersol Brook release area; presumably, it was familiar with the area and immediately returned to Oquossoc.

The exact mechanism bears use to home is unknown, but it is likely that the ability improves with age. The majority of adults (63%) homed in this study, but no subadult returned to its capture area. This skewed return rate is consistent with other translocation studies (McLaughlin 1981, Massopust and Anderson 1984, Rogers 1986, Fies et al. 1987, Landriault et al. 2009), though Annis (2007) found no difference by age class in Florida. It could simply be that young bears have less affinity for an area than adults with established home ranges (Rogers 1976, Brannon 1987, Eastridge and Clark 2001), or they have poorer navigational skill and homing ability (Harger 1967, Landriault et al. 2009). Regardless, "permanent" translocation appears more successful with subadults than adults.

Even those adults not homing (i.e., female N39; Appendix C) exhibited greater dispersal than many subadults. Although subadults were recovered an average of 60 km away, adults simply moved farther. The experience of adults may allow them to locate food sources more effectively during travel, while subadults may stop after encountering a viable food source, which in most cases was anthropogenic (e.g., campgrounds and communities); subadults tended not to remain in such areas permanently, perhaps due to lack of dominance and social pressure from resident bears.

Bears stayed in the release area for a short time (1.7 ± 1.1 days; Table 1.6) immediately after release, which is characteristic of translocations (Landriault 1998, Beckman and Lackey 2004) and may relate to the effects of immobilization. Bears had the highest movement rates during the first week after dispersal (Table 1.6), with female N39 moving nearly 18 km/d (Appendix F). Adults exhibited higher movement rates than subadults during this time, but only male N43 homed almost directly to its capture area, returning in <17 days; for those with recovered collars, female N49 and male N05 homed in 74 and 48 days, respectively, suggesting that the high initial movement rate is not due solely to homing.

The first week movement rate was also different between years (Table 1.6), though confounding factors make it difficult to explain. The lower movement rate in 2011 could be due to a greater abundance of natural food relative to 2012 (Fig. 1.5) because mast failures often increase movement (Beeman and Pelton 1980, Garshelis and Pelton 1981, Noyce and Garshelis 1997). The relative food availability in a release site can influence the success of translocation because lack of food could hasten dispersal (Rutherglen and Herbison 1977, Brannon 1987). Abundant food levels in the release area in 2011 could have reduced initial movements, whereas in 2012 bears may have been forced to seek better foraging conditions. However, because all collared bears were subadults in 2011, the lower movement rates were probably age-related in part (Table 1.6). The difference between years is likely a relic of age class distribution as there was no difference in movement rate when subadults were compared between years ($P = 0.58$).

Movement rate decreased seasonally, with the spring movement rate significantly higher (Fig. 1.3), which probably reflects displacement effects that essentially force a translocated bear to return to its original range or establish a new one. The relatively low food abundance in spring prior to the emergence of summer berries may have influenced movement (Young and Ruff 1982). Spring also coincides with the mating season when bears are particularly active and exhibit high movement (Alt et al. 1980, Young and Ruff 1982, Rogers 1987), though it is unknown if breeding had any impact on study bears.

Bears tend to shift areas of concentrated activity in response to seasonal food sources (Jonkel and Cowan 1971, Garshelis and Pelton 1981, Rogers 1987) which either increases or decreases movement rate (Piekielek and Burton 1975, Young and Ruff 1982). Such behavior was documented for a number of bears in response to fall mast production, with bears generally moving to higher elevations for beech nuts, acorns (*Quercus* spp.), and mountain ash (*Sorbus americana*). Such shifts are not reflected in the fall movement rate because movements are rapid and bears concentrated foraging activity in areas of high and preferred forage.

*Habitat Selection*

Bears selected for a combination of natural and anthropogenic habitat types which is probably characteristic of bears that regularly engage in conflict behavior (Table 1.7). Regenerating areas and wetlands are typical sources of soft mast and green vegetation and are important bear habitat (Costello and Sage 1994, Samson and Huot 2001, Matthews et al. 2006, Brodeur e al. 2008). Selection for softwood stands was peculiar, given the lack of selection reported in other studies attributed to lack of food (Young and Ruff 1982, Matthews et al. 2006, Brodeur et al. 2008); these areas may have been used for shade and cooling or for feeding on colonial insects in downed wood. Selection against, but still close to human-dominated areas (i.e., development, buildings, and agriculture) is likely due to bear behavior in fragmented landscapes. While much of northern New England is rural, there are pockets of developed and agricultural areas that are generally surrounded by contiguous forest. Bears that are active in these areas typically use the surrounding forest as security cover. Therefore, more locations would be proximate to communities and farmland than actually within these areas. The proximity-to-building analysis supports this in that more locations were located within 500 than 100 m of a building (Table 1.8). In and of itself this does not suggest continued nuisance behavior, but it does indicate a lack of avoidance regarding human presence.

The overall model indicated that bears selected for areas close to the release site, but this was likely influenced by the behavior of subadult bears. Models for each age class, though not statistically sound due to small sample sizes, show that only subadults were located closer to the release site (Table 1.8) which corresponds with adults being recovered farther from the release site (Table 1.5). However, subadults did not remain in the release area as all were recovered >27 km away.

*Nuisance Recidivism*

The proportion of bears documented in conflict situations after translocation (55%) was similar to that in Wisconsin (65%; Massopust and Anderson 1984) and Florida (46%; Annis 2007), yet higher than in Virginia (3%; Fies et al. 1987, 2%; Comly-Gericke and Vaughan 1997) and Ontario (30%; Landriault et al. 2009). The relative availability of anthropogenic attractants near release sites could explain these differences, as bears released in areas with greater conflict potential may be more likely to resume such behavior (Linnell et al. 1997). While the Ingersol Brook release site itself is remote, human development is present 10-40 km in all directions; this study indicates that such distances are trivial for a dispersing translocated bear. The majority of translocated bears in New Hampshire have persistently engaged in conflict behavior prior to translocation, and are therefore most likely already food-conditioned and habituated to human presence. It is probably unrealistic to expect that these animals will not utilize human food sources if available after relocation.

Despite the negative experience of translocation, it is apparent that most bears did not alter their behavior to avoid humans. Habitat selection and proximity-to-building analyses revealed bears selected for areas close to buildings (Table 1.7), and the proximity-to-building analysis indicated that bears in 2012 and adults were located close to buildings more often than bears in 2011 and subadults, respectively (Table 1.9). Bears in 2012 may have utilized areas close to buildings more than those in 2011 due to the low availability of natural food that year (Fig. 1.5). All adults were relocated in 2012, so it is difficult to determine if age or food availability caused them to be located close to buildings more often than subadults. It may have been a combination of both factors, as adults may have a greater propensity than subadults to resume nuisance activity post-translocation (Landriault et al. 2009).

This does not necessarily suggest that these animals were engaging in nuisance activity, however. Bears that were documented in a conflict situation after translocation were located within 100 (12.3 ± 8.0%) and 500 m (45.6 ± 25.7%) of a building in similar proportions to those that were not recorded in a conflict (9.3 ± 8.3% and 49.4 ± 23.2, respectively; $P = 0.49$ and 0.71, respectively). It is likely that some bears that were not documented in a conflict situation were simply not observed; bears, particularly adult males, generally shift to nocturnal activity in human environments (Ayres et al. 1986, Beckman and Berger 2003, Lyons 2005, Matthews et al. 2006), reducing the likelihood of observation in a conflict situation. However, any conflicts that went undocumented were likely minor as no significant action (i.e., translocation or lethal removal) was necessary.

While a bear's presence close to buildings does not necessarily indicate it resumed behavior, it does suggest the animal showed some level of fidelity, or at least lack of avoidance, towards human development. Bears may have selected for areas close to buildings due to the presence of other favorable habitat types in close proximity to these human-occupied areas. Regenerating areas and wetlands were located within 500 m of 84% and 63% of buildings in the study area, respectively. Habitat analysis indicated selection for both of these habitat types, as well as for areas close to buildings (Table 1.7). Bears may have been attracted to such areas due to the presence of natural forage and not necessarily in search of human attractants.

*Management Implications*

Translocated bears had high survival (0.73) and low harvest rate (0.11) the first fall, with harvest rate increasing in subsequent years. Bears dispersed widely after release, with adults moving farther than subadults. Five adults (28%) returned to their capture area indicating that homing may be related to age; however, the overall return rate was lower than in most previous studies indicating that distance is an important factor, particularly for subadults. Many bears (55%) were involved in conflict situations after release and were generally active proximate to human development.

One concern this study raises is the dispersal of bears (and the conflicts they may cause) into western Maine. Relocating the release site approximately 20 km south might alleviate this concern as the Aziscohos-Parmachenee Lake system could block easterly movement. Moving the release site further south into New Hampshire might limit dispersal into Maine, but could compromise low return rates and increase recidivism by reducing translocation distance and releasing bears in areas of higher human density.

Relocating bears before they become food-conditioned could reduce recidivism rates (Annis 2007), as aversive conditioning seems more effective prior to food-conditioning (Clark et al. 2002b, Beckman et al. 2004, Mazur 2010). However, such an approach might create the public expectation that any nuisance bears will immediately be relocated, thus undermining efforts to reduce attractants on the landscape; such a policy would also be prohibitively expensive and labor intensive.

The low return rates documented in this study, especially for subadults, suggest that translocation may be an effective means to temporarily resolve conflicts in a local area. It is unknown if bears return in successive years, but even if not, the root of the problem remains unresolved; as long as food attractants are available and accessible to bears, conflicts will persist. It is apparent that translocation did not effectively alter nuisance behavior, as the study bears selected for areas close to human development and many were documented in subsequent conflict situations; in essence, translocation often relocated the bear and conflicts occurred elsewhere.

Town ordinances have the potential to reduce attractants and receive strong public support in New Hampshire (Comeau 2012). The current policy of translocating only in situations of persistent conflict should be maintained, in concert with increased education and policy aimed at reducing attractants and conflicts. This combined strategy would provide landowners short-term relief from persistent nuisance bears and address the foundational relationship between conflicts and attractants associated with predictable human behavior.

# CHAPTER II

# EVALUATING THE SUCCESS OF REHABILITATING ORPHAN BLACK BEARS IN NEW HAMPSHIRE

## Introduction

The orphaning of bear cubs occurs through both natural and anthropogenic means; however, most orphan cubs result either directly or indirectly from human activity. For example, typical mortality of maternal females is through hunting, vehicular collision, or nuisance removals (Beecham 2006). A mother may also abandon her cub(s) due to poor food conditions, or they may become separated due to weather or den disruption (Clark et al. 2002a, Beecham 2006). If old enough, black bear cubs may survive on their own, as 5.5-6.5 month old cubs have successfully denned after being orphaned (Erickson 1959, Payne 1975, Rogers 1985). However, much orphaning occurs either at an earlier age when cubs are clearly not self-sufficient or in high-profile situations that garner significant public attention. Such animals were historically either euthanized or placed permanently in captivity, outcomes that lend no benefit to the local bear population (Jonkel et al. 1980, Beecham 2006). Dispatching orphan cubs may also negatively impact public perception regarding bear management programs (Binks 2008). For example, a survey of New Hampshire landowners regarding nuisance bear management revealed the majority do not favor lethal removal of nuisance bears in most situations, specifically property damage, home entry, and even aggressive behavior

(Comeau 2012). Non-lethal techniques, such as continued monitoring, hazing, and translocation were the preferred responses in these situations.

Survival of orphaned cubs can be enhanced with human intervention, and a number of techniques are used to release orphaned bears into the wild. Fostering cubs with a lactating female in the den has been successful (Clarke et al. 1980, Alt and Beecham 1984), though cub rejection may occur, particularly in poor food years (Carney and Vaughan 1987). Cubs can also be fostered after den emergence by placing them with a captured, immobilized female; the chances of rejection are reduced by eliminating the female's ability to smell the difference between her own and orphan cubs (Jonkel et al. 1980, Alt and Beecham 1984). However, fostering requires having adult females radio-collared and knowledge of their reproductive cycles.

Alternatively, orphaned cubs can be held in captivity and rehabilitated until deemed ready for release, the timing of which varies (Beecham 2006). Releases have occurred during the first summer or fall (Erickson 1959, Skripova 2009), the winter into pre-constructed dens (Jonkel et al. 1980, Skripova 2009), and as yearlings in spring or early summer (Alt and Beecham 1984, Clark et al. 2002a, Binks 2008). Success varies with all approaches, but to enhance survival, it is recommended that orphaned cubs be released as yearlings to coincide with the timing of natural family break-up (Alt and Beecham 1984, Beecham 2006, Binks 2008).

Release sites that provide adequate availability of natural forage should improve survival (Alt and Beecham 1984, Beecham 2006, Beecham and Ramanathan 2007). Both regular and soft releases have been successful (Alt and Beecham 1984, Clark et al. 2002a, Beecham 2006, Beecham and Ramanathan 2007, Binks 2008), with regular releases (transport and immediate release) more common. Soft release involves holding the bear in an enclosure on site and releasing after a period of acclimation, a more labor-intensive and costly method.

A major concern regarding rehabilitation is that cubs may habituate to humans while in captivity, and develop subsequent nuisance behavior after release (Jonkel et al. 1980, Beecham 2006, Binks 2008, Huber 2010). Although conflict behavior has been documented to some extent (Alt and Beecham 1984, Stiver et al. 1997), there are also cases where such behavior was not observed (Clark et al. 2002a) or restricted to random, isolated incidents during movement/dispersal (Binks 2008). A survey of bear rehabilitators revealed that <2% of 576 released bears engaged in nuisance behavior within a year after release (Beecham 2006); albeit, it is unknown what methods were used to quantify this measurement. It is likely that some level of habituation occurs during the first year of captivity, but such behavior may be lost after emergence from the winter den (Smeeton and Waters 2005; B. Kilham, pers. comm.). Limiting a bear's contact with humans and allowing it to socialize with other bears may help prevent habituation (Beecham 2006).The establishment of home ranges in isolated areas or natural forage availability may preclude the use of anthropogenic food.

Of lesser concern is the likelihood of rehabilitated bears returning to the captive facility (Binks 2008), assuming that the release point is distant. The lack of homing is most likely attributed to their young age because subadult nuisance bears also have low return rates after translocation (Harger 1967, Harms 1980, Rogers 1986, Landriault et al. 2009). Young bears probably have less affinity for an area, underdeveloped homing abilities, or poorer navigational skills than older animals (Harger 1967, Rogers 1976, Eastridge and Clark 2001, Landriault et al. 2009).

From 2000-2010, 37 rehabilitated bears were released in New Hampshire (A. Timmins, NHFG, unpublished data; B. Kilham, unpublished data), with most orphaned or abandoned cubs, but malnourished or injured yearlings were also rehabilitated and released. While most were ear-tagged, there remains a paucity of information regarding their survival, movements, and behavior. It is important to measure and interpret the outcome of releases in northern New Hampshire which, despite being nearly contiguous forest, has few areas without human activity within a typical bear home range.

The purpose of this study was to determine the relative success of releasing rehabilitated orphaned cub and malnourished yearling black bears in New Hampshire. Specific objectives were to: 1) measure mortality and survival, 2) measure movement and dispersal patterns, and 3) determine nuisance behavior and fidelity to anthropogenic food sources. Addressing each of these would provide specific measurements to best evaluate the technique of rehabilitation and release of young black bears.

## Methods

### *Rehabilitation and Release*

In New Hampshire, orphaned or abandoned cubs and injured or malnourished yearlings are taken to a state-licensed rehabilitator where they are held in captivity until deemed ready for release. Bears are segregated by age class, with cubs held in a 71 $m^2$ pen until yearlings from the previous year are released. The primary holding facility is a 3.2 ha forested enclosure that includes a small pond, wetlands, large climbing trees, and a mosaic of tree/shrub species common to bear habitat in New Hampshire. To reduce the possibility of habituation, contact with humans is reduced through the use of a single caregiver in most situations. Very young cubs are bottle fed until they are capable of consuming solid food consisting of a mixture of dog food, fruits, vegetables, and natural vegetation; natural forage (e.g., forbs, leaves, berries, insects, and hard mast) exists within the enclosure. Cubs overwinter at the facility in dens constructed with natural materials, though occasionally construct dens of their own. They are captured and released the following spring or early summer as yearlings; malnourished/injured yearlings are released when they gain sufficient weight.

Bears were captured at the facility in June 2011 and May 2012 using culvert traps and dart guns, and immobilized by NHFG staff with Telazol (6 mg/kg body weight). Each was sexed, its weight estimated, and fitted with a GPS radio-collar and a numbered metal tag in both ears. Radio-collars included ATS G2110D (Advanced Telemetry Systems, Isanti, Minnesota, USA) and Lotek GPS3300L (Lotek Wireless, Newmarket, Ontario, Canada), both equipped with VHF capabilities and mortality beacons. Collars were programmed to record a GPS fix every 2 h and drop-off in early November. Bears were transported in culvert traps by truck and released in Nash Stream Forest (Fig. 1).

*Monitoring and Collar Retrieval*

Ground and aerial telemetry were conducted routinely to monitor collared animals after release. Mortality signals were investigated to verify mortality or determine if a collar had dropped. Collars from harvested or dispatched bears were retrieved or delivered to NHFG if mortality occurred outside of New Hampshire. The hunting method (i.e., bait, hounds, stalking) or reason for dispatch was recorded, and the kill location if available. Collars that dropped off were collected from the field and those failing to release were retrieved via den check. Ground and aerial telemetry locations were analyzed for certain animals if a collar was irretrievable.

Location data were downloaded from recovered collars and screened for accuracy by removing locations with high error. GPS radio-collars record both 2-dimensional (2D) and 3-dimensional (3D) locations by communicating with either 3 or $\geq 4$ satellites, respectively; 3D fixes are generally more accurate than 2D fixes (Lewis et al. 2007). Dilution of precision (DOP) values measure the geometry of satellites which can indicate the accuracy of a location; lower values correlate to wider satellite spacing, minimizing error. Locations were screened by keeping all 3D and 2D locations with DOP $\leq 5$ (Lewis et al. 2007). Screened locations were then plotted and analyzed in ArcMap 10 (Environmental Systems Research Institute, Redlands, California, USA).

*Data Analysis*

<u>Survival</u>

Survival was calculated as the percentage of animals surviving during 3 time periods: 1 month after release, to fall (15 September), and to 1 November. Bears with failed collars or premature drops were censored after the last known date that the collar was either functioning or attached to the bear. The cause of mortality was determined in each case; the only forms of mortality in this study were hunter harvest, nuisance dispatch, and illegal harvest. Fisher's exact test was used to test for differences ($P \leq 0.05$) in survival between the 2 years.

## Movement

A bear was considered dispersed from the release area when it was located >3 km from the release site for at least 48 h. The distance between the recovery location and the release site was measured for each bear; recovery locations included collar drop-off, den, or mortality site. In cases where the final location was unknown, recovery was defined as the last known point the collar was attached to the bear. Average daily movement was calculated for the first week after release and seasonally. Seasons were spring (release-15 July), summer (16 July-15 September), and fall (16 September-collar drop-off/den entrance) and corresponded to delineations used in other regional bear studies (Meddleton and Litvaitis 1989, Samson and Huot 1998, NHFG 2003). All means were reported as mean ± SD. T-tests were performed to test for statistical differences ($P \leq 0.05$) between years, acknowledging that the small sample sizes inhibited the detection of all but large differences.

## Habitat Selection

Resource selection functions (RSF) with a used vs. available design fit to a logistic regression function were developed to identify habitat features selected for after release (Manly et al. 2002). Typical models of habitat selection define available habitat as that within a delineated area (e.g., a predefined study area or an individual home range), assuming that this entire area is available to the animal at any given time (Arthur et al. 1996, Compton et al. 2002). This assumption is invalid, however, for animals that lack well-defined home ranges or that exhibit frequent long-distance movements, such as bears in this study; a more appropriate sampling design is a matched used vs. available design (Duchesne et al. 2010). For each bear, each actual location was matched with 10 random locations sampled from a circle centered on the actual location. The radius of the circle was equal to the 95% movement distance for that GPS relocation interval (i.e., 1-2, 3-4, 5-6, 7-12, 13-24, and 25+ h), thus basing the random locations on where the animal could have moved in that time period (Arthur et al. 1996, Johnson and Gillingham 2008, Fortin et al. 2009, van Beest et al. 2012).

Eleven habitat features were used in this analysis: land cover, elevation, slope, aspect, distance to a road, distance to a highway, distance to a building, distance from the release site, distance to agriculture, distance to a wetland, and distance to a regenerating stand. Land cover data were obtained from the 2006 National Land Cover Dataset (NLCD); data for Quebec were obtained from the Canadian Forest Service (CFS) Earth Observation for Sustainable Development (EOSD) project and the National Land and Water Information Service (NLWIS). Land cover was collapsed into 7 types: water, developed, hardwood-mixed forest, softwood forest, regenerating areas, agriculture, and wetland. Buildings were digitized in ArcGIS 10 using aerial images from the 2011 and 2012 National Agriculture Imagery Program (NAIP). Aerial images for Quebec were not available, so Google Earth was used at a scale approximate to that in ArcGIS.

If substantial, low fix rates caused by habitat features restricting satellite reception can be problematic in habitat selection studies (Frair et al. 2004, Hebblewhite et al. 2007). It is believed that data loss <10% does not significantly influence the results of such analyses (D'Eon 2003, Frair et al. 2004, Hebblewhite et al. 2007). I opted not to account for habitat bias as my initial collar tests indicated fix rates of >93% in all major habitat types with canopy (i.e., hardwood forest, softwood forest, mixed forest, and wetlands).

Because GPS collars are capable of gathering high amounts of data in short intervals, the locations often show high spatial and temporal autocorrelation (Boyce 2006). This lack of independence can result in models with biased parameter estimates, but incorporating each individual as a random effect in a mixed effects model can address this autocorrelation (Gillies et al. 2006). It can also be used to control for different numbers of observations among individuals (Gillies et al. 2006) and to account for variability in selection among individuals (Duchesne et al. 2010). Models were solved in the program R (R Development Core Team 2012) using the lmer function within the lme4 package (Bates et al. 2012). Models were selected based on AIC value, and the model with fewer variables was selected when $\Delta AIC \leq 2.0$ (Burnham and Anderson 2002). Models were developed for data from both years and each year separately, but due to small sample sizes, firm conclusions cannot be drawn from the individual year models.

Nuisance Behavior

Conflict reports associated with the released bears were used to gauge the development of nuisance behavior in rehabilitated bears. Because the ear tags were not visible from a distance, telemetry and current locations were used to identify the animal. Sightings of collared bears unrelated to any nuisance activity were not considered a nuisance incident. The potential for nuisance behavior was estimated by calculating the percentage of locations within 100 and 500 m of a building for each bear's used and available locations (method for selecting available locations followed that used for habitat selection analysis) after dispersal from the release site. All means were reported as mean ± SD. Kruskal-Wallis tests were used to test for statistical differences ($P \leq 0.05$) between years and between used and available locations.

## Results

Eleven rehabilitated bears (9M, 2F) were released in Nash Stream Forest: 7 (6M, 1F) in 2011 and 4 (3M, 1F) in 2012 (Appendix B). Collars were recovered from 10 (8M, 2F), with the single unrecovered collar presumed a VHF signal malfunction. One female slipped its collar <2 weeks after release in 2012 and was censored after that period. Maps of GPS locations for individual bears can be found in Appendix D. After screening, 266-1579 locations were available per bear (70 locations from the slipped collar); 12 ground and aerial telemetry locations were collected for the bear with an unretrieved collar and used to meet research objectives (Appendix E).

*Survival*

All bears survived the first month after release both years (Table 2.1). Overall survival to the fall season (15 September) was 0.80, dropping to 0.60 by 1 November. Three mortalities occurred in New Hampshire, including 2 hunter harvests and 1 illegal harvest (the cut collar was located in the Connecticut River), 6.0-20.1 km from the release site; 1 bear was dispatched (bee hive conflict) in Quebec, 73.1 km from the release site (Table 2.2). All bears released in 2011 survived until the fall season (Fig. 2.1), with only 1 mortality (harvest) afterwards. No bears released in 2012 survived beyond mid-October (Fig. 2.1); survival to 1 November was higher ($P = 0.03$) in 2011 than 2012. Female R132 released in 2011 was harvested during the 2012 hunting season in Vermont, 58.7 km from the release site and 55.3 km from where the collar was recovered in 2011; the bear was in good condition with a field-dressed weight of 60 kg.

