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Experimental Repatriation of Black Bears to the Big South Fork Area of Kentucky and Tennessee

Rick Eastridge
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Rick Eastridge entitled "Experimental Repatriation of Black Bears to the Big South Fork Area of Kentucky and Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Joseph D. Clark, Major Professor

We have read this thesis and recommend its acceptance:

David A. Beuhler, David A. Etnier, Micheal R. Pelton

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Associate Vice Chancellor and
Dean of the Graduate School

EXPERIMENTAL REPATRIATION OF BLACK BEARS TO THE BIG SOUTH FORK AREA OF KENTUCKY AND TENNESSEE

A Thesis Presented for the Master of Science Degree

University of Tennessee

Rick Eastridge

May 2000

DEDICATION

I dedicate this thesis to my wife, Christi Eastridge, for her untiring love, patience, and understanding.

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ABSTRACT

Black bears (*Ursus americanus*) have been extirpated from the Big South Fork Area (BSFA) of Kentucky and Tennessee since the turn of the 20th century. Although this area is within the bear's historic range, it may be unreachable to individual bears through natural dispersal. Wildlife managers and the public were interested in reestablishing a population of black bears to BSFA. A habitat analysis found that the area could support bears. However, managers remained concerned about how humans would interact with bears; furthermore, managers needed to know how to overcome the homing ability of translocated bears.

I tested 2 translocation techniques designed to limit the homing ability of bears. Both techniques were based on the concept of a soft release, involving a short period of acclimation prior to release. The first was a winter-release technique, involving the translocation of pre- or post-parturient bears from their dens and placing them in dens within the release area. The second, a summer-release technique, involved translocating bears to the release area during the summer and holding the bears in pens for a 2-week acclimation period.

I translocated a total of 14 bears from the Great Smoky Mountains National Park to BSFA, a distance of approximately 160 km. I translocated 8 bears with the winter-release technique and 6 bears with the summer-release technique.

I compared post-release movements between the 2 release techniques for the first 2 weeks post-release with the Wilcoxon signed-rank test. No difference in total movement ($Z = 1.357$, $P = 0.1747$) or net movement ($Z = 1.214$, $P = 0.100$) was found

between winter- and summer-released bears. However, because of rapid movements outside BSFA, complete movement data for 2 summer-released bears were not available. Therefore, I substituted the mean total and net movements of summer-released bears for these 2 bears during the interim when their signals were lost. The total movement of winter-released bears was less (Z = 2.227, $P = 0.013$) than summer-released bears for the first 2 weeks post-release. Also, the net movement of winter-released bears was less (Z = 2.217, $P = 0.013$) than summer-released bears for the first 2 weeks post-release. The average daily movement of winter-released bears was less (Z = 2.214, $P = 0.027$) than summer-released bears during the first 2 weeks post-release. Circuity was less (Z = 2.074, $P = 0.038$) for winter-released bears than for summer-released bears during the first 2 weeks post-release.

I determined site fidelity for 7 winter-released bears and 6 summer-released bears with the site fidelity test from the MOVEMENT module (Hooge et al. 1999) of ArcView (Environmental Research Institute, Inc. Redlands, Ca.). Within 1 year post-release, movements were too constrained to be random for all winter-released bears. One year after release, movements were too constrained to be random for 3 of the 6 summer-released bears; 1 summer-released bear continued to show random movements 1 year after release; the 2 remaining summer-released bears could not be evaluated at 1 year post-release because of mortality or homing.

I applied the multi-response permutation procedure to the post-release movements of translocated bears that established themselves in BSFA, regardless of release technique, to determine if movements became more concentrated as bears adjusted to the release area. The movements of 6 of 8 bears became more concentrated within 6 months;

the movements of the remaining 2 bears became more concentrated within 9 months. This could indicate that translocated bears are establishming home ranges within the release area.

I estimated adult survival for translocated bears using the Kaplan-Meier staggered entry procedure. I compared annual survival between winter- and summer-release techniques. Survival of winter-released bears (0.875) was greater ($Z = 3.084$, $P = 0.001$) than summer-released bears (0.200). Vehicle collisions accounted for 3 of the 6 mortalities of summer-released bears.

Den visits were performed in the winters of 1997, 1998, and 1999. Researchers visited the dens of the 2 remaining radio-collared bears in BSFA and confirmed natural reproduction had occurred. This could mean that the translocation of adult males to BSFA is unnecessary.