Table 2.1. The number of bears surviving to 3 time periods for rehabilitated black bears released in Nash Stream Forest, New Hampshire, June 2011 (n = 7) and May 2012 (n = 3). Statistical differences ($P \leq 0.05$) between years in each column denoted by *.

| | 1 Month after Release | 15 September | 1 November |
|---|---|---|---|
| 2011 | 7 (100%) | 7 (100%) | 6 (86%)* |
| 2012 | 3 (100%) | 1 (33%) | 0 (0%) |
| Total | 10 (100%) | 8 (80%) | 6 (60%) |

Table 2.2. Causes of mortality for rehabilitated black bears released in Nash Stream Forest, New Hampshire, June 2011 and May 2012.

| Date | Bear ID | Cause | Location | Distance from Release Site (km) |
|---|---|---|---|---|
| 9/19/2011 | R143 | Harvest | Nash Stream Forest, NH | 6.0 |
| 6/25/2012[a] | R283 | Illegal Kill[b] | Northumberland, NH | 15.0 |
| 10/11/2012 | R286 | Conflict[c] | Sherbrooke, QC | 73.1 |
| 9/2/2012 | R288 | Harvest | Northumberland, NH | 20.1 |
| 10/11/2012 | R132 | Harvest | Waterford, VT | 58.7 |

[a] Exact date unknown, approximation based on collar data
[b] Collar found cut in Connecticut River
[c] Bear trapped and dispatched after damaging bee hive

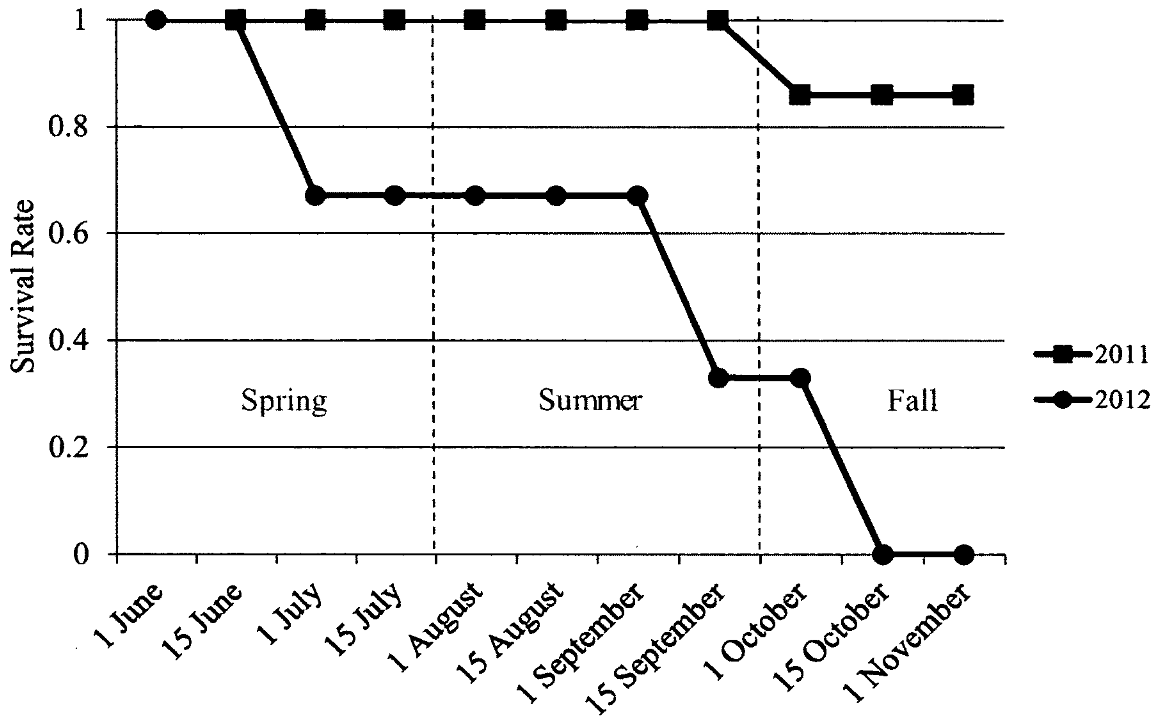


Figure 2.1. Survival rates of rehabilitated black bears released in Nash Stream Forest, New Hampshire, June 2011 (n = 7) and May 2012 (n = 3).

*Movement*

While measurable differences occurred in the movement metrics, none was statistically significant ($P > 0.05$), reflecting the small sample size and large variance (Table 2.3). The mean dispersal time for all bears was 6.9 ± 6.0 days. Bears in 2011 (8.5 ± 7.1 days) dispersed 4 days later than those in 2012 (4.5 ± 3.7 days) and moved 2.4 km/d less than bears in 2012 (5.0 ± 2.7 km/d) in the initial week after release. The mean recovery distance from the release site for all bears was 15.6 ± 22.1 km (range = 3.4-73.1 km), with bears in 2011 (6.6 ± 2.4 km, range = 3.4-10.0 km) recovered ~27 km closer to the release site than bears in 2012 (33.5 ± 34.9, range = 7.4-73.1 km). Movement rate declined seasonally in 2011, from a high of 3.4 ± 1.7 km/d in spring to a low of 1.8 ± 0.9 km/d in fall; seasonal movement data was limited in 2012 to data from 2 bears in summer and 1 bear in fall.

Table 2.3. Mean dispersal, recovery, and movement metrics for rehabilitated bears released in Nash Stream Forest, New Hampshire, June 2011 and May 2012. Dispersal was calculated as the number of days until a bear was located ≥3 km from the release site for at least 48 h. Movement rate was calculated for the 1st week after release, by season (spring = release-15 July, summer = 16 July-15 September, fall = 16 September-collar drop-off or den), and for the duration of collar deployment. All means reported as mean ± SD. Measureable differences were observed, though none was statistically significant ($P$ >0.05).

| | | | | **Movement Rate (km/d)** | | | |
|---|---|---|---|---|---|---|---|
| | **Days Deployed** | **Days to Dispersal** | **Recovery Distance (km)** | **1st Week** | **Spring** | **Summer** | **Fall** |
| 2011 | 149.1 ± 31.0 | 8.5 ± 7.1 | 6.6 ± 2.4 | 2.6 ± 2.0 | 3.4 ± 1.7 | 2.5 ± 0.8 | 1.8 ± 0.9 |
| (n) | (7) | (6) | (6) | (6) | (6) | (6) | (5) |
| 2012 | 93.3 ± 56.3 | 4.5 ± 3.7 | 33.5 ± 34.9 | 5.0 ± 2.7 | 3.5 ± 1.3 | 3.1 ± 2.1 | 1.2 ± 0.0 |
| (n) | (4) | (4) | (3) | (4) | (3) | (2) | (1) |
| Total | 132.4 ± 45.5 | 6.9 ± 6.0 | 15.6 ± 22.1 | 3.6 ± 2.5 | 3.4 ± 1.5 | 2.7 ± 1.1 | 1.7 ± 0.8 |
| (n) | (11) | (10) | (9) | (10) | (9) | (8) | (6) |

*Habitat Selection*

The top model for both years combined was the full model (Appendix G) which indicated bears selected for regenerating areas, wetlands, and high slopes and against agriculture, development, softwood, and open water (Table 2.4). Bears were also located closer to regenerating areas, wetlands, agriculture, and roads and farther from streams and the release site.

While firm conclusions cannot be drawn from the annual models, they indicate that bears in 2011 selected for natural habitats consisting of typical summer and fall bear foods, primarily regenerating areas, wetlands, and high slopes; developed and agricultural areas were avoided (Table 2.5). The 2012 model suggests bears selected for areas close to buildings, roads, regenerating areas, and wetlands, while avoiding developed and agricultural areas.

Table 2.4. Variables, coefficients, standard errors, and z values of the top model for habitat selection by rehabilitated black bears released in Nash Stream Forest, New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| **Covariate** | **β** | **SE** | **z value** |
|---|---|---|---|
| (Intercept) | -2.274 | 0.079 | -28.922 |
| Distance to Release Site | 0.086 | 0.042 | 2.052 |
| Agriculture | -1.706 | 0.139 | -12.290 |
| Developed | -0.692 | 0.118 | -5.843 |
| Regeneration | 0.388 | 0.056 | 6.964 |
| Softwood | -0.102 | 0.036 | -2.875 |
| Water | -1.963 | 0.712 | -2.756 |
| Wetland | 0.243 | 0.098 | 2.464 |
| Distance to Building | -0.035 | 0.025 | -1.362 |
| Distance to Road | -0.093 | 0.026 | -3.572 |
| Distance to Highway | 0.013 | 0.038 | 0.327 |
| Distance to Agriculture | -0.157 | 0.038 | -4.117 |
| Distance to Regeneration | -0.055 | 0.017 | -3.303 |
| Distance to Stream | 0.072 | 0.014 | 5.287 |
| Distance to Wetland | -0.149 | 0.023 | -6.593 |
| Slope | 0.288 | 0.018 | 16.138 |
| Elevation | 0.030 | 0.035 | 0.852 |

Table 2.5. Variables, coefficients, standard errors, and z values of the top annual models for habitat selection by rehabilitated black bears released in Nash Stream Forest, New Hampshire, June 2011 and May 2012. Models were developed using a resource selection function based on a used vs. available design.

| | **2011** | | | **2012** | | |
|---|---|---|---|---|---|---|
| **Covariate** | **β** | **SE** | **z value** | **β** | **SE** | **z value** |
| (Intercept) | -2.317 | 0.078 | -29.694 | -2.764 | 0.153 | -18.063 |
| Distance to Release Site | | | | 0.079 | 0.050 | 1.598 |
| Distance to Building | | | | -0.441 | 0.081 | -5.467 |
| Distance to Highway | | | | 0.062 | 0.070 | 0.884 |
| Distance to Road | | | | -0.276 | 0.076 | -3.635 |
| Distance to Agriculture | -0.101 | 0.040 | -2.497 | -0.006 | 0.048 | -0.131 |
| Distance to Regeneration | 0.001 | 0.018 | 0.047 | -0.590 | 0.059 | -10.047 |
| Distance to Wetland | -0.137 | 0.028 | -4.834 | -0.187 | 0.036 | -5.142 |
| Distance to Stream | 0.100 | 0.016 | 6.441 | 0.030 | 0.028 | 1.075 |
| Agriculture | -1.676 | 0.359 | -4.671 | -1.944 | 0.153 | -12.720 |
| Developed | -1.364 | 0.209 | -6.538 | -0.308 | 0.150 | -2.049 |
| Regeneration | 0.219 | 0.071 | 3.098 | 0.376 | 0.094 | 4.016 |
| Softwood | -0.189 | 0.041 | -4.568 | -0.082 | 0.071 | -1.150 |
| Water | -1.326 | 0.716 | -1.853 | -13.164 | 269.942 | -0.049 |
| Wetland | 0.713 | 0.154 | 4.631 | -0.057 | 0.132 | -0.436 |
| Elevation | -0.031 | 0.037 | -0.834 | 0.072 | 0.104 | 0.691 |
| Slope | 0.310 | 0.019 | 16.617 | 0.282 | 0.058 | 4.866 |

*Nuisance Behavior*

There were no nuisance reports associated with bears released in 2011, though male R145 was located <1 km from human development and farmland. Inspection of its locations using aerial imagery revealed concentrated activity along powerline corridors and early successional sites in the area. Nuisance activity was recorded for 3 bears released in 2012. Male R288 was reported raiding a birdfeeder 10 km from the release site in early June; nuisance activity ceased after removal of the attractant, though the bear remained in the area for 2 months. The collar of male R283 was found cut in the Connecticut River in early July. Investigations by NHFG Conservation Officers indicated the bear was illegally killed by a landowner after approaching livestock. Male R286 was trapped and dispatched in early October after damaging a beehive in Quebec, 73 km from the release site.

Bears in 2011 were located within 100 m (0.8 ± 1.8%) of a building less often than bears in 2012 (8.5 ± 6.7%; $P = 0.02$; Table 2.6); the same trend occurred at 500 m, but was not statistically different ($P = 0.07$). Bears in 2011 were located within 100 m of a building less than what was available (3.7 ± 4.6%; $P = 0.04$); this also occurred at 500 m, but was not statistically different ($P = 0.23$). Bears in 2012 were located within 100 and 500 m of a building more than what was available, but no statistical differences existed ($P = 1.0$ and 0.7, respectively).

Table 2.6. Mean percent of used and available locations within 100 m and 500 m of a building for rehabilitated black bears released in Nash Stream Forest, New Hampshire, June 2011 and May 2012. Available locations were derived on a 10:1 sampling design based on movement distance between points for each animal. All means reported as mean ± SD. Statistical differences ($P \leq 0.05$) in each column denoted by *.

| Year | Used or Available (n) | Locations/bear | Locations within 100 m (%) | Locations within 500 m (%) |
|---|---|---|---|---|
| 2011 | Used (6) | 905.5 ± 418.4 | 0.8 ± 1.8* | 11.5 ± 20.8 |
| | Available (6) | 9055.0 ± 4183.6 | 3.7 ± 4.6 | 16.0 ± 20.6 |
| 2012 | Used (3) | 479.8 ± 418.5 | 8.5 ± 6.7 | 56.6 ± 16.0 |
| | Available (3) | 4797.5 ± 4185.4 | 8.0 ± 2.2 | 46.5 ± 11.2 |

## Discussion

*Survival*

All bears survived the first month after release, with one censored due to a slipped collar. High survival was similar in the Great Smoky Mountains National Park where 10 of 11 rehabilitated yearlings (1 slipped collar) survived the first month (though releases occurred in January and March; Clark et al. 2002a), and Alt and Beecham (1984) recaptured 9 of 14 yearlings after 30 days in Idaho and Pennsylvania. High survival during the first month is probably due to the optimal fitness of cubs in captivity that are typically heavier than those in the wild (Huber et al. 1993, Beecham 2006). The average release weight was estimated at 43 kg, about twice the weight of yearlings in New Hampshire (20.5 kg; NHFG unpublished data) and Montana (22.3 kg; Jonkel and Cowan 1971). This extra weight probably helps rehabilitated bears by providing extra time for acclimation in the wild.

Mortality after 30 days was all human-induced: 2 legal harvests, 1 illegal kill, and 1 nuisance removal (Table 2.2). Humans are largely responsible for mortality of subadult black bears (Schwartz and Franzmann 1992, Beringer et al. 1998, Lee and Vaughan 2005) and rehabilitated yearlings in Ontario (Binks 2008). While mortality due to conflict or vehicle collision is undesirable, harvest of rehabilitated bears should not be construed as an entirely negative result. Orphan bears are released with the intention of becoming a functioning part of a bear population, which includes as a potential harvest resource. Of concern would be if a large proportion of rehabilitated bears were harvested in their first fall, indicating high susceptibility to hunting.

Previous studies of rehabilitated yearlings did not document natural mortality due to starvation or predation (Alt and Beecham 1984, Stiver et al. 1997, Clark et al. 2002a); however, many bears were not recovered or tracked successfully, hence absolute survival is unknown. Mortality by other bears (usually adult males) is uncommon, but can occur in areas of high bear density and/or low food abundance (Jonkel and Cowan 1971, Kemp 1976, Garshelis and Pelton 1981, LeCount 1982, Alt and Gruttadauria 1984, NHFG 2003). Exploited populations are generally dominated by younger bears and dispersing subadults, as the resident adult males are often harvested (Rogers 1976, Beecham 1983), which can disrupt the social hierarchy in that population (Beecham 2006). Possibly, a lack of dominant adult males in the release area reduced the risk of intraspecific mortality, though it is more likely that such mortality is simply uncommon.

Total survival (0.60) was lower than that estimated for female yearlings in New Hampshire (0.83; NHFG 2013); survival estimates for males are not conducted. Survival for all yearlings in New Hampshire is likely <0.84 as subadult males are more susceptible to mortality, particularly hunting and conflict removals (Bunnell and Tait 1985, Schwartz and Franzmann 1992, Klenzendorf 2002, Lee and Vaughan 2005). Survival in 2011(0.86) was similar to the estimate for female yearlings in New Hampshire (0.83), and would be higher than a combined estimate with males. It was also higher than that of yearling black bears in Alaska (0.75; Schwartz and Franzmann 1992), Oregon (0.74; Lindzey and Meslow 1980), and an unexploited population in Alberta (0.63; Kemp 1972). Male survival in 2011 (0.83) was higher than yearling male survival reported in Virginia (0.32; Lee and Vaughan 2005) and Oregon (0.71; Lindzey and Meslow 1980).

Survival in 2011 (0.86) was similar to that of bears released from 3 different rehabilitation facilities in Ontario (Binks 2008). Bears rehabilitated under conditions most resembling those in New Hampshire had a slightly higher survival rate (0.93), but were released in July. Extra time in captivity probably increases fitness, reduces time spent in the wild during the first year, and reduces exposure to mortality; releases in mid-summer also coincide with the emergence of soft mast, an important and usually plentiful forage. Conversely, in the Great Smoky Mountains National Park Clark et al. (2002a) reported high survival of bears released in January and March when food sources are scarce. Climatic differences across study areas could explain this discrepancy, particularly regarding activity periods, denning chronology, food persistence, and length of winter.

The annual difference in survival could be attributed to food availability. Mast surveys indicated high abundance of important mast species in the release area in 2011, but low abundance in 2012 (Fig. 2.2; NHFG 2012, 2013) may have elevated movement rate and dispersal which increase susceptibility to harvest and other forms of mortality (Beeman and Pelton 1980, Bunnell and Tait 1985, Kane 1989, Kasbohm et al. 1994). Bears seek alternate food sources when natural food availability is limited, and this behavior often causes conflict leading to higher mortality via hunting, management action, or illegal killing (Rogers 1976, Knight et al. 1988, Noyce and Garshelis 1997, Baruch-Mordo et al. 2008). Bears may have been more susceptible to such mortality in their search for food in 2012, especially given their increased use of human-associated areas (Table 2.6).

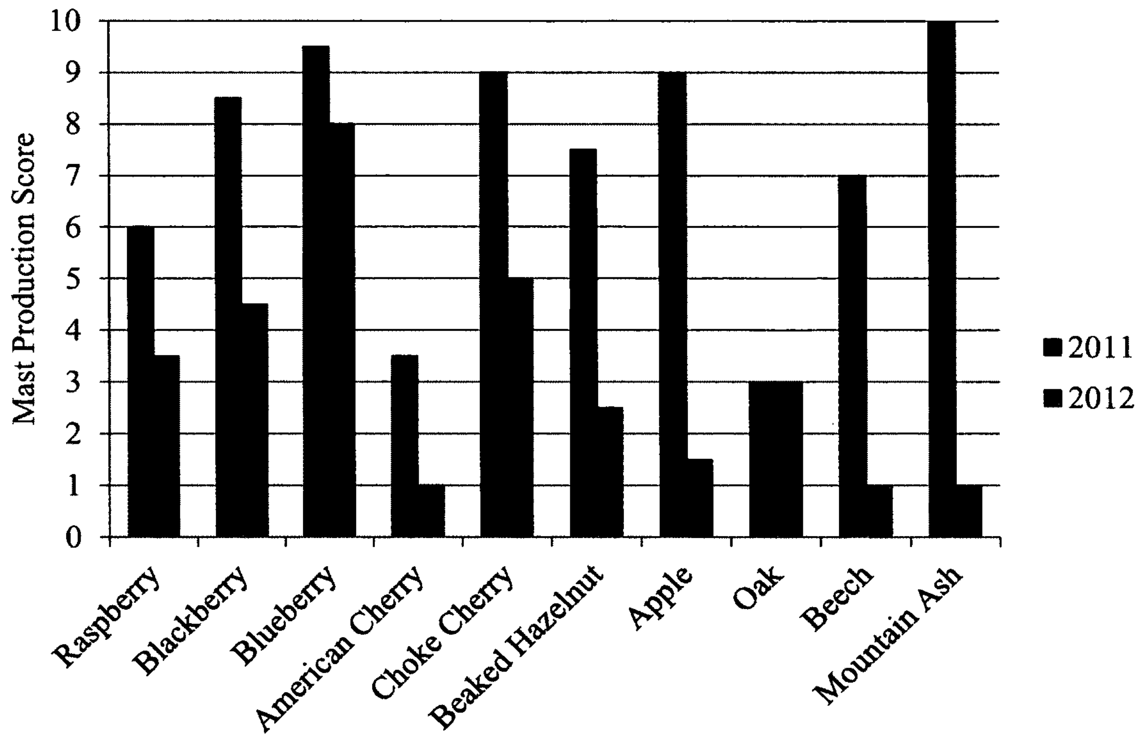


Figure 2.2. Mast production scores for 10 hard and soft mast species in Wildlife Management Unit B, New Hampshire, 2011-2012 (1 = not abundant, 10 = very abundant) where the release site was located (NHFG 2012, 2013).

*Movement*

Rehabilitated bears were released at an age and time that coincided with the timing of natural family breakup, as black bears generally disperse from their natal ranges as yearlings during early summer (Jonkel and Cowan 1971, Clevenger and Pelton 1990, Schwartz and Franzmann 1992). This dispersal distance ($\bar{x} = 33.5 \pm 34.9$ km, range = 3.4-73.1 km; Table 2.3) was similar to the average (38.4 km, range = 1.5-171.7 km) of rehabilitated bears in Ontario (Binks 2008), and was mid-range of values reported in Minnesota (Rogers 1987), Virginia (Lee and Vaughan 2003), and Ontario (Binks 2008) that averaged 33.2 km (range = 0.9-219 km).

The difference in dispersal between 2011 and 2012 was presumably caused by relative availability of natural forage. Previous studies have identified forage as an important consideration when releasing rehabilitated bears (Alt and Beecham 1984, Beecham 2006, Beecham and Ramanathan 2007) because of variability and unfamiliarity of food resources in the release area. Mast surveys indicated higher availability of a number of important spring and summer foods in 2011 than 2012 (Fig. 2.2), and aerial imagery indicated concentrated activity in and around regenerating cuts (characteristic of soft mast species), which was also supported by habitat analysis (Table 2.4). In that year, mast from various species, including apple (*Malus* spp.), beech, and mountain ash, was highly abundant during late summer and fall (Fig. 2.2) which likely reduced foraging movement. All recovered collars (except 1 mortality) were located on ridges or mountain tops containing abundant beech and mountain ash $\leq$10 km from the release site.

In contrast, mast surveys indicating lower abundance of summer and fall mast species in 2012 (Fig. 2.2) likely induced longer movements as bears move more frequently and farther in years of low food abundance (Beeman and Pelton 1980, Garshelis and Pelton 1981, Noyce and Garshelis 1997). Further, bears released earlier in 2012 (May) probably experienced lower food availability than in 2011 (June). Although not an immediate survival problem given their relatively larger size that should sustain them through the transition period (Beecham and Ramanathan 2007), movement rates were probably elevated because berries are generally not available in May in northern New Hampshire. Greater movement rates were also documented prior to the emergence of natural foods during spring and early summer in Alberta (Young and Ruff 1982). Low availability of fall mast species, particularly apples, beech, and mountain ash, likely influenced the movement and mortality of male R288 that was harvested in early September feeding in roadside clover, 20 km from the release site.

As expected, bears did not home to the rehabilitation facility nor appear to attempt return. Binks (2008) also reported no evidence of homing by rehabilitated bears in Ontario. The absence of this behavior is likely due to the age of these animals, as subadult nuisance bears show low return rates after translocation (Rogers 1986, Landriault et al. 2009). Young bears have less affinity for their original ranges, in this case the rehabilitation facility, and so may have less motivation to return to that area (Rogers 1976, Eastridge and Clark 2001). They may also have underdeveloped homing abilities or poorer navigational skills than older animals (Harger 1967, Landriault et al. 2009).

*Habitat Selection*

Bears selected primarily for natural habitats with regenerating areas and wetlands as important habitat types, likely due to the availability of soft mast (despite annual production differences) and green vegetation (Table 2.4). Habitat selection studies in New York (Costello and Sage 1994), Quebec (Samson and Huot 2001, Brodeur et al. 2008), and Montana (Matthews et al. 2006) also identified regenerating sites as important. The avoidance of softwood stands was probably due to a lack of food in such areas (Young and Ruff 1982, Matthews et al. 2006, Brodeur et al. 2008).

Bears selected against developed areas, yet were located closer to roads and buildings than expected based on availability. This apparent dichotomy (selection against, but still close to development) is likely attributable to bear behavior and community structure; communities are generally surrounded by contiguous forest that provide security cover for bears active near developed areas. These animals tend not to spend considerable time in heavily developed areas, but instead are active on the fringes of such areas; GPS locations reflected this in that more locations were proximate to developed areas than actually within them. The proximity-to-building analysis also supported this notion, as a greater percentage of locations were located within 500 than 100 m of a building (Table 2.6). This same conclusion may also explain selection against, but still close to agricultural land that is generally open and prone to human activity that may make bears hesitant to spend considerable time in such areas. Similar to bears that forage in developed areas, bears utilizing farmland may prefer to use adjoining forest as security cover between short feeding bouts.

There were differences in features selected for between 2011 and 2012, though small sample sizes prevent any strong conclusions. The primary variation was bears in 2011 selecting for entirely natural habitats, whereas those in 2012 were located closer to buildings and roads (Table 2.5). This difference is likely attributed to the relatively high abundance of natural food in 2011 compared to 2012.

*Nuisance Behavior*

As with movement and survival, there was a difference in nuisance behavior between 2011 and 2012. No reports of nuisance activity occurred in 2011, but conflicts were documented for 3 bears in 2012. This trend reflects conflicts reported statewide, with far fewer reports in 2011than the record number in 2012 (Fig. 2.3; NHFG 2013). The conflicts with the released bears were relatively minor and not requiring any notable management action based on New Hampshire's nuisance bear policy. For example, male R288 was involved in a birdfeeder conflict in early June, but ceased this nuisance activity after the feeder was removed; NHFG recommends and urges landowners to remove feeders after 1 April to avoid such conflicts. Location data showed subsequent activity in adjacent wetlands and patch/clear cuts, suggesting that removal of the attractant and emergence of summer forage effectively negated nuisance behavior. Binks (2008) also observed such opportunistic behavior in rehabilitated bears in Ontario, and attributed it to incidental contact with humans during dispersal.

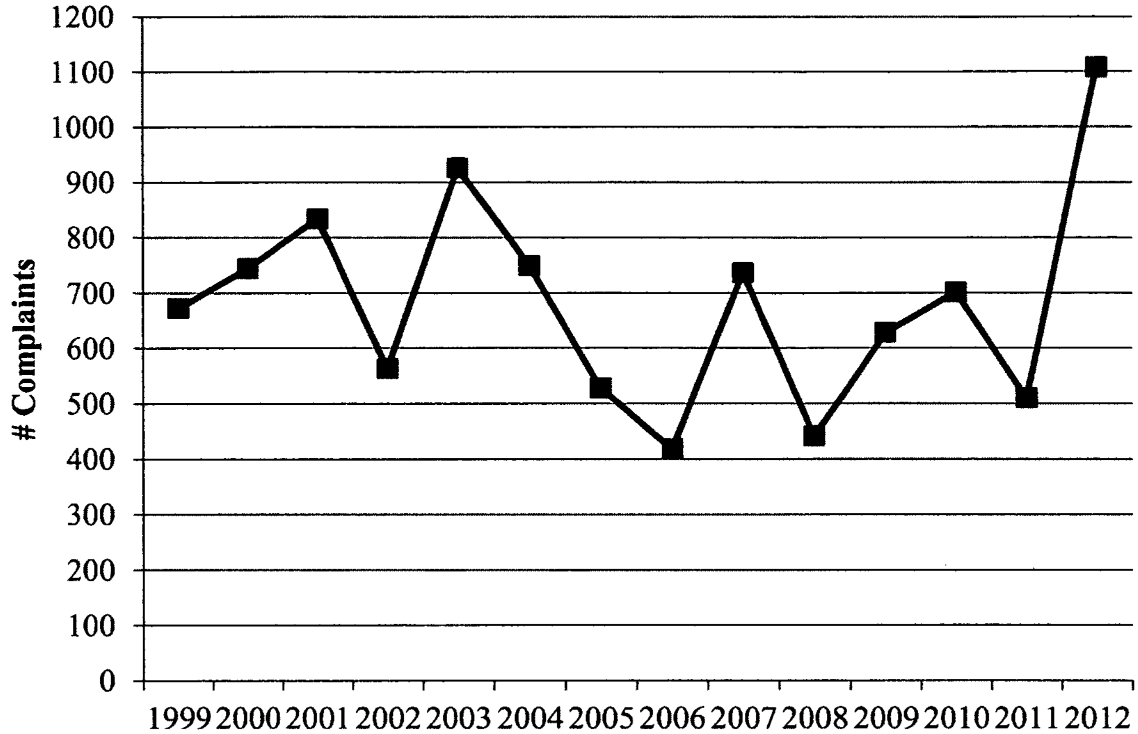

Figure 2.3. Annual reported human-bear conflicts in New Hampshire, 1999-2012 (NHFG 2013). Human-bear conflicts during 2012 (1,108) more than doubled the 510 complaints logged in 2011.

This activity is characteristic of normal food-seeking behavior in bears, as they are adept at finding and utilizing concentrations of highly nutritious foods (McCullough 1982, Bacon and Burghardt 1983, Eagle and Pelton 1983). Such behavior causes inevitable conflicts when anthropogenic food sources are readily available, especially when natural forage is limited; this relationship was evident in 2012 when natural forage production was low (Fig. 2.2) and conflicts were high (Fig. 2.3).

The proximity-to-building analysis also indicated a difference in the relationship between bears and human development between years, as bears in 2012 were located closer to buildings than expected (Tables 2.6); habitat selection models for 2012 also support this, though sample sizes preclude drawing firm conclusions (Table 2.5). Although this suggests that bears in 2012 selected for areas close to humans because they were habituated or were repetitively involved in nuisance behavior, an alternative explanation is that these bears were active on the fringes of developed areas, as suggested by the habitat analysis. The high frequency of locations within 500 m of a building, compared to 100 m, supports this conclusion. Again, this is likely due to the limited availability of natural food in 2012 (Fig. 2.2). There may also be a social explanation that other bears (possibly those released in 2011) may have already occupied remote areas, forcing bears in 2012 into subprime areas closer to human developments (Rogers et al. 1976, Young and Ruff 1982, Tietje and Ruff 1983, Pacas and Paquet 1994, Matthews et al. 2006). Combined with normal food-seeking behavior, this makes conflict inevitable, but not because these animals were habituated or conditioned to humans.

When evaluating nuisance behavior in rehabilitated bears, it is important to distinguish between random, isolated incidents and chronic nuisance activity resulting from extreme habituation. The former is a product of food-seeking behavior in bears, and is contingent primarily upon the availability of natural and anthropogenic food; the latter could be a result of food rewards or the rehabilitation process. Any bear can engage in some form of conflict behavior to utilize human sources of food, especially in landscapes like New Hampshire where human development abuts large tracts of contiguous forest; however, not all of these bears become food-conditioned or highly habituated. If the objective of rehabilitation is to release a bear that is as similar to its wild counterparts as possible (Binks 2008), it would be inappropriate to label the rehabilitation process a failure if some bears engage in minor nuisance activity, as this is behavior exhibited by many wild bears. It is likely that the rehabilitation process generates some level of habituation, or at least tolerance of human presence (Beecham 2006), but this does not automatically lead to development of chronic nuisance behavior. For example, Binks (2008) recorded very few occurrences of nuisance behavior in bears that were rehabilitated with levels of human contact ranging from very low to very high. Arguably, human contact should still be minimized during the rehabilitation process in order to limit the chance of nuisance behavior. Rehabilitated bears that show excessive levels of habituation (e.g., persistent nuisance behavior, panhandling, home entry) after release may indicate an unsuccessful rehabilitation program that requires modification.

*Management Implications*

The overall high survival and low nuisance activity measured in this study indicates that rehabilitating orphan black bears is a viable technique as conducted in New Hampshire. However, both were apparently influenced by the availability of natural forage as bears exhibited high survival, low movement, and little nuisance activity during a good food year (2011), with the opposite largely occurring during 2012 with lower mast production. The minor conflicts reported in 2012 were indicative of normal food-seeking behavior and reflected high levels of reported conflicts statewide. There was no evidence of excessive habituation or unacceptable nuisance activity, suggesting current techniques are effective at minimizing a rehabilitated bear's association with humans. Given the small sample sizes and short duration of this study, further research on a longer time scale is recommended to provide a better indication of long-term movement, survival, and behavior of rehabilitated bears.

Despite the success of rehabilitation in New Hampshire, the technique should remain a secondary option when addressing orphan bear issues. Currently, orphan bears are given the opportunity to survive on their own before any action is taken and only bears that are in obvious need of human intervention are considered candidates for rehabilitation. Policy should remain as such to avoid elevating public expectations and burdening an effective rehabilitation program.

# CONCLUSIONS AND RECOMMENDATIONS

This study indicates that translocating nuisance bears and rehabilitating orphan bears are viable management techniques in New Hampshire. However, reducing the availability of anthropogenic attractants, the primary source of human-bear conflicts, should remain the management priority to effectively reduce conflicts. As many orphan bears result from the dispatch of nuisance females, reducing conflicts should also reduce the number of bears requiring rehabilitation. The following should aid managers in evaluating current techniques to manage human-bear conflicts and orphan bears in New Hampshire.

## I. Assessing the efficacy of translocation as a nuisance bear management tool in New Hampshire

1) More bears were translocated in 2012 than 2011, reflecting annual differences in human-bear conflicts and natural food availability. Males comprised the majority (77%) of translocated bears.
2) Bears exhibited high survival (0.73) and low harvest rate (0.11) the first fall. Harvest rate increased in subsequent years after translocation, indicating that these bears are utilized by hunters, but are not at excessive risk.
3) Few bears (28%) homed to the capture area, and translocation distance and age class were important factors in return rate. Translocations of greater distance and of subadults appear more successful at reducing returns.

4) Movement rate was highest the first week after release, and bears dispersed throughout the region; adults moved farther than subadults. Annual forage availability may impact movement rates and dispersal distances.
5) Bears selected for natural and human-dominated habitats, particularly regenerating forest and areas proximate to buildings; this is probably characteristic of nuisance bears.
6) Many bears (55%) were documented in subsequent conflict situations either at the capture area or elsewhere, reflecting the habituated nature of these bears and the availability of attractants on the landscape.
7) Translocation is a viable tool for temporarily managing local conflicts and can provide time to reduce anthropogenic attractants.

**II. Evaluating the success of rehabilitating orphan black bears in New Hampshire**

8) Rehabilitated bears released in 2011 (n = 7) had high survival (0.86), but none (n = 3) survived in 2012. All mortality was human-induced and included harvest, illegal kill, and nuisance removal.
9) Bears in 2011 remained near the release area, but those in 2012 showed greater dispersal; bears that do not disperse the first year may do so in subsequent years.
10) Bears in 2011 selected for natural habitats, primarily regenerating forest and wetlands; those in 2012 selected for both natural and human-dominated areas.
11) There were no reported conflicts involving bears released in 2011, but conflicts were documented for 3 bears in 2012. All conflicts involved unsecured attractants and were characteristic of normal food-seeking behavior in bears; there was no evidence of excessive habituation or chronic nuisance behavior.

12) The availability of natural forage affected survival, movement, and behavior of rehabilitated bears. Releases appear more successful in years of abundant natural forage, though continued monitoring is advised given the small sample sizes and short duration of this study.

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APPENDICES

# APPENDIX A. UNIVERSITY OF NEW HAMPSHIRE INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE LETTER OF APPROVAL

University *of* New Hampshire

Research Integrity Services, Service Building
51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

16-Dec-2010

Pekins, Peter J
Natural Resources & The Environment, James Hall
Durham, NH 03824

**IACUC #:** 101202
**Project:** Management of Nuisance Bears in New Hampshire
**Category:** D
**Approval Date:** 16-Dec-2010

The Institutional Animal Care and Use Committee (IACUC) reviewed and approved the protocol submitted for this study under Category D on Page 5 of the Application for Review of Vertebrate Animal Use in Research or Instruction - *Animal use activities that involve accompanying pain or distress to the animals for which appropriate anesthetic, analgesic, tranquilizing drugs or other methods for relieving pain or distress are used.* The IACUC made the following comment(s) on this protocol:

*1. In Section VI, D, iv and vi the IACUC added information for raccoons.*
*2. The researcher might want to consider whether other non-invasive samples (e.g., hair) might be collected at the time of tagging for future use or use by other researchers.*

Approval is granted for a period of three years from the approval date above. Continued approval throughout the three year period is contingent upon completion of annual reports on the use of animals. At the end of the three year approval period you may submit a new application and request for extension to continue this project. Requests for extension must be filed prior to the expiration of the original approval.

**Please Note:**
1. All cage, pen, or other animal identification records must include your IACUC # listed above.
2. Use of animals in research and instruction is approved contingent upon participation in the UNH Occupational Health Program for persons handling animals. Participation is mandatory for all principal investigators and their affiliated personnel, employees of the University and students alike. A Medical History Questionnaire accompanies this approval; please copy and distribute to all listed project staff who have not completed this form already. Completed questionnaires should be sent to Dr. Gladi Porsche, UNH Health Services.

If you have any questions, please contact either Dean Elder at 862-4629 or Julie Simpson at 862-2003.

For the IACUC,

Jessica A. Bolker, Ph.D.
Chair

cc: File

University of New Hampshire

Research Integrity Services, Service Building
51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

16-Nov-2011

Pekins, Peter J
Natural Resources & The Environment, James Hall
Durham, NH 03824

**IACUC #:** 101202
**Project:** Management of Nuisance Bears in New Hampshire
**Category:** D
**Next Review Date:** 16-Dec-2012

The Institutional Animal Care and Use Committee (IACUC) has reviewed and approved your request for a time extension for this protocol. Approval is granted until the "Next Review Date" indicated above. You will be asked to submit a report with regard to the involvement of animals in this study before that date. If your study is still active, you may apply for extension of IACUC approval through this office.

The appropriate use and care of animals in your study is an ongoing process for which you hold primary responsibility. Changes in your protocol must be submitted to the IACUC for review and approval prior to their implementation.

**Please Note:**

1. All cage, pen, or other animal identification records must include your IACUC # listed above.
2. Use of animals in research and instruction is approved contingent upon participation in the UNH Occupational Health Program for persons handling animals. Participation is mandatory for all principal investigators and their affiliated personnel, employees of the University and students alike. A Medical History Questionnaire accompanies this approval; please copy and distribute to all listed project staff who have not completed this form already. Completed questionnaires should be sent to Dr. Gladi Porsche, UNH Health Services.

If you have any questions, please contact either Dean Elder at 862-4629 or Julie Simpson at 862-2003.

For the IACUC,

Robert C. Drugan, Ph.D.
Chair

cc: File

Appendix B: Table 1. Nuisance black bears translocated in New Hampshire, 2011 and 2012. All bears released at Ingersol Brook, Pittsburg except where noted.

| | Bear ID | Sex | Age Class | Weight (kg) | Capture Date | Capture Town | Distance Translocated (km) |
|---|---|---|---|---|---|---|---|
| 2011 | N91[ab] | Male | Adult | 125 | 5/17/2011 | Gorham | 71.0 |
| | N16[c] | Female | Subadult | 68 | 6/2/2011 | Keene | 269.3 |
| | N17 | Male | Subadult | 39 | 6/14/2011 | Albany | 138.4 |
| | N26 | Male | Subadult | 41 | 7/8/2011 | Lincoln | 135.8 |
| | N29 | Male | Yearling | 41 | 7/14/2011 | Bartlett | 120.3 |
| | N31[a] | Male | Adult | 91 | 7/16/2011 | Piermont | 156.8 |
| | N33 | Male | Yearling | 66 | 7/19/2011 | Berlin | 83.5 |
| | -[ad] | - | - | ~70 | 9/3/2011 | Franconia | 128.4 |
| 2012 | N35 | Male | Subadult | 82 | 5/8/2012 | Rumney | 165.3 |
| | N37 | Male | Adult | 114 | 5/9/2012 | Gorham | 97.9 |
| | N39 | Female | Adult | 82 | 5/9/2012 | Jackson | 120.6 |
| | N41 | Male | Adult | 82 | 5/10/2012 | Jackson | 120.6 |
| | N24 | Female | Yearling | 45 | 5/29/2012 | Jackson | 121.3 |
| | N43 | Male | Adult | 80 | 6/1/2012 | Randolph | 95.5 |
| | N45 | Male | Yearling | 45 | 6/5/2012 | Bethlehem | 114.1 |
| | N47 | Male | Yearling | 57 | 6/6/2012 | Bethlehem | 114.7 |
| | N49 | Female | Adult | 82 | 6/18/2012 | Jackson | 121.3 |
| | N48 | Male | Adult | 80 | 6/19/2012 | Franconia | 128.4 |
| | N03 | Male | Adult | 91 | 6/19/2012 | Berlin | 83.4 |
| | -[ad] | Male | Adult | >150 | 6/19/2012 | North Conway | 130.8 |
| | N05 | Male | Adult | 114 | 7/2/2012 | Bethlehem | 113.3 |
| | N07 | Male | Subadult | 90 | 7/12/2012 | Warren | 155.1 |

[a] Not radio-collared
[b] Released in Atkinson & Gilmanton Grant
[c] Captured with 2 cubs of the year
[d] Not ear tagged

Appendix B: Table 2. Recovery information for nuisance black bears translocated in New Hampshire, 2011 and 2012.

| | Bear ID | Recovery Type | Recovery Town | Days until Deployed[a] | Distance from Capture Site (km) | Distance from Release Site (km) |
|---|---|---|---|---|---|---|
| 2011 | N91[b] | Harvest | Gorham, NH | 114 | 1.2 | 72.1 |
| | N16 | Harvest | Woburn, QC | 4 | 293.0 | 27.1 |
| | N17 | Den Check | Byron, ME | 139 | 101.2 | 72.0 |
| | N26 | Drop-off | Roxbury, ME | 131 | 105.0 | 74.4 |
| | N29 | Drop-off | Grafton, ME | 129 | 58.7 | 74.7 |
| | N31[b] | - | - | - | - | - |
| | N33 | Drop-off | Stark, NH | 128 | 23.7 | 70.4 |
| 2012 | N35 | Dispatch | Phillips, ME | 19 | 167.3 | 73.0 |
| | N37 | Dispatch | Avon, ME | 49 | 88.8 | 82.0 |
| | N39 | Drop-off | Wales, ME | 116 | 90.8 | 148.9 |
| | N41[c] | Den Check | Sargent's Purchase, NH | 209 | 12.7 | 110.9 |
| | N24 | Translocation | Dallas Plantation, ME | 9 | 100.7 | 49.9 |
| | N43 | Drop-off | Randolph, NH | 135 | 2.3 | 97.8 |
| | N45 | Den Check | Stratford, NH | 170 | 52.6 | 64.1 |
| | N47 | Harvest | Scotstown, QC | 12 | 135.5 | 30.8 |
| | N49 | Den Check | Jackson, NH | 135 | 0.6 | 121.5 |
| | N48 | Collar Failure[d] | Rangeley PLT, ME | 117 | 115.3 | 47.6 |
| | N03 | Collar Failure | - | - | - | - |
| | N05 | Den Check | Franconia, NH | 99 | 13.7 | 124.3 |
| | N07 | Drop-off | Stratford, NH | 94 | 98.0 | 58.0 |

[a] Days until den entrance for collars recovered via den check, or until the date of den check when collars could not be recovered

[b] Not radio-collared

[c] Collar not recovered at den check

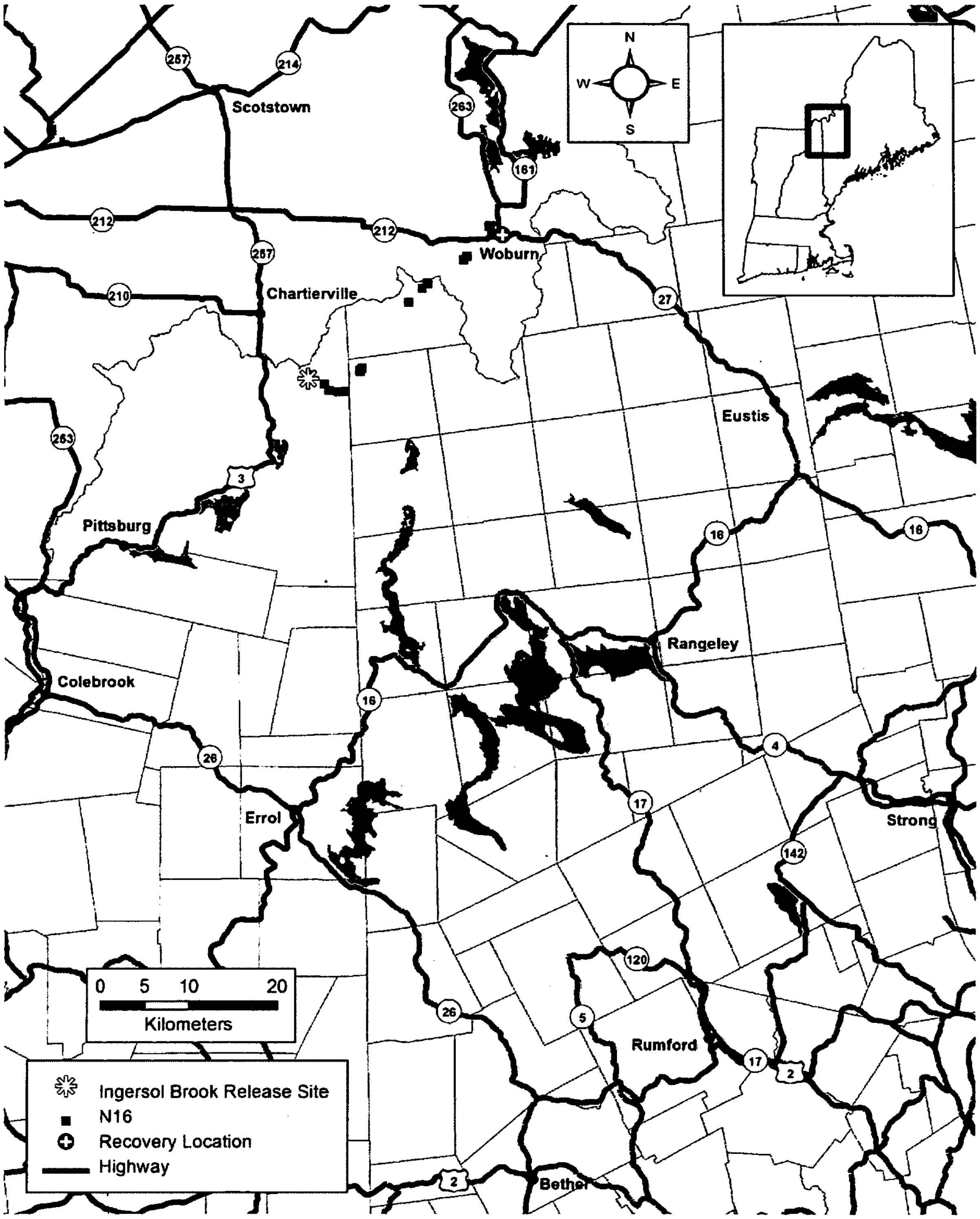
[d] Collar failed in 1st year, bear harvested and collared retrieved June 2013

Appendix B: Table 3. Release and recovery information for rehabilitated black bears released in Nash Stream Forest, NH, June 2011 and May 2012.

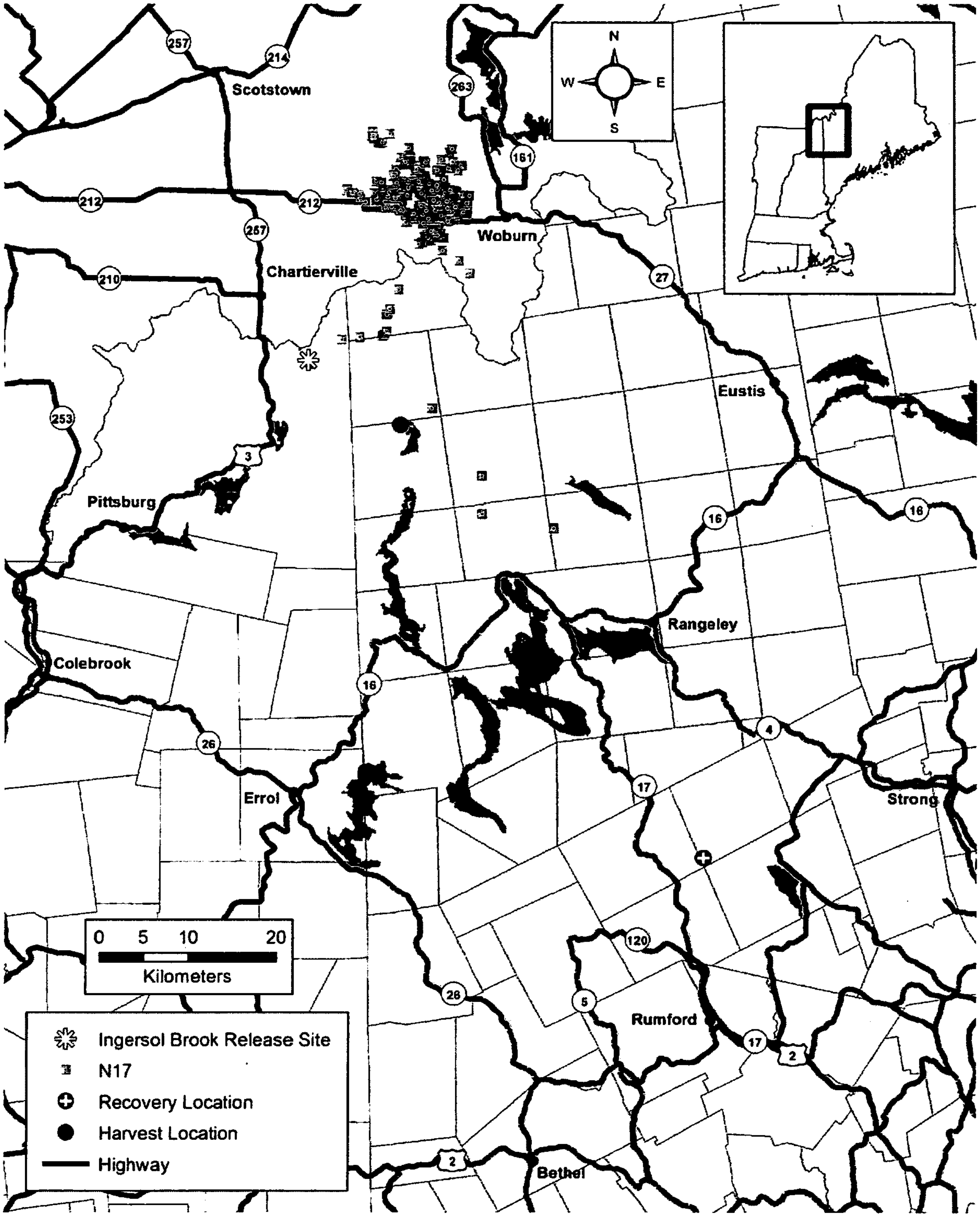
| Release Date | Bear ID | Sex | Age (yr) | Weight (kg) | Recovery Type | Recovery Distance (km) |
|---|---|---|---|---|---|---|
| 6/6/2011 | R138 | Male | 1.5 | 33 | Collar Failure | N/A[a] |
| 6/6/2011 | R140 | Male | 1.5 | 41 | Den Check | 6.5 |
| 6/6/2011 | R143 | Male | 1.5 | 32 | Harvest | 6.0 |
| 6/6/2011 | R145 | Male | 1.5 | 45 | Drop-off | 8.6 |
| 6/21/2011 | R132 | Female | 1.5 | 45 | Drop-off | 5.2 |
| 6/21/2011 | R134 | Male | 1.5 | 59 | Drop-off | 10.0 |
| 6/28/2011 | R126 | Male | 1.5 | 41 | Drop-off | 3.4 |
| 5/15/2012 | R286 | Male | 1.5 | 45 | Nuisance | 73.1 |
| 5/21/2012 | R283 | Male | 1.5 | 45 | Poached | 7.4 |
| 5/21/2012 | R297 | Female | 1.5 | 32 | Slipped Collar | 8.3 |
| 5/24/2012 | R288 | Male | 1.5 | 54 | Harvest | 20.1 |

[a] Collar was not recovered, but telemetry indicated the probable den site was 18.8 km from the release site.

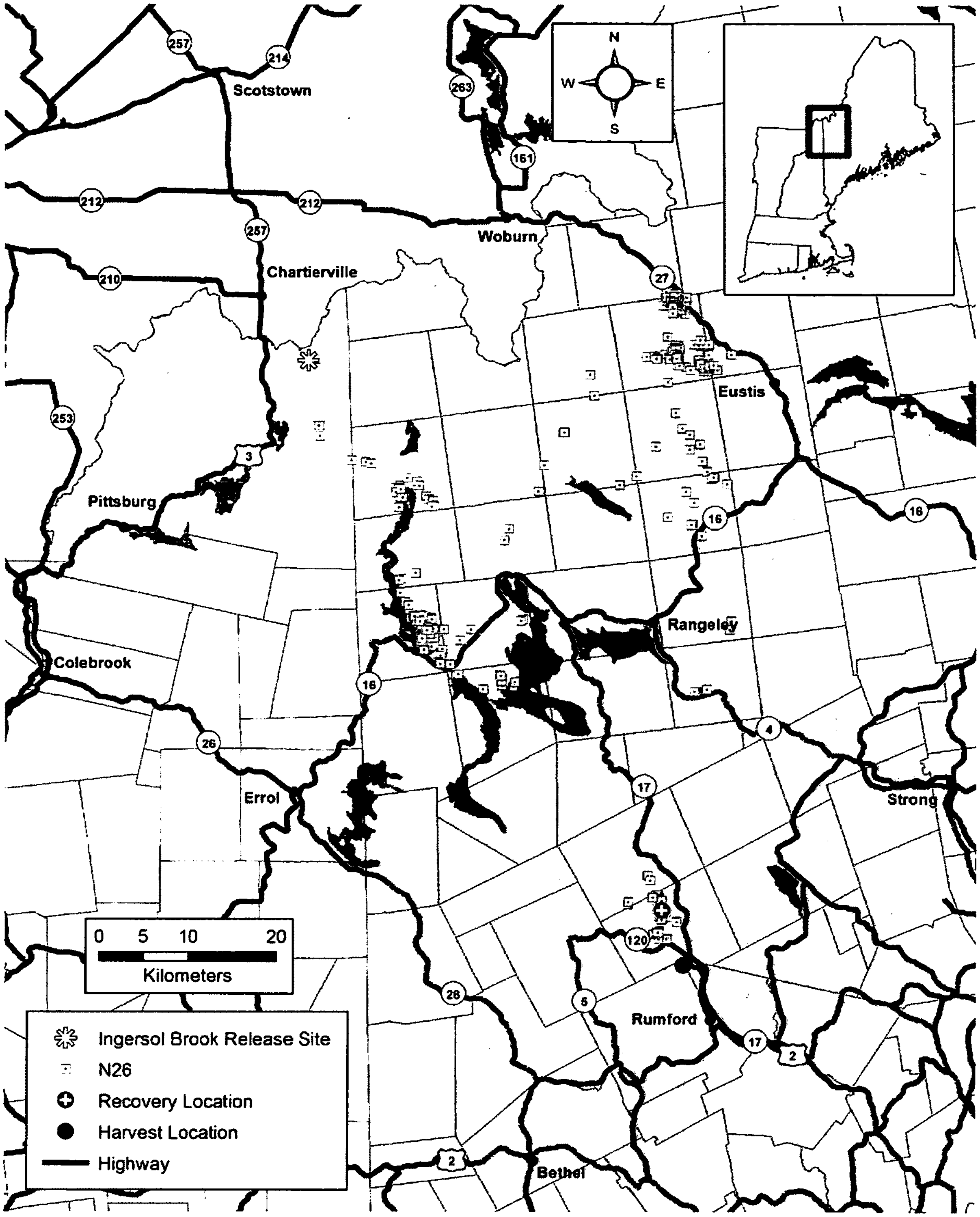
APPENDIX C. GPS COLLAR LOCATIONS OF TRANSLOCATED NUISANCE BLACK BEARS



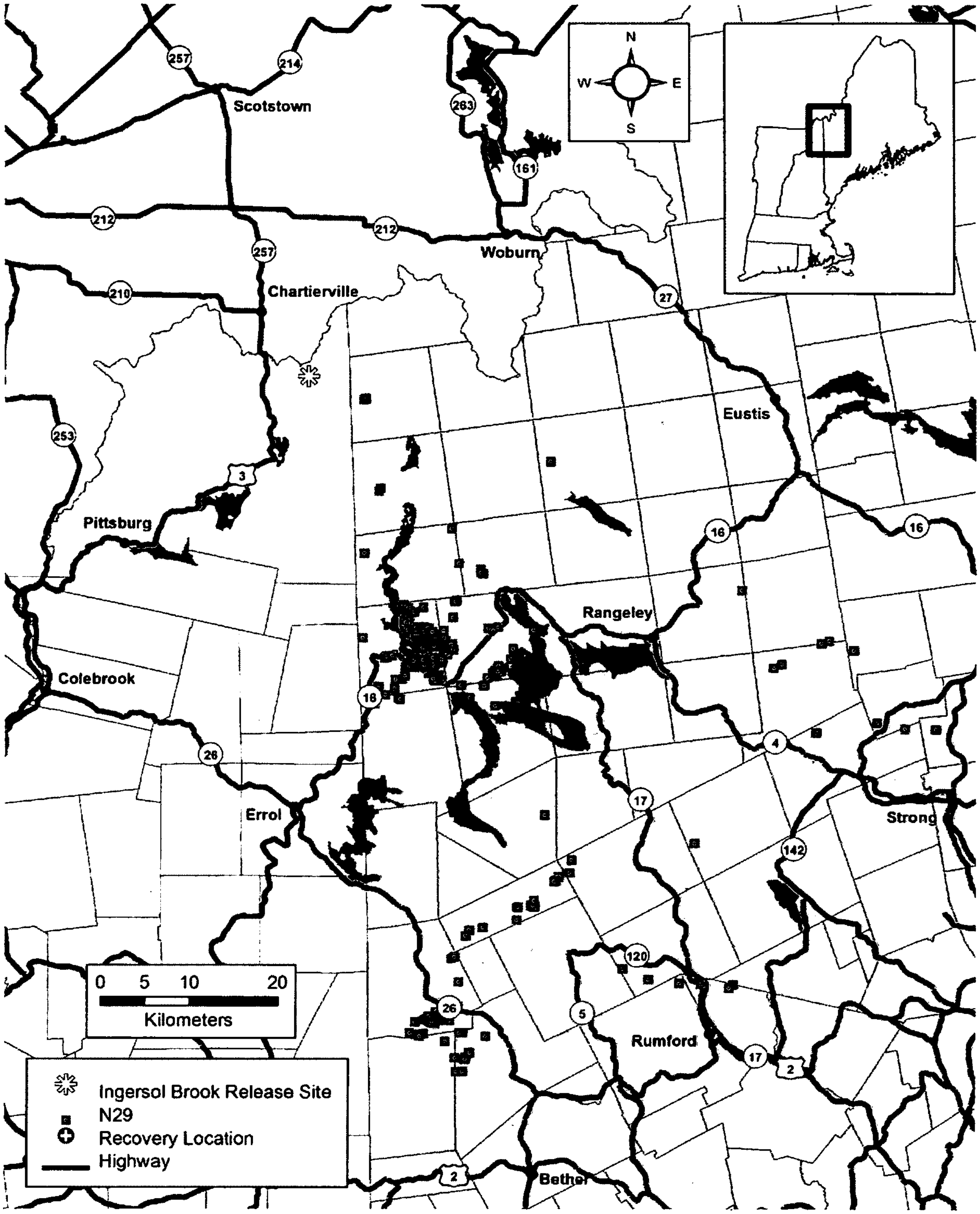

Appendix C: Figure 1. Locations of subadult female N16 captured in Keene, NH and translocated 269 km to Ingersol Brook on 3 June 2011. This bear was harvested in Woburn, QC, 27 km from the release site on 7 June 2011.



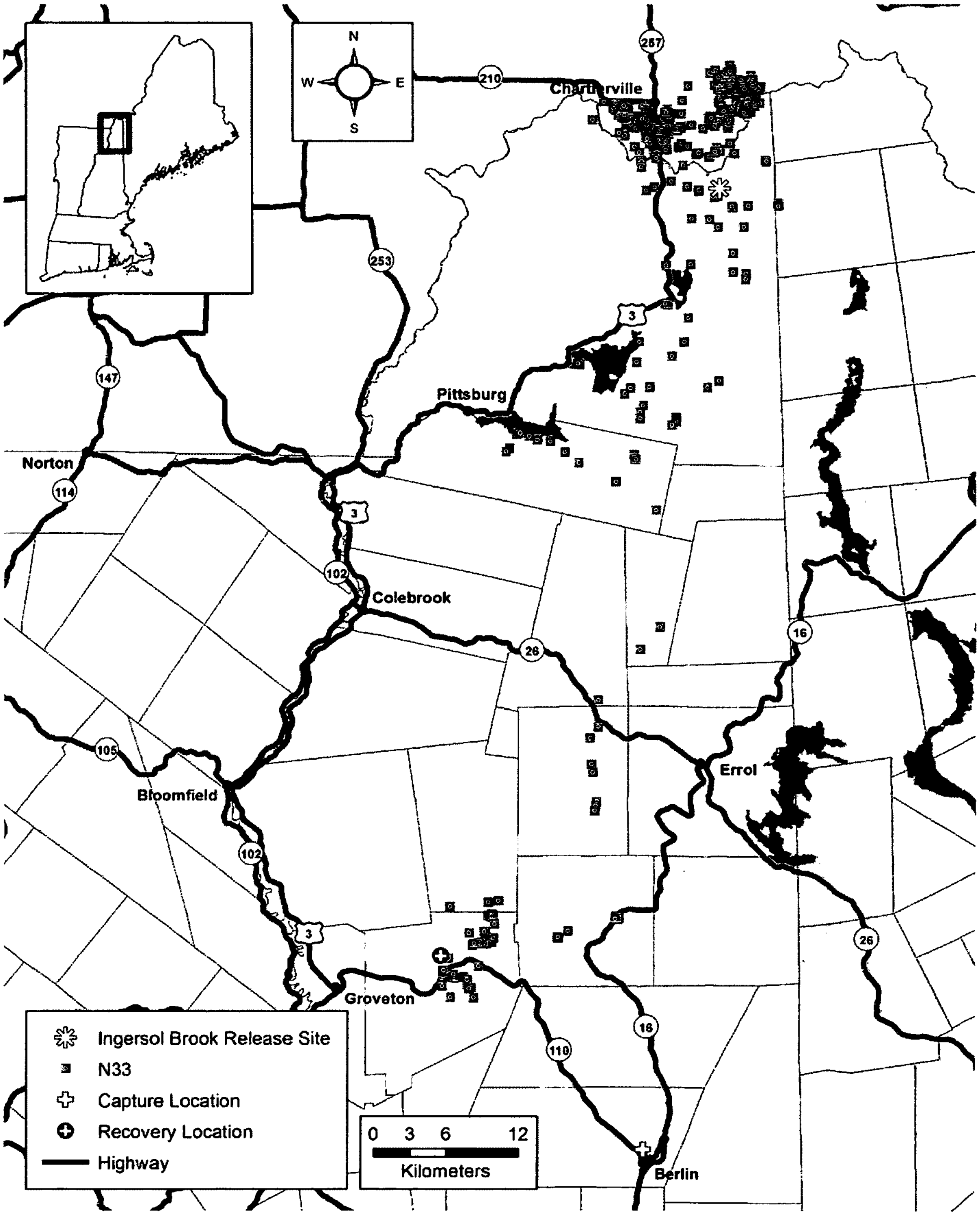

Appendix C: Figure 2. Locations of subadult male N17 captured in Albany, NH and translocated 138 km to Ingersol Brook on 14 June 2011. The collar was recovered during a den check after drop-off failure, 72 km from the release site and 101 km from the capture site. This bear was harvested the following year on 13 September 2012 in Lynchtown, ME, 13 km from the release site and 60 km from where the collar was recovered the previous year.



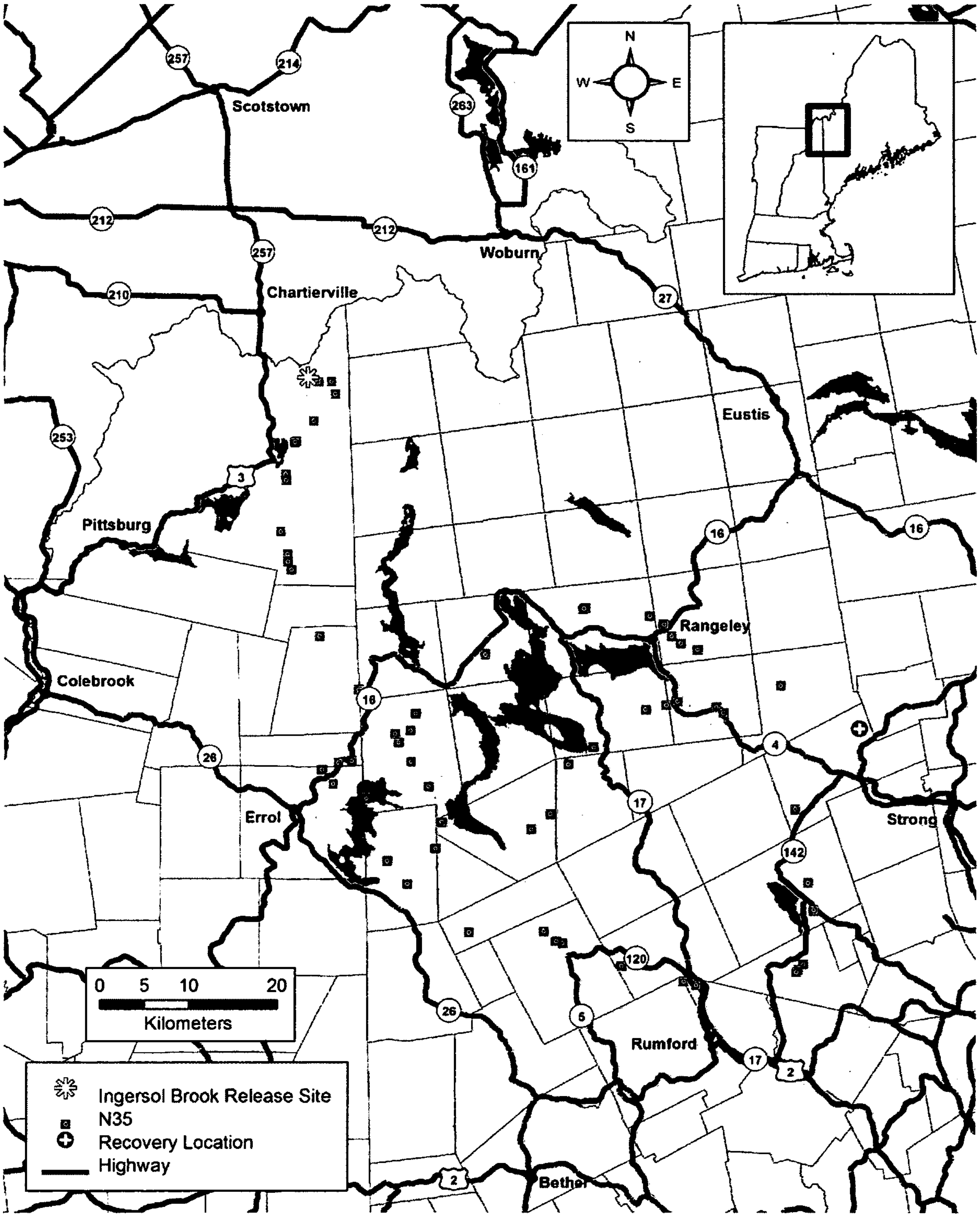

Appendix C: Figure 3. Locations of subadult male N26 captured in Lincoln, NH and translocated 136 km to Ingersol Brook on 8 July 2011. The collar was recovered after drop-off, 74 km from the release site and 105 km from the capture site. This bear was harvested the following year on 29 August 2012 in Rumford, ME, 81 km from the release site and 7 km from where the collar was recovered the previous year.



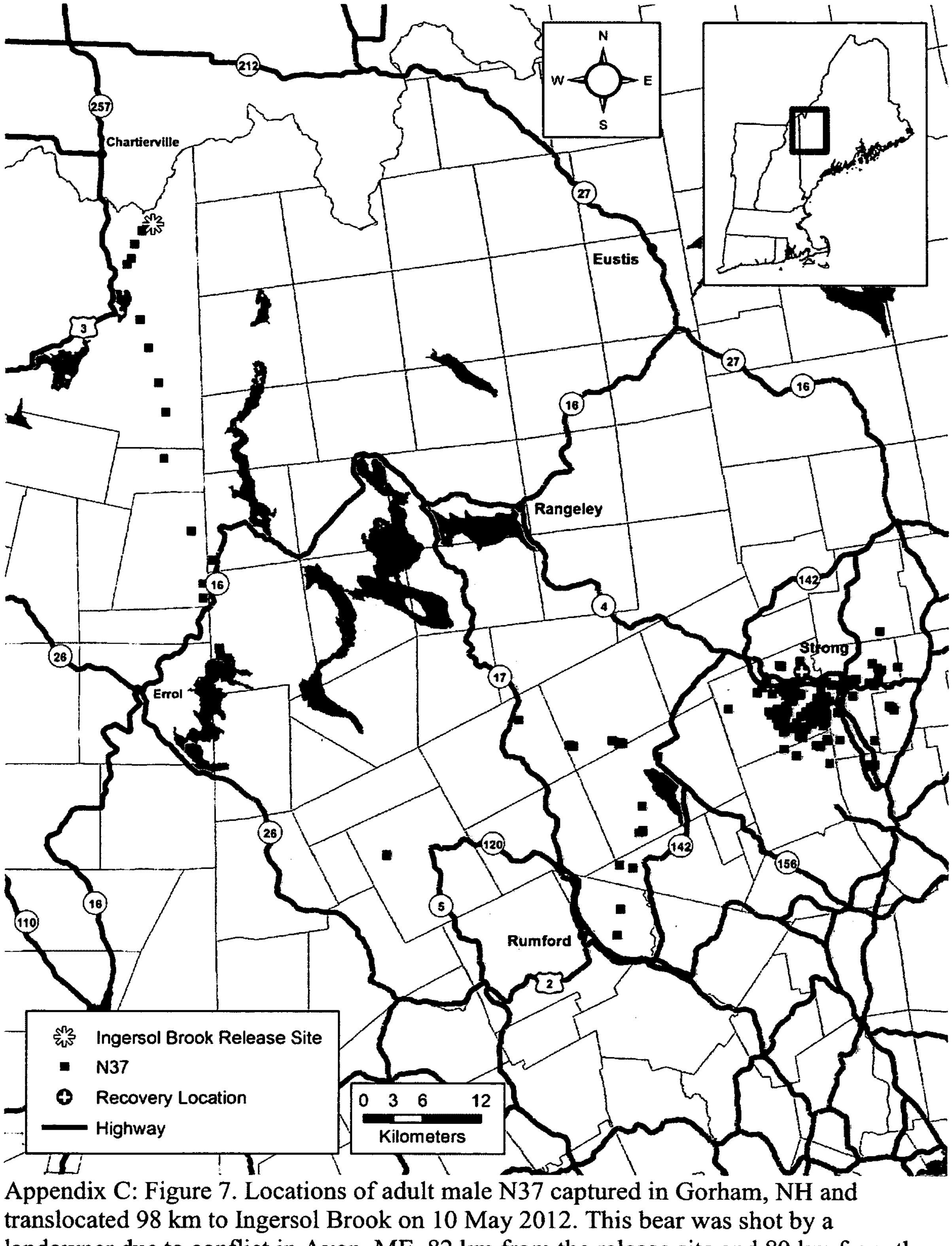

Appendix C: Figure 4. Locations of subadult male N29 captured in Hart's Location, NH and translocated 120 km to Ingersol Brook on 14 July 2011. The collar was recovered after drop-off, 75 km from the release site and 59 km from the capture site.



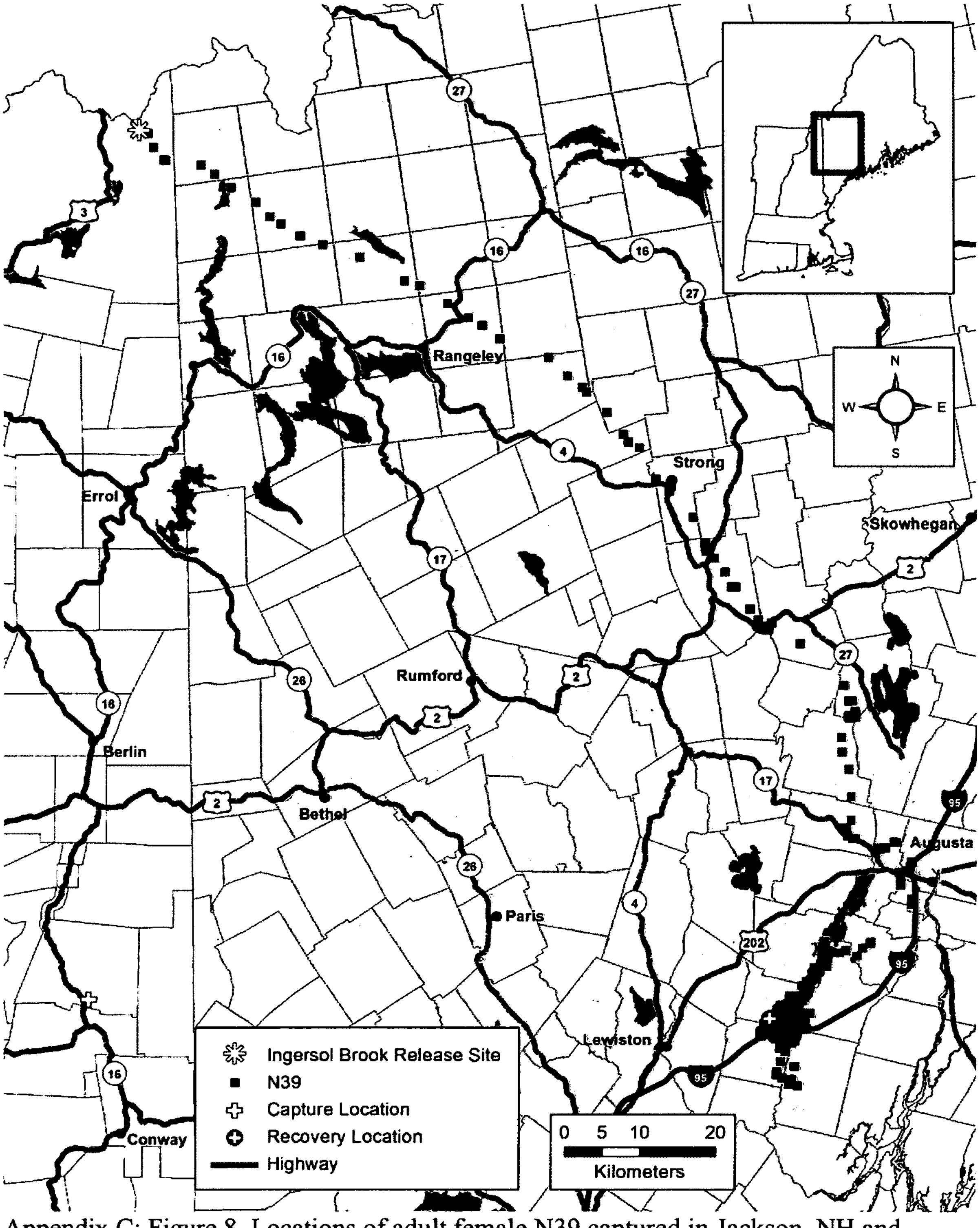

Appendix C: Figure 5. Locations of subadult male N33 captured in Berlin, NH and translocated 84 km to Ingersol Brook on 19 July 2011. The collar was recovered after drop-off, 70 km from the release site and 24 km from the capture site.



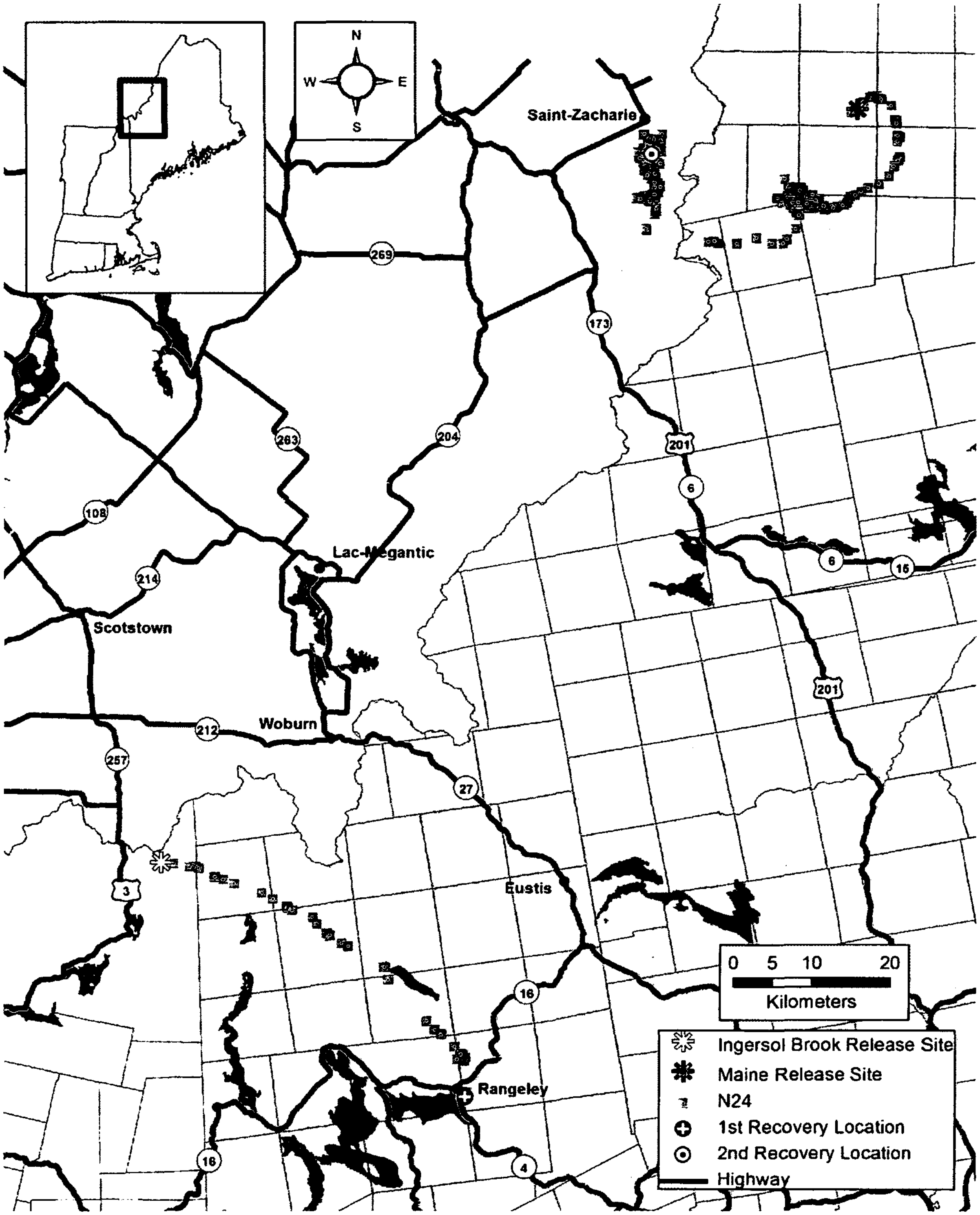

Appendix C: Figure 6. Locations of subadult male N35 captured in Rumney, NH and translocated 165 km to Ingersol Brook on 9 May 2012. This bear was shot by a landowner due to conflict in Phillips, ME, 73 km from the release site and 167 km from the capture site, on 28 May 2012.



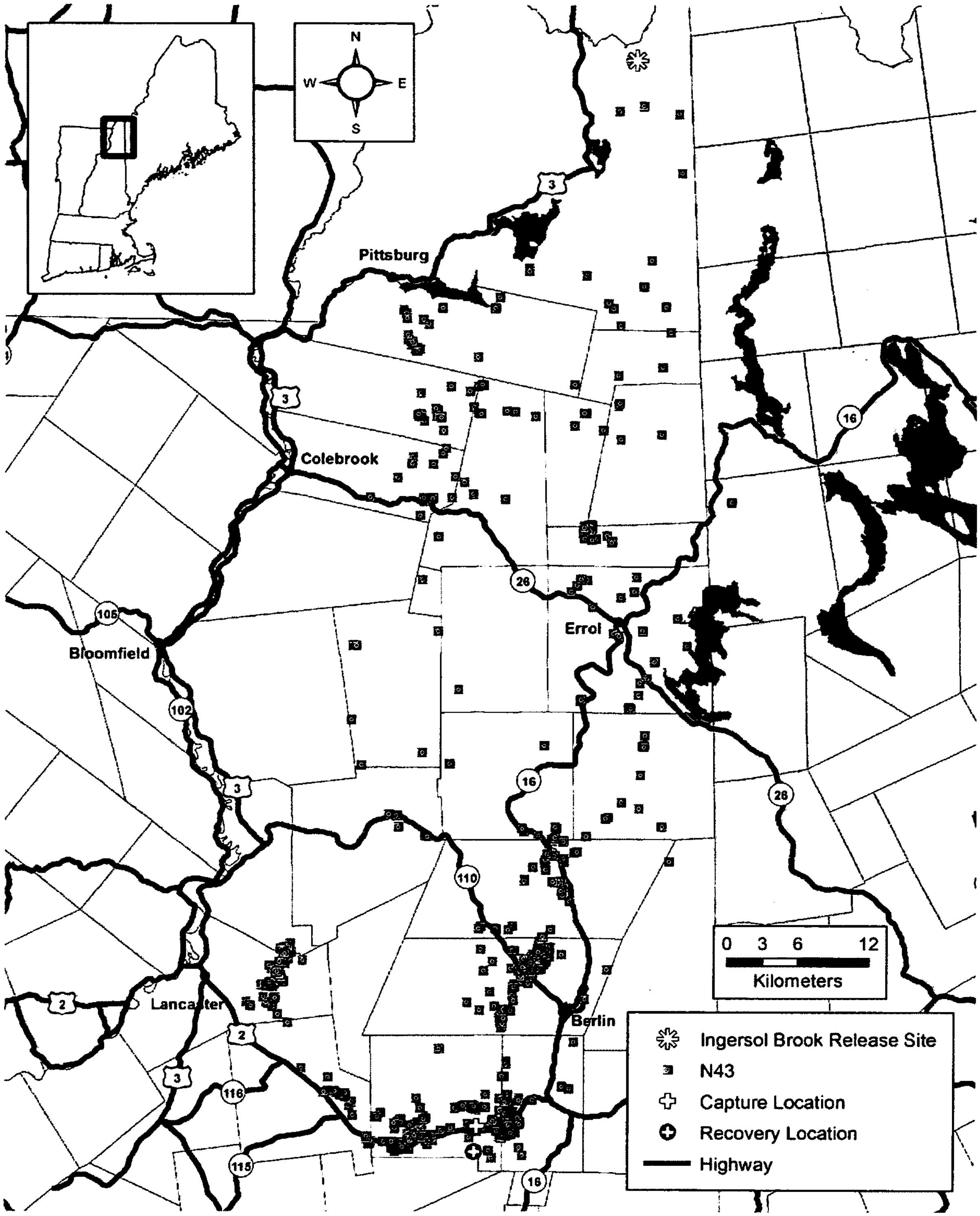
Appendix C: Figure 7. Locations of adult male N37 captured in Gorham, NH and translocated 98 km to Ingersol Brook on 10 May 2012. This bear was shot by a landowner due to conflict in Avon, ME, 82 km from the release site and 89 km from the capture site, on 28 June 2012.



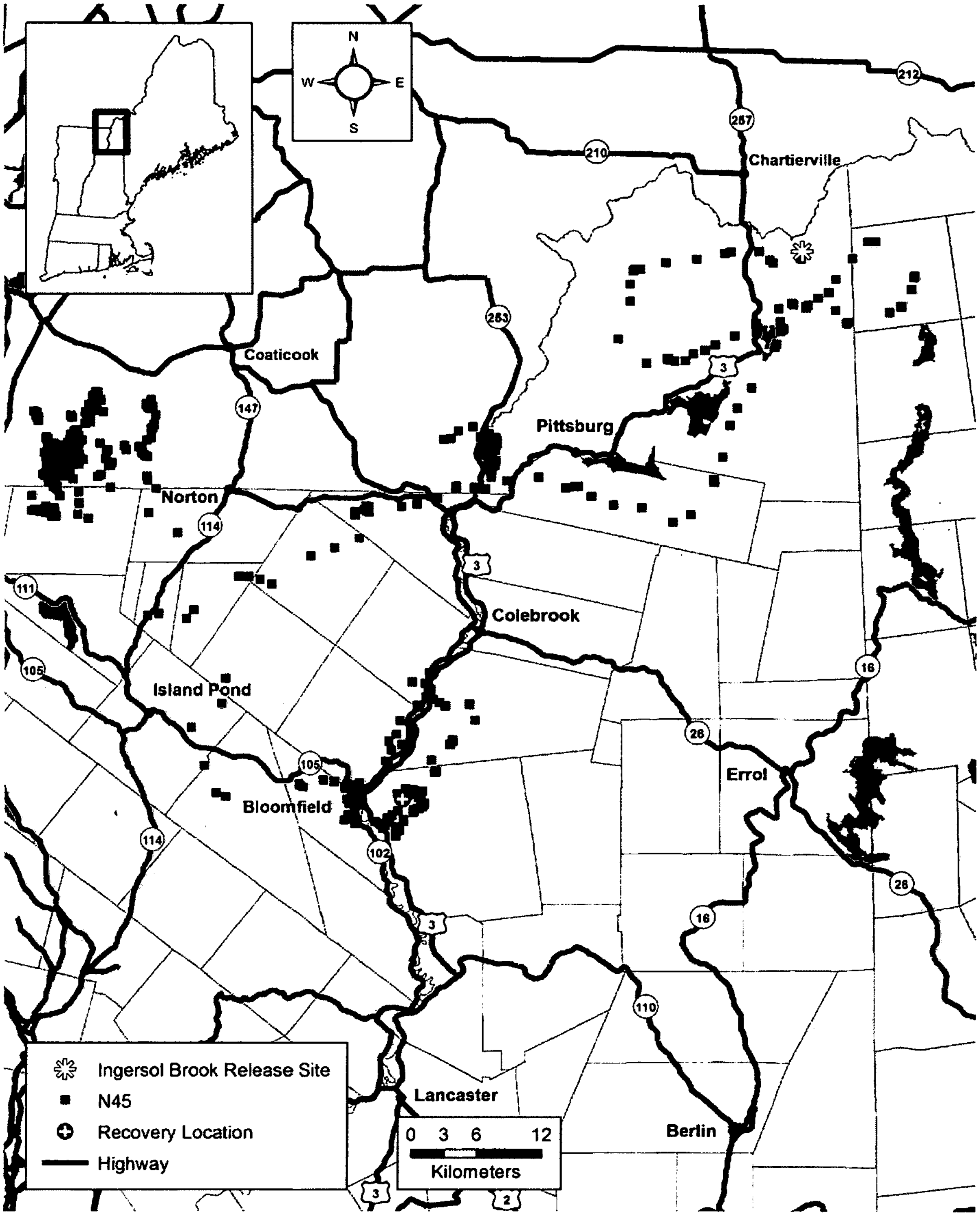

Appendix C: Figure 8. Locations of adult female N39 captured in Jackson, NH and translocated 121 km to Ingersol Brook on 10 May 2012. The collar was recovered after drop-off, 149 km from the release site and 91 km from the capture site. This bear was observed with 2 cubs of the year in May 2013.



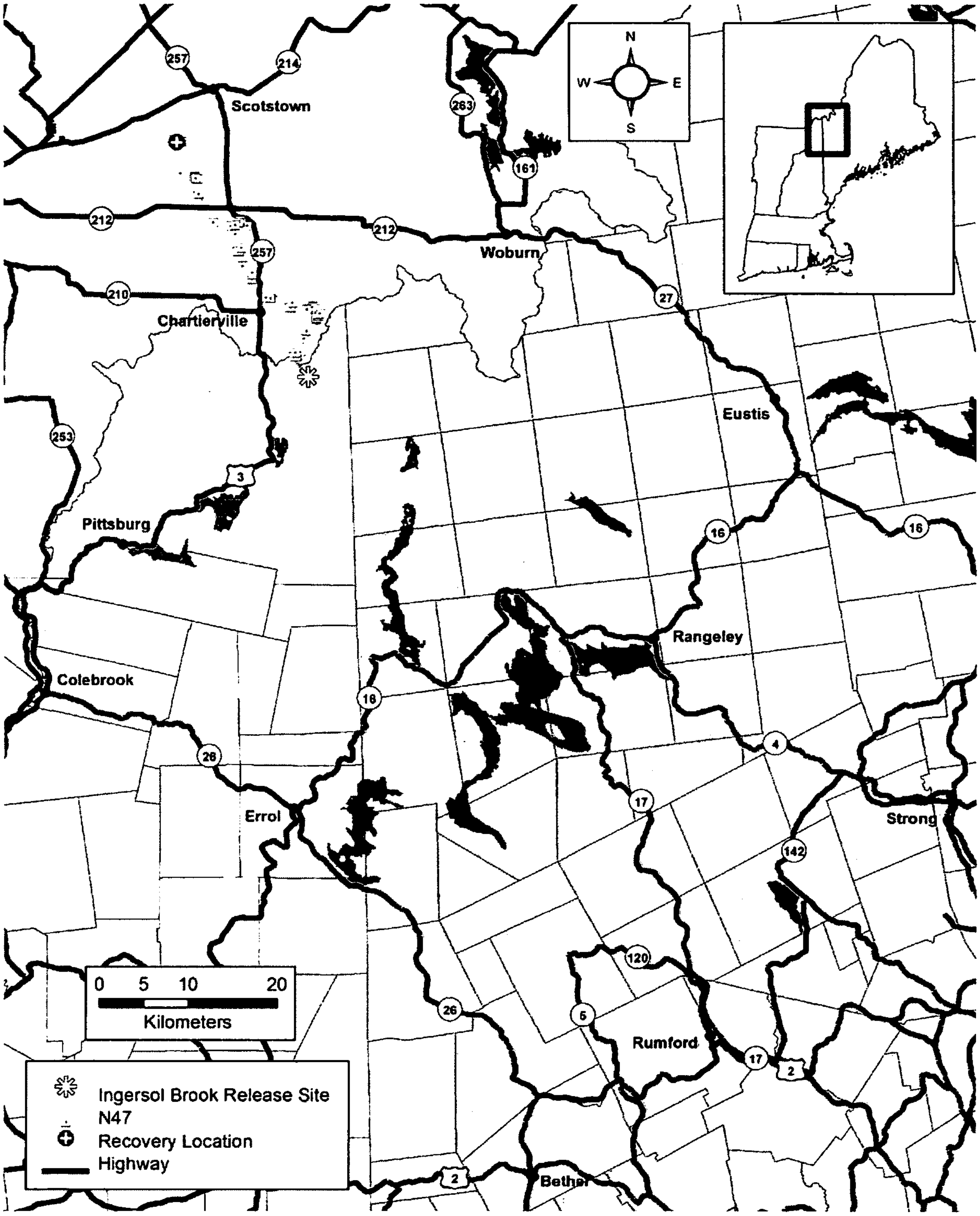

Appendix C: Figure 9. Locations of subadult female N24 captured in Jackson, NH and translocated 121 km to Ingersol Brook on 29 May 2012. This bear was later captured in Rangeley, ME on 8 June due to conflict and translocated 140 km to northern Maine. It was destroyed by Quebec wildlife officials on 3 October 2012 due to conflict in Saint-Zacharie, QC, 26 km from the Maine release site.



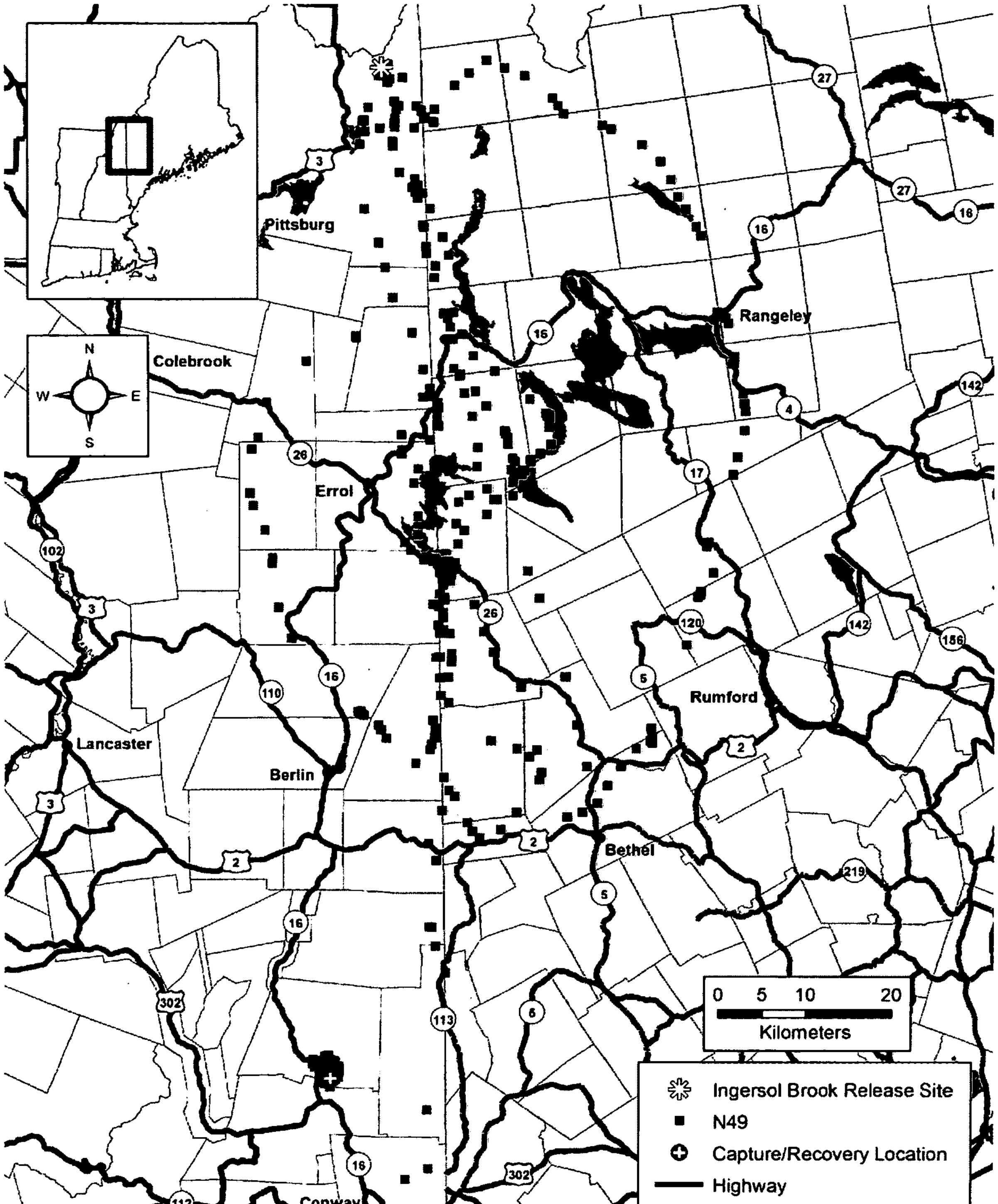

Appendix C: Figure 10. Locations of adult male N43 captured in Randolph, NH and translocated 96 km to Ingersol Brook on 1 June 2012. This bear returned to the capture area on 18 June; the collar was recovered after drop-off, 98 km from the release site and 2 km from the capture site.



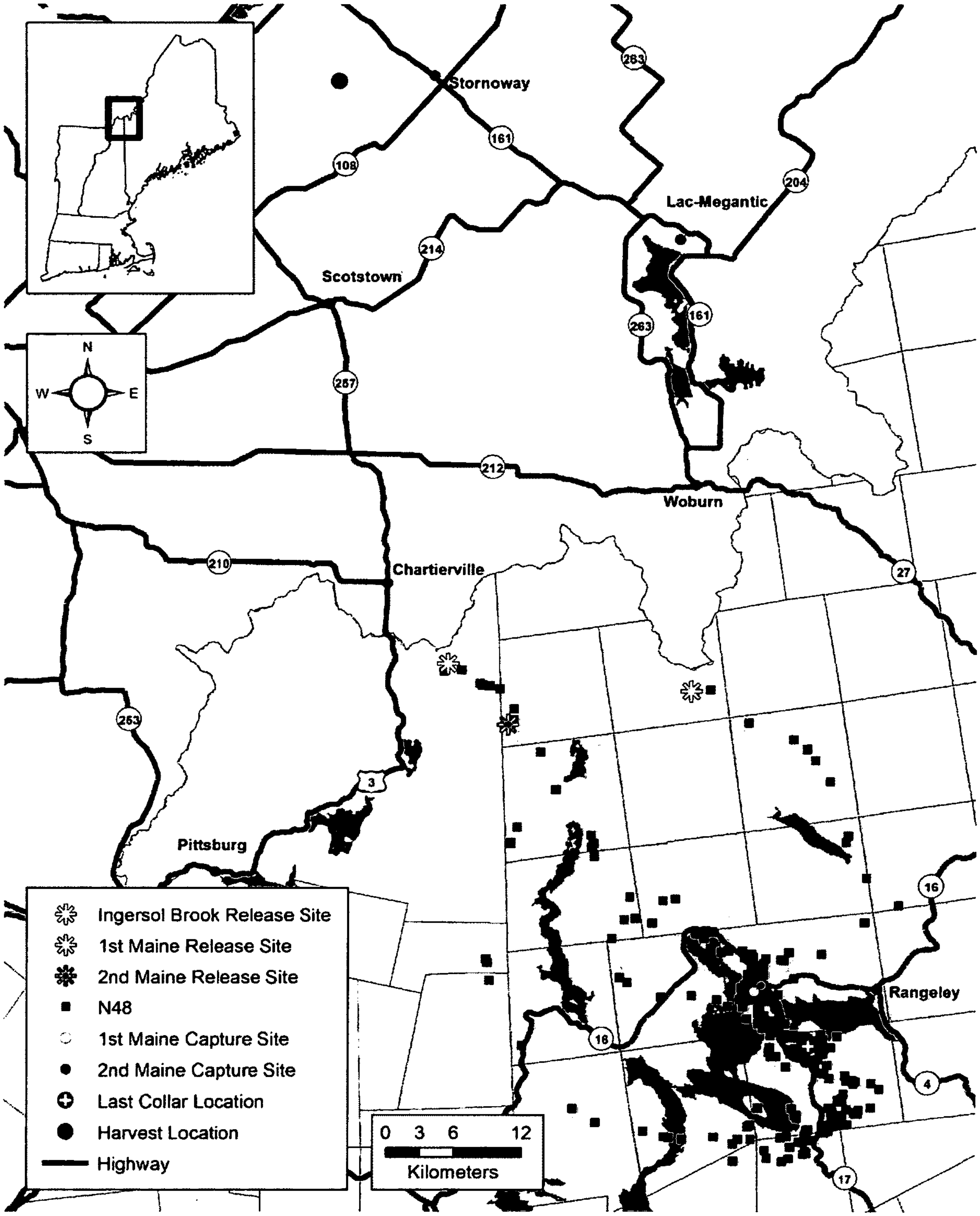

Appendix C: Figure 11. Locations of subadult male N45 captured in Bethlehem, NH and translocated 114 km to Ingersol Brook on 5 June 2012. The collar was recovered during a den check after drop-off failure, 64 km from the release site and 53 km from the capture site.



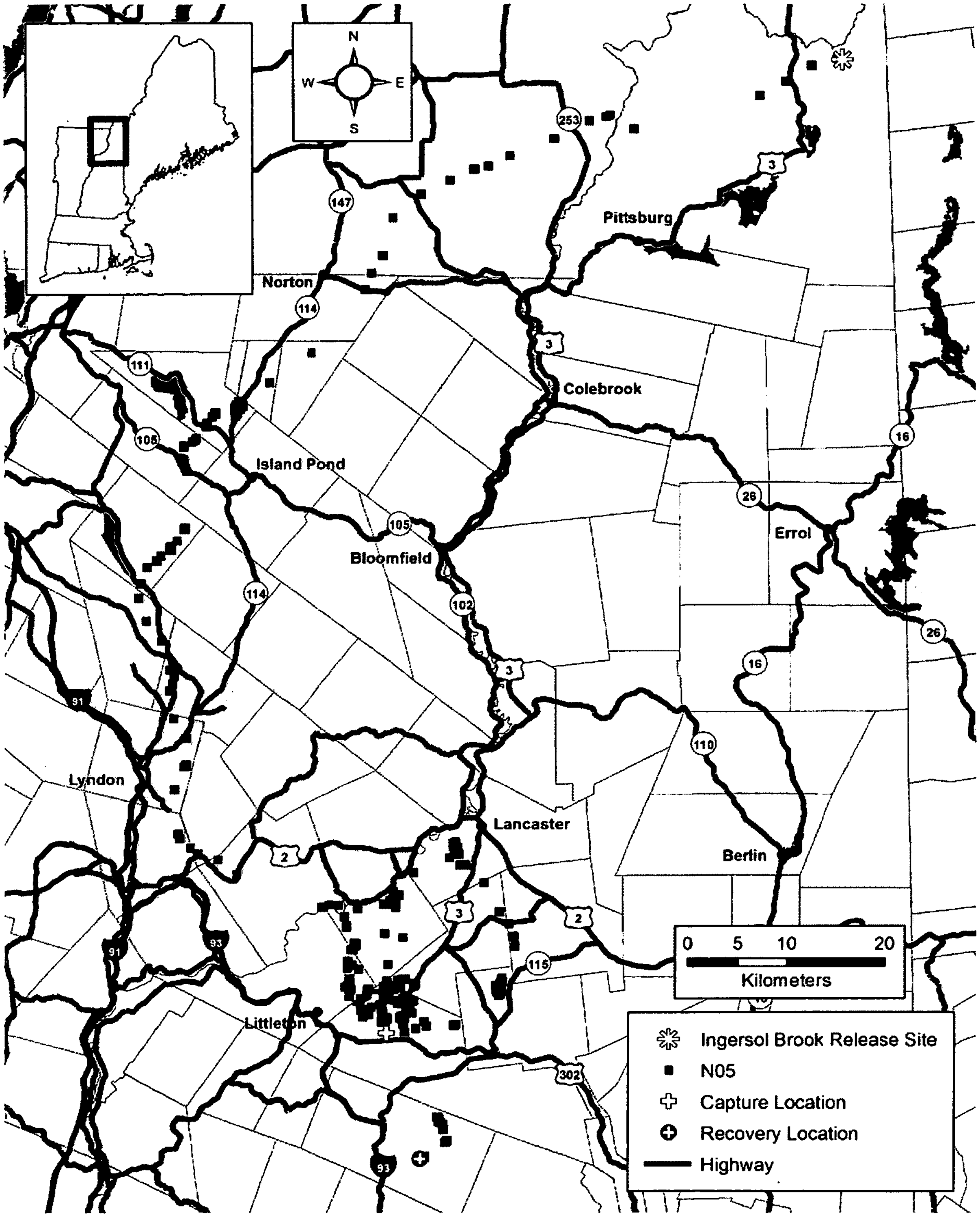

Appendix C: Figure 12. Locations of subadult male N47 captured in Bethlehem, NH and translocated 115 km to Ingersol Brook on 6 June 2012. This bear was harvested in Scotstown, QC, 31 km from the release site and 136 km from the capture site, on 18 June 2012.



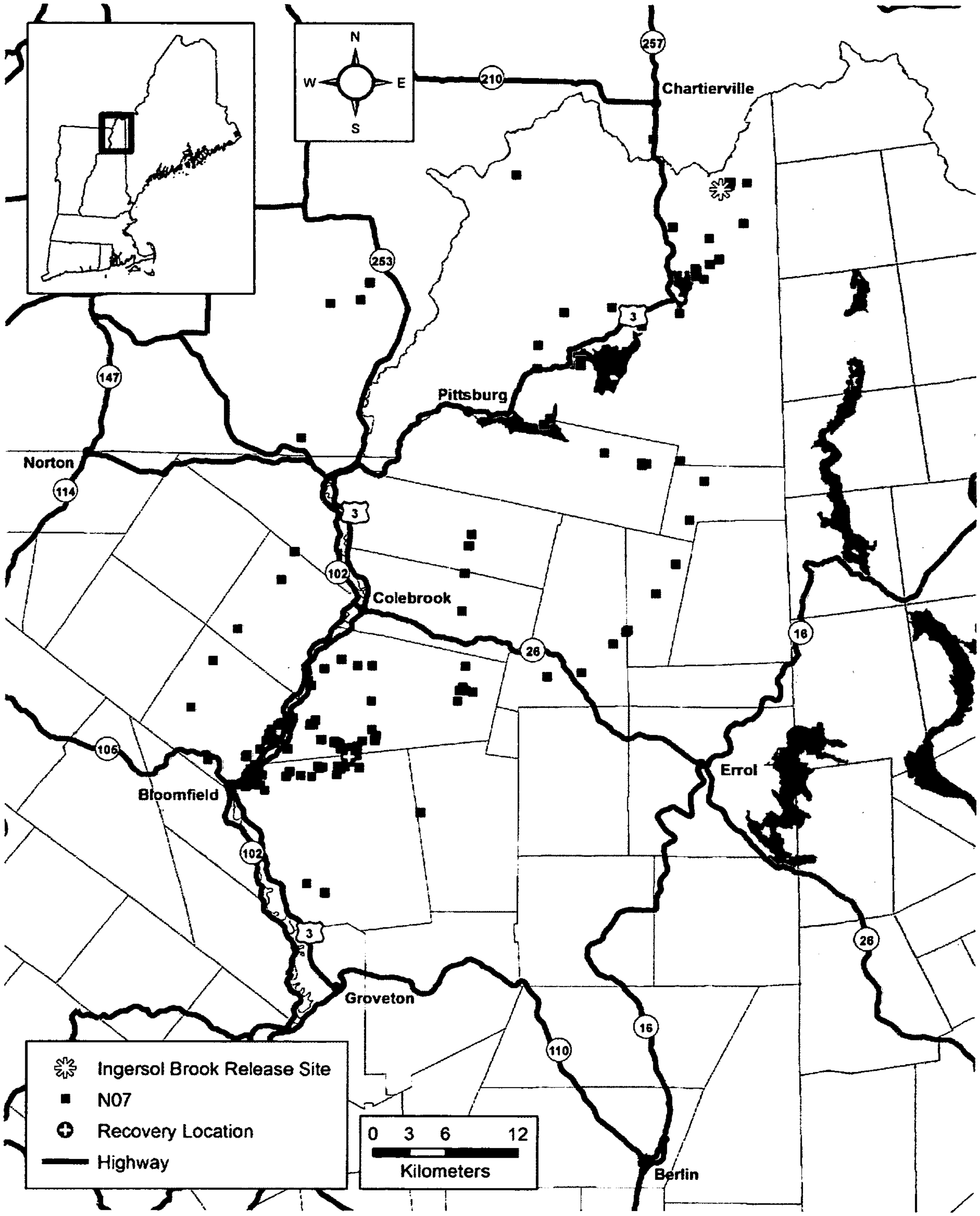

Appendix C: Figure 13. Locations of adult female N49 captured in Jackson, NH and translocated 121 km to Ingersol Brook on 18 June 2012. This bear returned to the capture area on 1 August. The collar was recovered during a den check, 121 km from the release site and <1 km from the capture site; 4 cubs of the year were found in the den.




Appendix C: Figure 14. Locations of adult male N48 captured in Franconia, NH and translocated 128 km to Ingersol Brook on 19 June 2012. This bear was translocated 28 and 33 km by Maine wildlife officials on 7 and 15 July, respectively; it returned to the Maine capture area in <3 days both times. The last location on the collar was 48 km from the Ingersol Brook release site and 115 km from the original capture site. This bear was harvested the following year on 7 June near Stornoway, QC, 55 km from the release site.

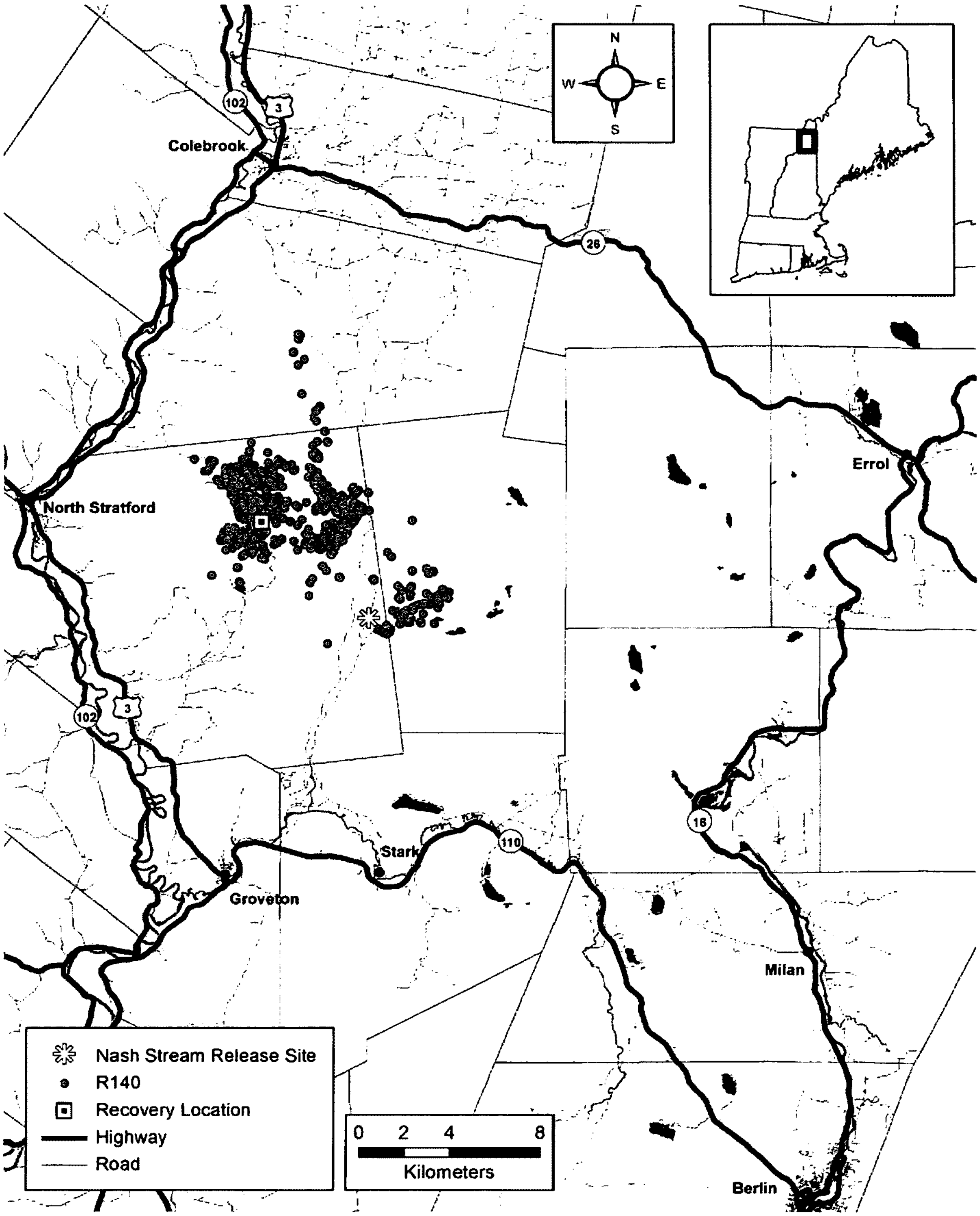



Appendix C: Figure 15. Locations of adult male N05 captured in Bethlehem, NH and translocated 113 km to Ingersol Brook on 2 July 2012.This bear returned to the capture area on 19 August; the collar was recovered during a den check after drop-off failure, 124 km from the release site and 14 km from the capture site.

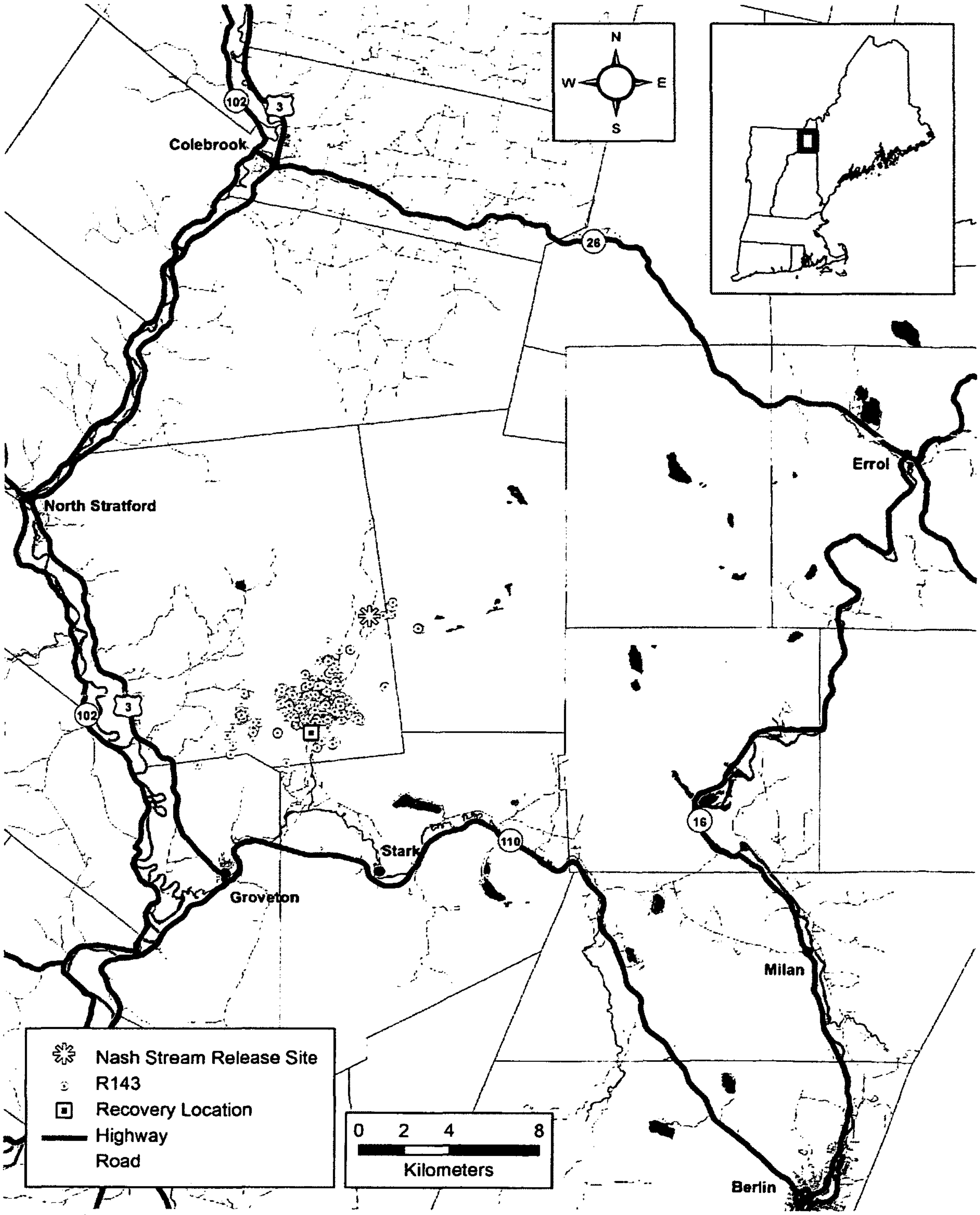



Appendix C: Figure 16. Locations of subadult male N07 captured in Warren, NH and translocated 155 km to Ingersol Brook on 12 July 2012. The collar was recovered after drop-off 58 km from the release site and 98 km from the capture site.

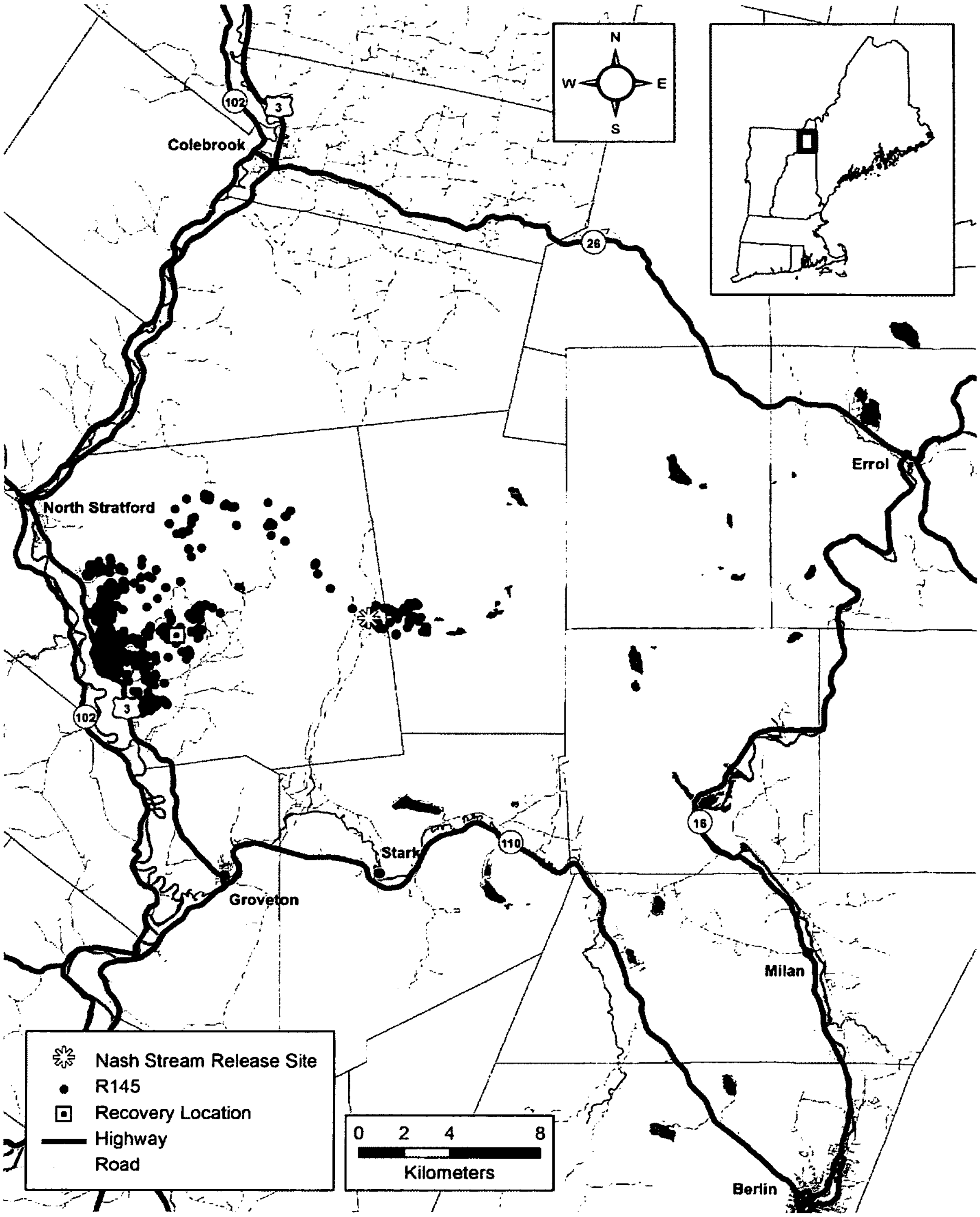
APPENDIX D. GPS COLLAR LOCATIONS OF REHABILITATED ORPHAN BLACK BEARS



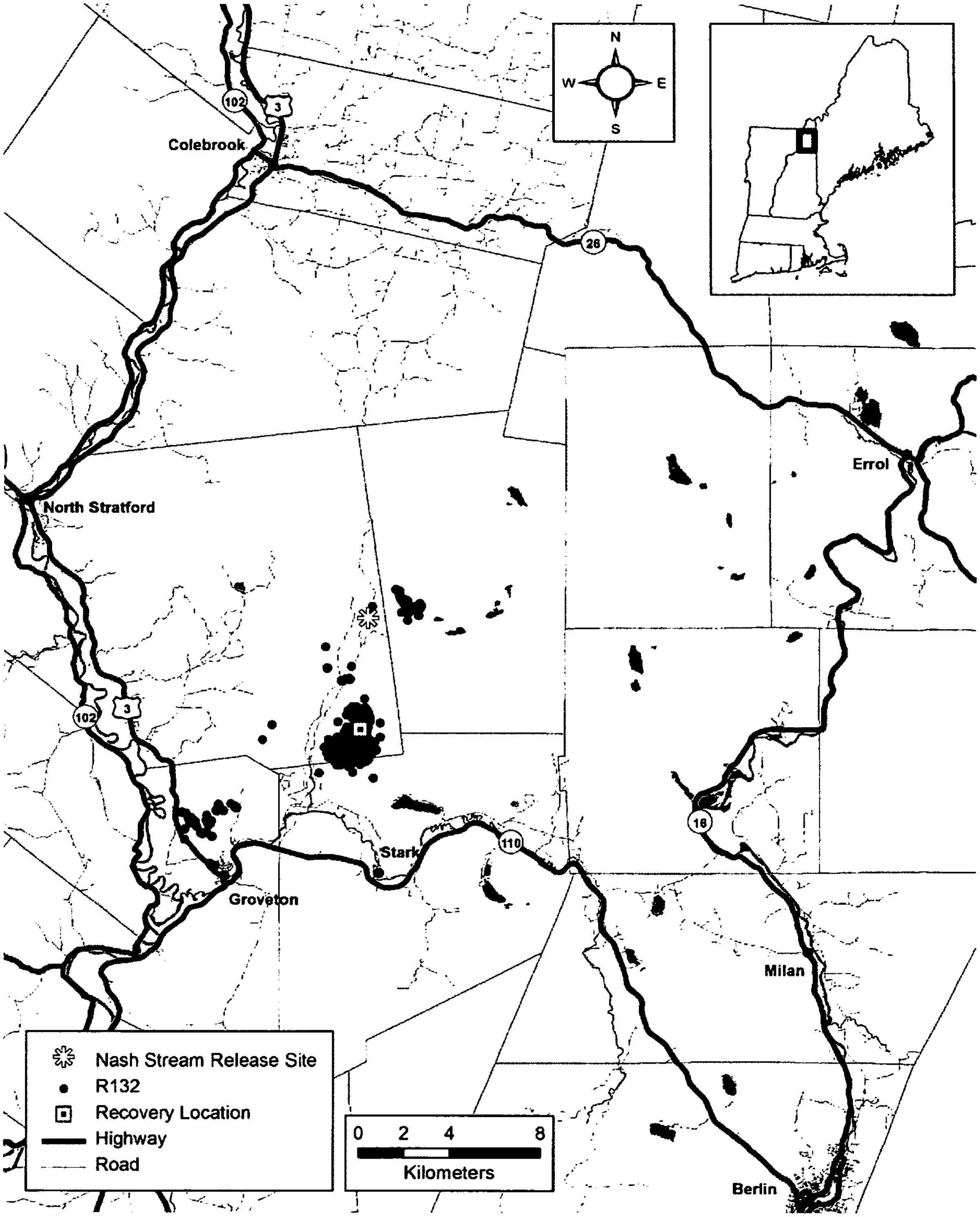

Appendix D: Figure 1. Locations of male R140 released at Nash Stream on 6 June 2011. The collar was recovered at a den check after failed drop-off, 7 km from the release site.



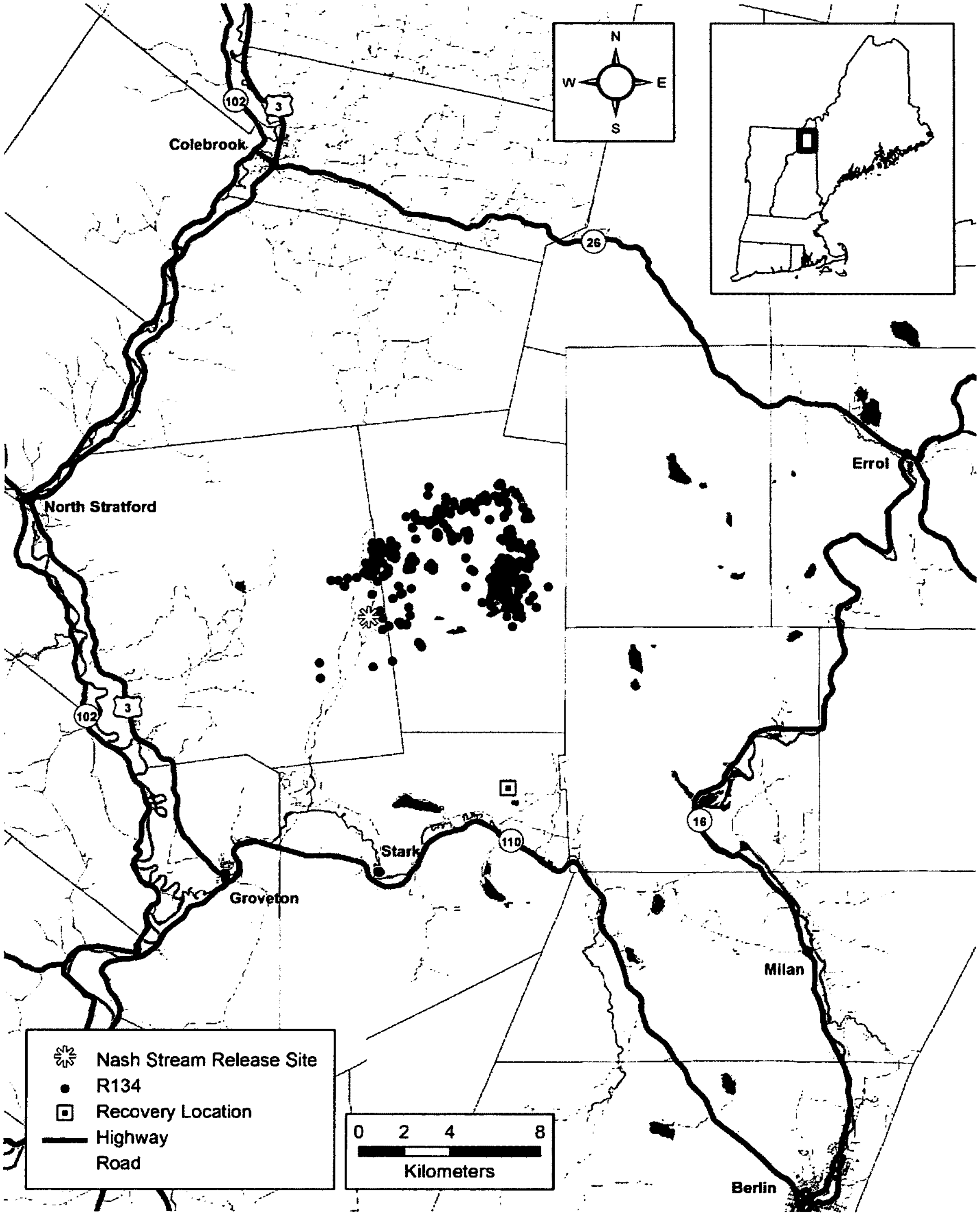
Appendix D: Figure 2. Locations of male R143 released at Nash Stream on 6 June 2011. This bear was harvested on 19 September 2011, 6 km from the release site.



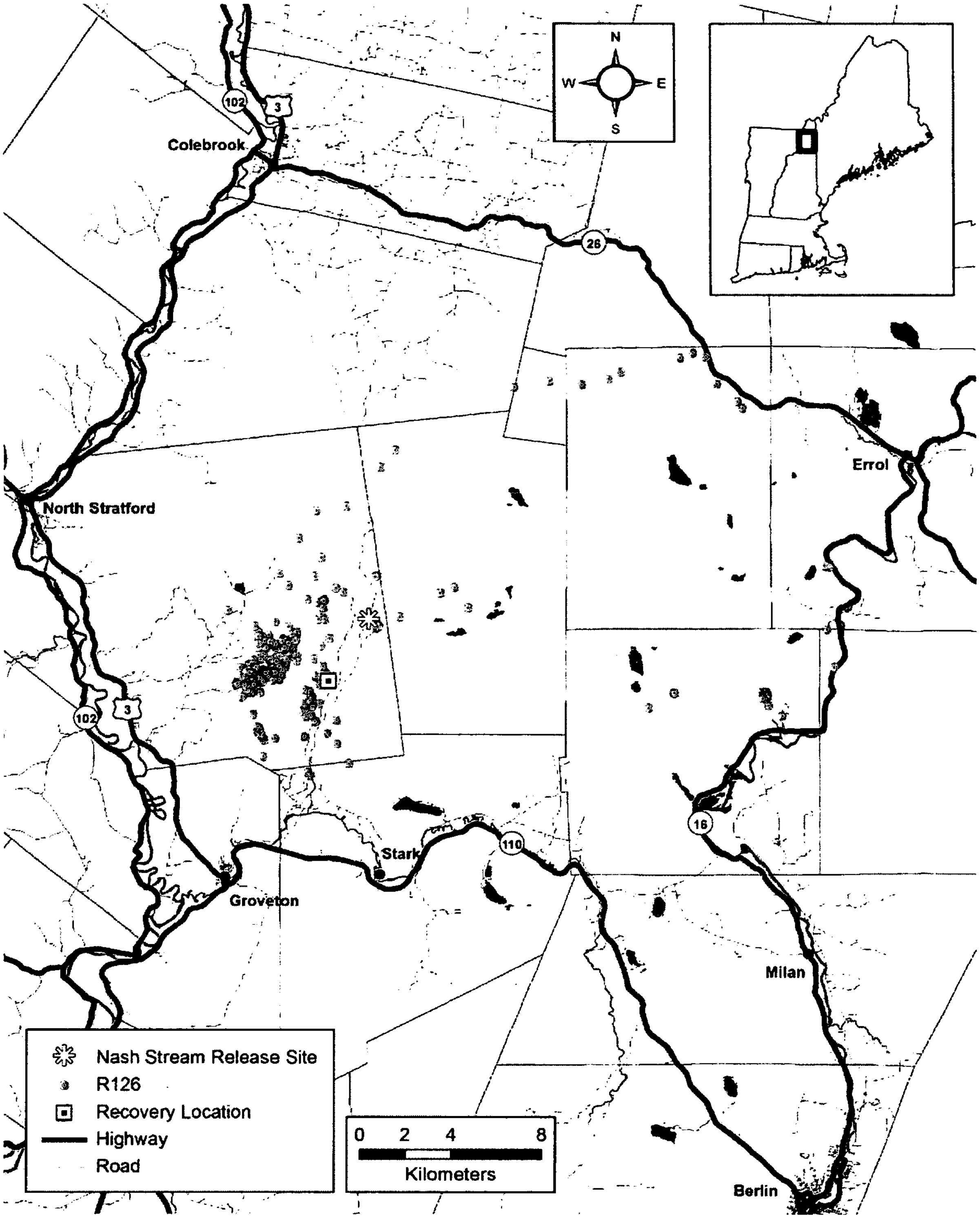

Appendix D: Figure 3. Locations of male R145 released at Nash Stream on 6 June 2011. The collar was recovered after drop-off, 9 km from the release site.



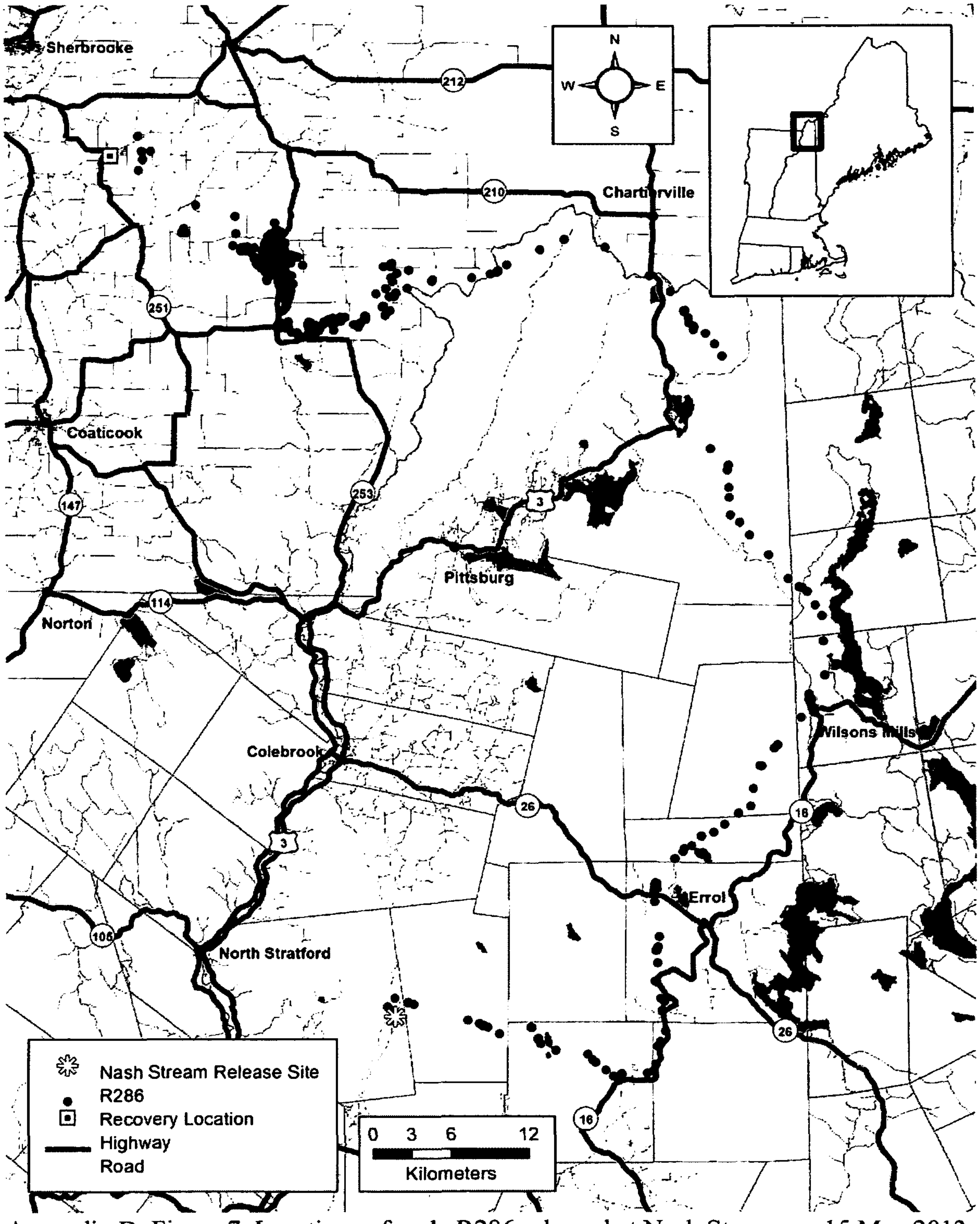

Appendix D: Figure 4. Locations of female R132 released at Nash Stream on 21 June 2011. The collar was recovered after drop-off, 5 km from the release site. This bear was harvested the following year on 11 October 2012 in Waterford, VT, 59 km southwest of the release site and 55 km from where the collar was recovered the previous year.



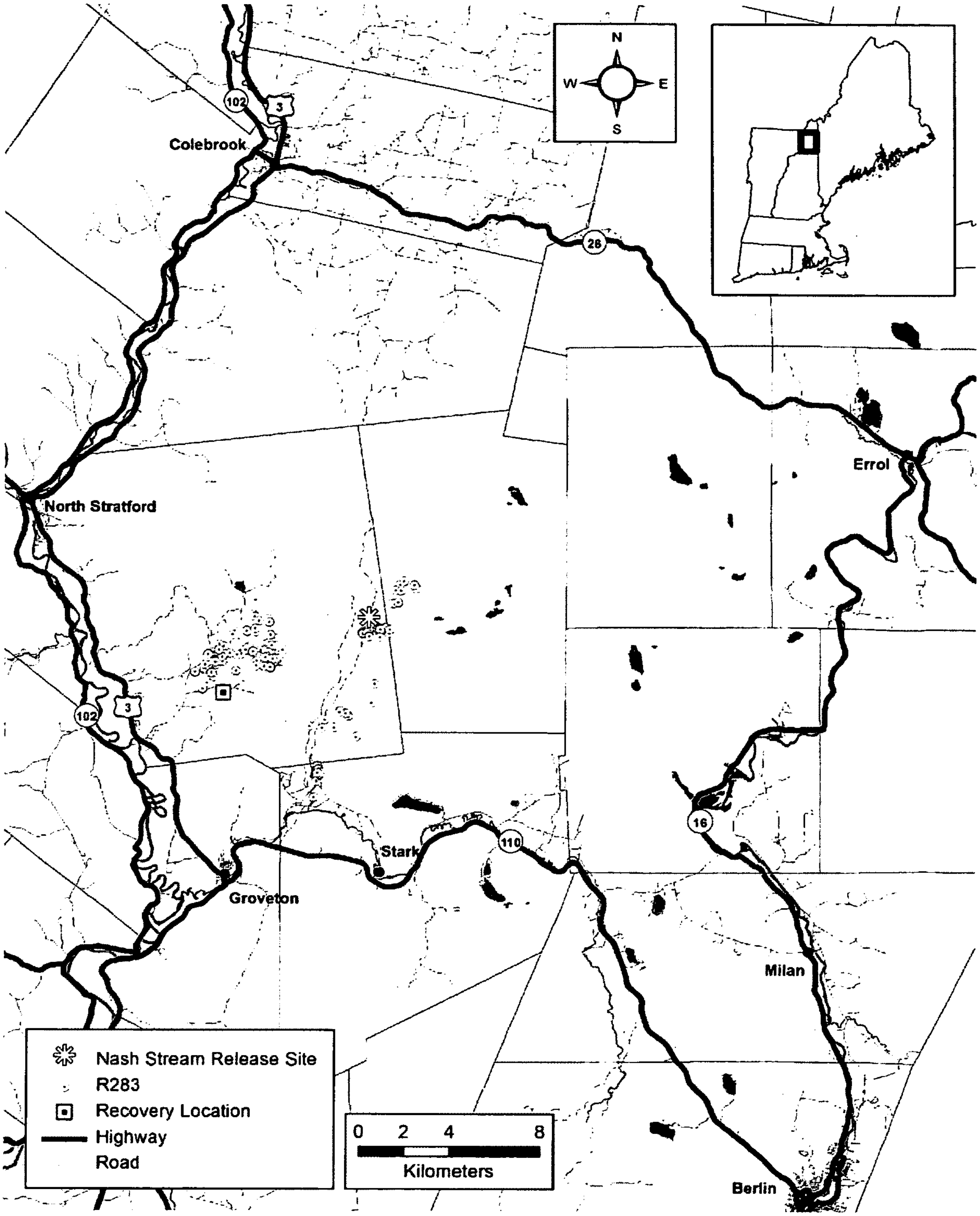

Appendix D: Figure 5. Locations of male R134 released at Nash Stream on 21 June 2011. The collar was recovered after drop-off, 10 km from the release site.



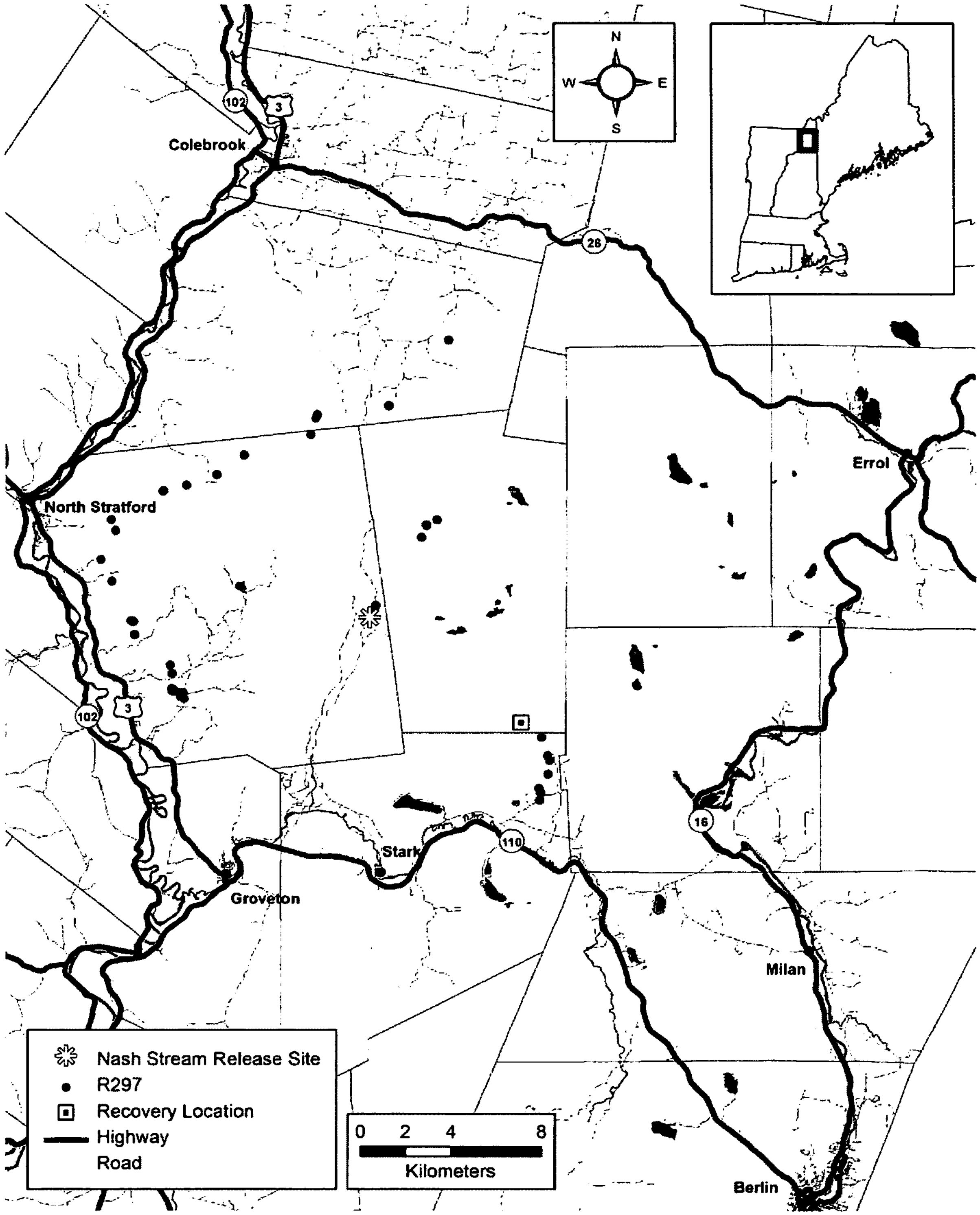

Appendix D: Figure 6. Locations of male R126 released at Nash Stream on 28 June 2011. The collar was recovered after drop-off, 3 km from the release site.



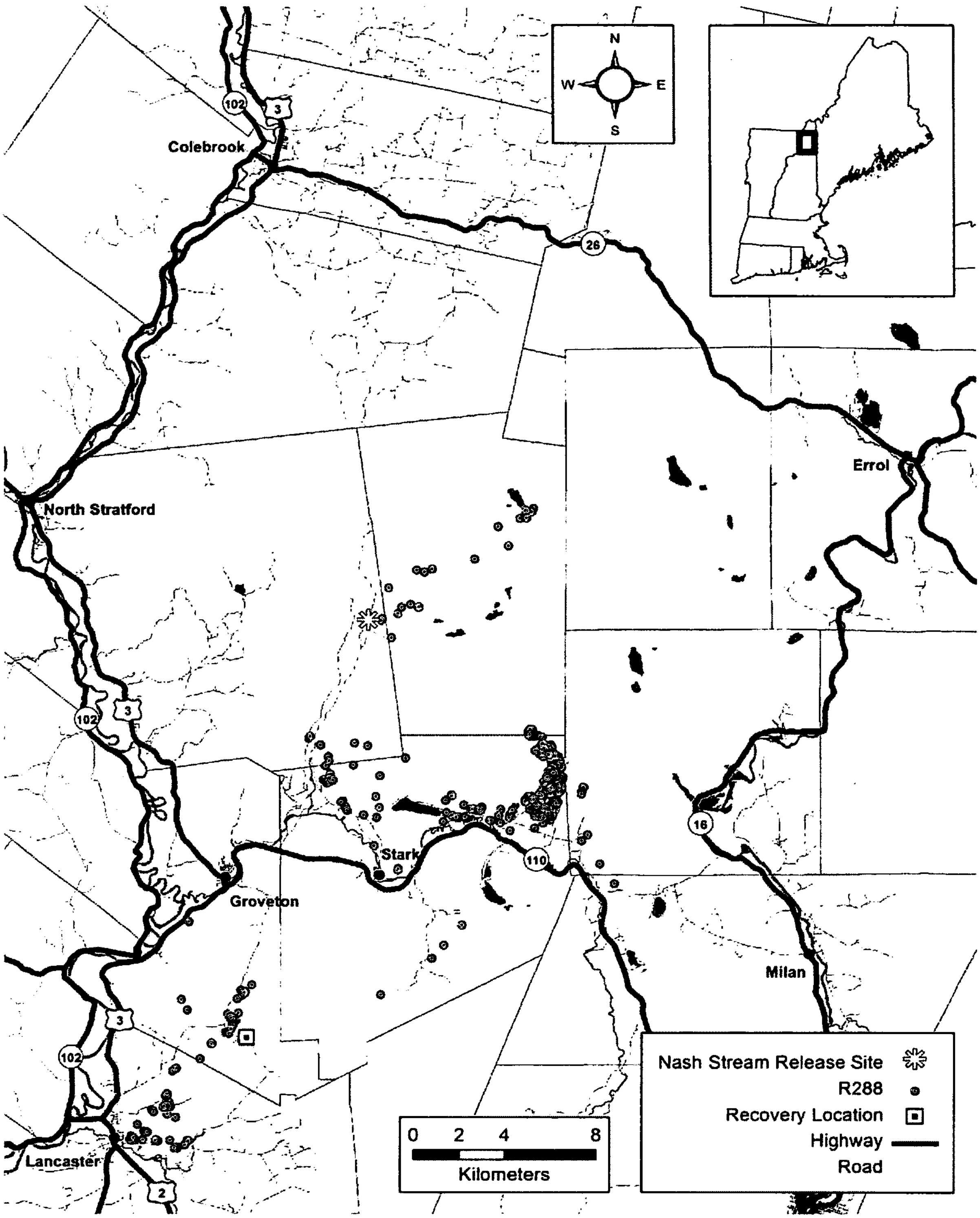

Appendix D: Figure 7. Locations of male R286 released at Nash Stream on 15 May 2012. This bear was destroyed due to conflict on 11 October 2012 near Sherbrooke, QC, 73 km from the release site.



Appendix D: Figure 8. Locations of male R283 released at Nash Stream on 21 May 2012. This bear was illegally killed by a landowner in a conflict situation in late June 2012, 15 km from the release site.




Appendix D: Figure 9. Locations of female R297 released at Nash Stream on 21 May 2012. The bear slipped the collar <2 weeks after release; it was recovered 8 km from the release site.



Appendix D: Figure 10. Locations of male R288 released at Nash Stream on 24 May 2012. This bear was harvested on 2 September 2012, 20 km from the release site.

APPENDIX E. GPS COLLAR PERFORMANCE

Appendix E: Table 1. Individual GPS collar performance for black bears released in northern New Hampshire, 2011-2012.

| Year | Bear ID | Brand | # Potential Fixes | # Fixes | Fix Rate (%)[a] | # Usable Fixes[b] | Screening Data Loss (%)[c] | Total Data Retention (%)[d] |
|---|---|---|---|---|---|---|---|---|
| 2011 | N16 | Lotek | 47 | 38 | 80.9 | 38 | 0.0 | 80.9 |
| | N17 | ATS | 1656 | 447 | 27.0 | 424 | 5.1 | 25.6 |
| | N26 | ATS | 1564 | 625 | 40.0 | 597 | 4.5 | 38.2 |
| | N29 | ATS | 1543 | 562 | 36.4 | 519 | 7.7 | 33.6 |
| | N33 | ATS | 1534 | 616 | 40.2 | 590 | 4.2 | 38.5 |
| | R138 | Lotek | Collar not recovered; 12 telemetry locations available | | | | | |
| | R140 | Lotek | 2323 | 1580 | 68.0 | 1579 | 0.1 | 68.0 |
| | R143 | Lotek | 1260 | 1010 | 80.2 | 1010 | 0.0 | 80.2 |
| | R145 | Lotek | 1763 | 1381 | 78.3 | 1381 | 0.0 | 78.3 |
| | R132 | ATS | 1666 | 987 | 59.2 | 938 | 5.0 | 56.3 |
| | R134 | ATS | 1666 | 643 | 38.6 | 602 | 6.4 | 36.1 |
| | R126 | ATS | 1666 | 350 | 21.0 | 314 | 10.3 | 18.8 |
| 2012 | N35 | Lotek | 223 | 131 | 58.7 | 131 | 0.0 | 58.7 |
| | N37 | Lotek | 591 | 377 | 63.8 | 377 | 0.0 | 63.8 |
| | N39 | ATS | 1394 | 1212 | 86.9 | 1013 | 16.4 | 72.7 |
| | N41 | Lotek | Collar not recovered; 9 telemetry locations available | | | | | |
| | N24 | Lotek | 104 | 89 | 85.6 | 88 | 1.1 | 84.6 |
| | N43 | Lotek | 1622 | 1250 | 77.1 | 1250 | 0.0 | 77.1 |
| | N45 | ATS | 2042 | 1335 | 65.4 | 1258 | 5.8 | 61.6 |
| | N47 | ATS | 146 | 135 | 92.5 | 131 | 3.0 | 89.7 |
| | N49 | ATS | 1614 | 937 | 58.1 | 885 | 5.5 | 54.8 |
| | N48 | ATS | 1393 | 690 | 49.5 | 633 | 8.3 | 45.4 |
| | N03 | ATS | Collar not recovered; 6 telemetry locations available | | | | | |
| | N05 | ATS | 1392 | 840 | 60.3 | 785 | 6.5 | 56.4 |
| | N07 | Lotek | 1130 | 920 | 81.4 | 920 | 0.0 | 81.4 |
| | R286 | ATS | 1769 | 829 | 46.9 | 785 | 5.3 | 44.4 |
| | R283 | Lotek | 419 | 266 | 63.5 | 266 | 0.0 | 63.5 |
| | R297 | ATS | 145 | 77 | 53.1 | 70 | 9.1 | 48.3 |
| | R288 | Lotek | 1208 | 942 | 78.0 | 942 | 0.0 | 78.0 |

[a] The percentage of successfully fixes (based on a 2 h fix schedule)
[b] The number of fixes after screening for GPS error (removed all 2D with DOP > 5)
[c] The percentage of location data eliminated as a result of screening
[d] The percentage of locations remaining after accounting for unsuccessful fixes and screening

Appendix E: Table 2. Summary of GPS collar performance data for black bears released in northern New Hampshire, 2011-2012.

| | Brand | # Potential Fixes | # Fixes | Fix Rate (%)[a] | # Usable Fixes[b] | Screening Data Loss (%)[c] | Total Data Retention (%)[d] |
|---|---|---|---|---|---|---|---|
| Mean ± SD | ATS | 1354 ± 627.0 | 730 ± 407.8 | 57.4 ± 20.1 | 674 ± 373.0 | 7.4 ± 3.6 | 53.1 ± 18.5 |
| | Lotek | 972 ± 752.2 | 726 ± 563 | 74.1 ± 9.0 | 726 ± 562.5 | 0.1 ± 0.3 | 74.0 ± 8.8 |
| | Total | 1161 ± 640.7 | 720 ± 436.8 | 64.9 ± 18.0 | 689 ± 420.3 | 4.1 ± 4.6 | 62.5 ± 18.2 |

[a] The percentage of successfully fixes (based on a 2 h fix schedule)

[b] The number of fixes after screening for GPS error (removed all 2D with DOP > 5)

[c] The percentage of location data eliminated as a result of screening

[d] The percentage of locations remaining after accounting for unsuccessful fixes and screening

Appendix F: Table 1. Movement metrics for translocated nuisance black bears released in northern New Hampshire, summer 2011 and 2012.

| | | | | Recovery Distance (km) | | Movement Rate (km/d) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Bear ID | Days Deployed | Days to Dispersal | From Capture Site | From Release Site | 1st Week | Spring | Summer | Fall |
| 2011 | N91 | - | - | 1.2 | 97.7 | - | - | - | - |
| | N16 | 4 | 0.9 | 293.0 | 27.1 | 8.7 | - | - | - |
| | N17 | 138 | 1.1 | 101.2 | 72.0 | 5.2 | 4.5 | 5.5 | - |
| | N26 | 130 | 1.1 | 105.0 | 74.4 | 6.0 | - | 4.4 | 3.6 |
| | N29 | 128 | 0.3 | 58.7 | 74.7 | 9.5 | - | 4.2 | 5.5 |
| | N33 | 127 | 5.0 | 23.7 | 70.4 | 8.0 | - | 5.9 | 2.8 |
| 2012 | N35 | 18 | 2.2 | 167.3 | 73.0 | 11.6 | 14.6 | - | - |
| | N37 | 48 | 2.1 | 88.8 | 82.0 | 13.2 | 8.9 | - | - |
| | N39 | 115 | 1.3 | 90.7 | 148.9 | 17.8 | 6.7 | 3.3 | - |
| | N24 | 8 | 0.7 | 100.7 | 49.9 | 7.0 | - | - | - |
| | N41 | 179 | - | 12.7 | 110.9 | - | - | - | - |
| | N43 | 134 | 1.9 | 2.3 | 97.8 | 14.9 | 8.7 | 5.9 | 6.2 |
| | N45 | 169 | 1.9 | 52.6 | 64.1 | 7.7 | 4.9 | 3.9 | 5.9 |
| | N47 | 11 | 2.2 | 135.5 | 30.8 | 4.2 | - | - | - |
| | N49 | 134 | 0.9 | 0.6 | 121.5 | 14.8 | 16.8 | 6.9 | 1.2 |
| | N48 | 117 | 1.2 | 115.3 | 47.6 | 13.0 | 11.4 | 3.5 | 2.0 |
| | N03 | 140 | - | - | - | - | - | - | - |
| | N05 | 99 | 1.7 | 13.7 | 124.3 | 10.9 | 7.1 | 3.5 | 3.2 |
| | N07 | 93 | 2.5 | 98.0 | 58.0 | 11.4 | - | 5.2 | 2.1 |

Appendix F: Table 2. Movement metrics for rehabilitated orphan black bears released in Nash Stream Forest, NH, June 2011 and May 2012.

| Bear ID | Days Deployed | Days to Dispersal | Recovery Distance from Release Site (km) | Movement Rate (km/day) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1st Week | Spring | Summer | Fall |
| R138 | 187 | - | | - | - | - | - |
| R140 | 193 | 20.3 | 6.5 | 1.4 | 2.8 | 2.5 | 3.1 |
| R143 | 104 | 3.5 | 6.0 | 2.2 | 2.5 | 3.0 | - |
| R145 | 146 | 12.1 | 8.6 | 1.1 | 2.8 | 2.0 | 2.2 |
| R132 | 138 | 9.8 | 5.2 | 1.4 | 2.5 | 1.9 | 1.6 |
| R134 | 138 | 2.1 | 10.0 | 3.3 | 2.9 | 3.8 | 1.1 |
| R126 | 138 | 3.0 | 3.4 | 6.3 | 6.8 | 1.8 | 1.0 |
| R286 | 146 | 2.1 | 73.1 | 6.3 | 4.8 | 1.6 | 1.2 |
| R283 | 34 | 9.9 | 7.4 | 1.1 | 2.3 | - | - |
| R297 | 11 | 2.0 | 8.3* | 6.4 | - | - | - |
| R288 | 100 | 4.0 | 20.1 | 6.4 | 3.5 | 4.6 | - |

* Not included in analysis due to slipped collar

APPENDIX G. CANDIDATE MODELS FOR HABITAT SELECTION

Appendix G: Table 1. The number of parameters (K), AICc scores, ΔAICc scores, weights and log likelihood of habitat selection models for translocated nuisance black bears released in northern New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| Model | K | AICc | ΔAICc | Weight | logLik |
|---|---|---|---|---|---|
| Full Model | 18 | 61353.92 | 0 | 1 | -30658.96 |
| Human Features w/ Land Cover | 12 | 61448.68 | 94.75 | 0 | -30712.34 |
| Univariates | 13 | 61465.80 | 111.87 | 0 | -30719.90 |
| Habitat w/ Elevation | 15 | 61487.00 | 133.08 | 0 | -30728.50 |
| Natural Food w/ Elevation | 13 | 61534.29 | 180.36 | 0 | -30754.14 |
| Natural Food w/o Elevation | 11 | 61642.95 | 289.02 | 0 | -30810.47 |
| Habitat w/o Elevation | 13 | 61644.96 | 291.03 | 0 | -30809.48 |
| Wetlands | 10 | 61648.59 | 294.66 | 0 | -30814.29 |
| Elevation | 4 | 63062.65 | 1708.72 | 0 | -31527.32 |
| Human Features w/o Land Cover | 6 | 62998.08 | 1644.16 | 0 | -31493.04 |

Appendix G: Table 2. The number of parameters (K), AICc scores, ΔAICc scores, weights and log likelihood of habitat selection models for adult translocated nuisance black bears released in northern New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| Model | K | AICc | ΔAICc | Weight | logLik |
|---|---|---|---|---|---|
| Full Model | 18 | 31653.03 | 0 | 1 | -15808.51 |
| Univariates | 13 | 31698.71 | 45.67 | 0 | -15836.35 |
| Habitat w/ Elevation | 15 | 31718.37 | 65.34 | 0 | -15844.18 |
| Natural Food w/ Elevation | 13 | 31719.70 | 66.67 | 0 | -15846.85 |
| Habitat w/o Elevation | 13 | 31738.42 | 85.38 | 0 | -15856.20 |
| Natural Food w/o Elevation | 11 | 31738.69 | 85.66 | 0 | -15858.34 |
| Wetlands | 10 | 31756.33 | 103.29 | 0 | -15868.16 |
| Human Features w/ Land Cover | 12 | 31793.68 | 140.64 | 0 | -15884.84 |
| Human Features w/o Land Cover | 6 | 32493.74 | 840.71 | 0 | -16240.87 |
| Elevation | 4 | 32522.93 | 869.90 | 0 | -16257.46 |

Appendix G: Table 3. The number of parameters (K), AICc scores, ΔAICc scores, weights and log likelihood of habitat selection models for subadult translocated nuisance black bears released in northern New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| Model | K | AICc | ΔAICc | Weight | logLik |
|---|---|---|---|---|---|
| Full Model | 18 | 29564.02 | 0 | 1 | -14764.00 |
| Univariates | 13 | 29584.36 | 20.33 | 0 | -14779.17 |
| Human Features w/ Land Cover | 12 | 29587.38 | 23.36 | 0 | -14781.69 |
| Habitat w/ Elevation | 15 | 29620.62 | 56.60 | 0 | -14795.31 |
| Natural Food w/ Elevation | 13 | 29633.56 | 69.53 | 0 | -14803.77 |
| Wetlands | 10 | 29674.45 | 110.43 | 0 | -14827.22 |
| Natural Food w/o Elevation | 11 | 29675.60 | 111.58 | 0 | -14826.80 |
| Habitat w/o Elevation | 13 | 29678.20 | 114.18 | 0 | -14826.10 |
| Human Features w/o Land Cover | 6 | 30510.60 | 946.58 | 0 | -15249.30 |
| Elevation | 4 | 30527.70 | 963.67 | 0 | -15259.85 |

Appendix G: Table 4. The number of parameters (K), AICc scores, ΔAICc scores, weights and log likelihood of habitat selection models for rehabilitated orphan black bears released in Nash Stream Forest, New Hampshire, 2011-2012. Models were developed using a resource selection function based on a used vs. available design.

| Model | K | AICc | ΔAICc | Weight | logLik |
|---|---|---|---|---|---|
| Full Model | 18 | 48082.17 | 0 | 1 | -24023.08 |
| Habitat w/ Elevation | 14 | 48099.65 | 17.48 | 0 | -24035.82 |
| Natural Food w/ Elevation | 13 | 48148.59 | 66.42 | 0 | -24061.29 |
| Univariates | 13 | 48148.59 | 66.42 | 0 | -24061.29 |
| Habitat w/o Elevation | 12 | 48415.18 | 333.01 | 0 | -24195.59 |
| Food w/o Elevation | 11 | 48430.86 | 348.70 | 0 | -24204.43 |
| Wetlands | 10 | 48445.11 | 362.94 | 0 | -24212.55 |
| Human Features w/ Land Cover | 12 | 48481.19 | 399.02 | 0 | -24228.59 |
| Elevation | 4 | 48574.50 | 492.33 | 0 | -24283.25 |
| Human Features w/o Land Cover | 6 | 48872.23 | 790.07 | 0 | -24430.12 |

Appendix G: Table 5. The number of parameters (K), AICc scores, ΔAICc scores, weights and log likelihood of habitat selection models for rehabilitated orphan black bears released in Nash Stream Forest, New Hampshire, June 2011. Models were developed using a resource selection function based on a used vs. available design.

| Model | K | AICc | ΔAICc | Weight | logLik |
|---|---|---|---|---|---|
| Habitat w/ Elevation | 14 | 35896.99 | 0 | 0.58 | -17934.49 |
| Full Model | 18 | 35898.12 | 1.13 | 0.33 | -17931.06 |
| Natural Food w/ Elevation | 13 | 35900.55 | 3.56 | 0.10 | -17937.27 |
| Univariates | 13 | 35913.40 | 16.41 | 0 | -17943.70 |
| Elevation | 4 | 36110.70 | 213.71 | 0 | -18051.35 |
| Wetlands | 10 | 36191.03 | 294.04 | 0 | -18085.51 |
| Natural Food w/o Elevation | 11 | 36192.45 | 295.46 | 0 | -18085.22 |
| Habitat w/o Elevation | 12 | 36193.96 | 296.96 | 0 | -18084.98 |
| Human Features w/ Land Cover | 12 | 36263.18 | 366.19 | 0 | -18119.59 |
| Human Features w/o Land Cover | 6 | 36419.82 | 522.82 | 0 | -18203.91 |

Appendix G: Table 6. The number of parameters (K), AICc scores, ΔAICc scores, weights and log likelihood of habitat selection models for rehabilitated orphan black bears released in Nash Stream Forest, New Hampshire, May 2012. Models were developed using a resource selection function based on a used vs. available design.

| Model | K | AICc | ΔAICc | Weight | logLik |
|---|---|---|---|---|---|
| Full Model | 18 | 11908.06 | 0 | 1 | -5936.01 |
| Univariates | 13 | 11921.43 | 13.37 | 0 | -5947.70 |
| Habitat w/ Elevation | 14 | 11985.10 | 77.04 | 0 | -5978.54 |
| Habitat w/o Elevation | 12 | 11999.45 | 91.40 | 0 | -5987.72 |
| Natural Food w/ Elevation | 13 | 12011.58 | 103.52 | 0 | -5992.78 |
| Natural Food w/o Elevation | 11 | 12038.51 | 130.46 | 0 | -6008.25 |
| Human Features w/ Land Cover | 12 | 12058.95 | 150.90 | 0 | -6017.47 |
| Wetlands | 10 | 12172.16 | 264.11 | 0 | -6076.08 |
| Human Features w/o Land Cover | 6 | 12404.52 | 496.47 | 0 | -6196.26 |
| Elevation | 4 | 12443.05 | 534.99 | 0 | -6217.52 |

APPENDIX H. PROXIMITY-TO-BUILDING ANALYSIS FOR INDIVIDUAL STUDY BEARS

Appendix H: Table 1. Percentage of locations within 100 m and 500 m of a building for translocated nuisance black bears released in northern New Hampshire, summer 2011 and 2012.

| | Bear ID | Type | Total Locations | Locations within 100 m (%) | Locations within 500 m (%) |
|---|---|---|---|---|---|
| 2011 | N16 | Used | 29 | 10.3 | 10.3 |
| | | Available | 290 | 0.7 | 16.6 |
| | N17 | Used | 420 | 5.7 | 27.4 |
| | | Available | 4200 | 10.1 | 31.8 |
| | N26 | Used | 592 | 0.2 | 10.3 |
| | | Available | 5920 | 1.0 | 9.2 |
| | N29 | Used | 518 | 1.2 | 14.3 |
| | | Available | 5180 | 1.4 | 11.0 |
| | N33 | Used | 560 | 5.0 | 28.6 |
| | | Available | 5600 | 4.1 | 29.6 |
| 2012 | N35 | Used | 117 | 20.5 | 47.9 |
| | | Available | 1170 | 5.0 | 26.1 |
| | N37 | Used | 357 | 9.0 | 52.4 |
| | | Available | 3570 | 7.4 | 41.3 |
| | N39 | Used | 999 | 23.4 | 91.9 |
| | | Available | 9990 | 27.9 | 88.0 |
| | N24 | Used | 80 | 5.0 | 48.8 |
| | | Available | 800 | 6.1 | 25.6 |
| | N43 | Used | 1235 | 8.0 | 46.8 |
| | | Available | 12350 | 7.6 | 35.9 |
| | N45 | Used | 1240 | 15.3 | 69.8 |
| | | Available | 12400 | 8.8 | 60.3 |
| | N47 | Used | 108 | 8.3 | 53.7 |
| | | Available | 1080 | 4.3 | 41.4 |
| | N49 | Used | 875 | 24.1 | 66.9 |
| | | Available | 8750 | 18.5 | 46.8 |
| | N48 | Used | 620 | 20.6 | 46.3 |
| | | Available | 6200 | 7.8 | 35.5 |
| | N05 | Used | 773 | 16.3 | 72.8 |
| | | Available | 7730 | 9.8 | 53.5 |
| | N07 | Used | 895 | 2.2 | 67.8 |
| | | Available | 8950 | 9.8 | 59.9 |

Appendix H: Table 2. Percentage of locations within 100 m and 500 m of a building for rehabilitated orphan black bears released in Nash Stream Forest, NH, June 2011 and May 2012.

| | **Bear ID** | **Type** | **Total Locations** | **Locations within 100 m (%)** | **Locations within 500 m (%)** |
|---|---|---|---|---|---|
| 2011 | R140 | Used | 1411 | 0.0 | 0.2 |
| | | Available | 14110 | 0.1 | 2.0 |
| | R143 | Used | 975 | 0.0 | 4.2 |
| | | Available | 9750 | 7.6 | 9.7 |
| | R145 | Used | 1285 | 4.5 | 53.5 |
| | | Available | 12850 | 11.2 | 56.3 |
| | R132 | Used | 875 | 0.3 | 1.1 |
| | | Available | 8750 | 0.7 | 4.1 |
| | R134 | Used | 590 | 0.0 | 1.5 |
| | | Available | 5900 | 0.4 | 5.4 |
| | R126 | Used | 297 | 0.0 | 8.4 |
| | | Available | 2970 | 2.1 | 18.4 |
| 2012 | R286 | Used | 766 | 1.4 | 52.7 |
| | | Available | 7660 | 5.5 | 45.8 |
| | R283 | Used | 187 | 8.6 | 43.9 |
| | | Available | 1870 | 8.4 | 45.7 |
| | R297 | Used | 60 | 6.7 | 50.0 |
| | | Available | 600 | 7.5 | 33.7 |
| | R288 | Used | 906 | 17.4 | 79.9 |
| | | Available | 9060 | 10.7 | 61.1 |