Interactions between humans and bears were documented by National Park Service personnel. Fifty-three sightings occurred between April 1996 and November 1999; no incidences of nuisance behavior by translocated bears was documented.

I used a population model developed for polar bears (*U. maritimus*; Taylor et al. 1987*a*, 1987*b*) and adapted for black bears to estimate population growth and probability of extinction of translocated bears. I modeled population growth under various stocking scenarios to determine the most timely and efficient way to reestablish bears to BSFA. If no more bears are translocated to BSFA, the data indicates the population will become extinct. The population model suggests that at least 1 additional stocking of 6 adult females with 12 cubs will be needed to sustain the population. The addition of 6 adult females with 12 cubs each year for 4-6 years will yield the most timely results.

I used compositional analysis (Aebischer et al. 1993) to compare habitat use of translocated bears to that predicted by the Habitat Suitability Index (HSI) values determined by van Manen (1990). Bears did not use the habitat at BSFA as determined by the HSI values; however, placement of release sites, improved habitat quality, and roads could have influenced this result.

The winter-release technique demonstrated clear advantages over the summer-release technique in terms of limiting post-release movements and increasing survival of translocated bears. The winter-release technique could be useful anytime managers need to establish or augment black bear populations.

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CHAPTER 1

INTRODUCTION

Justification for Repatriation

Black bears (*Ursus americanus*) once ranged throughout the forested areas of North America (Hall 1981). However, habitat loss and unregulated harvest of bears has led to the extirpation of this species in many areas of the United States. Range contraction and fragmentation is especially evident in the Southeast, where bears occupy only 20% of their original range (Pelton and van Manen 1997). Nevertheless, acquisition and management of portions of historic bear range by federal and state authorities, as well as land use changes, has led to marked recovery of habitat in many areas.

Unoccupied areas within the black bear's historic range exist, but these areas may be unreachable to individuals through natural dispersal (van Manen 1990). Caughley (1977:57) stressed that the survival of a species is as dependent on dispersal as it is on reproduction and longevity. In black bears, adults display strong affinity to their home ranges because of familiarity with the area and for the stability of established intraspecific social relationships (Beeman and Pelton 1976). Range expansion by subadult male bears is common because young males are forced to disperse from their natal range because of intraspecific strife; older, more established males force subadult males to disperse through acts of aggression (Kemp 1976, Young and Ruff 1982, Schwartz and Franzman 1992). Conversely, young female bears typically reside within a portion of their mother's home range, thereby limiting dispersal pressures for the female population segment (Alt 1978, Schwartz and Franzman 1992). Ounstead (1991) explained that repatriation of

many species would be unnecessary if suitable habitat was available. However, the limited dispersal capabilities of bears coupled with isolated habitat fragments make colonization of recovered habitats difficult at best. Human intervention will be required in many cases.

Bear repatriation can have many ecological and social benefits. The repatriation of bears helps to reestablish natural biodiversity and, as a keystone species, bears can be vital to the ecosystem (van Manen 1990, Estes 1996). Furthermore, bears use large areas and their habitat requirements typically encompass those of many other species. Because of this, bears are considered an umbrella species and, as such, can function as an important biological indicator (Noss et al. 1996). Also, because many bear populations in the southeastern United States are restricted to isolated fragments of habitat (Pelton 1990), range expansion to unoccupied habitats could reduce the risk of species loss from catastrophes (Griffith et al. 1989).

The repatriation of wildlife to areas where they once existed has long been a major emphasis for wildlife managers (Griffith et al. 1989) and is often popular with the public. The black bear is a natural resource that can be enjoyed by many outdoor enthusiasts including hikers, campers, photographers, and hunters. The bear has the potential to increase revenue for wildlife management agencies through license sales and boost local economies through tourism and increased visitation by outdoor enthusiasts (van Manen 1990). Apart from these personal use values, there are existence values (the ethical right of a species to exist apart from any direct benefit to man) that can be enhanced with repatriation (Glass and Stevens 1990).

Past Bear Translocation Efforts

Translocation is defined by the International Union for the Conservation of Nature and Natural Resources (1987) as the movement of living organisms from one area, with free release to another. Introductions are defined as the release of captive-born or wild-born animals to an area outside their original range (Kleiman 1989). Reintroduction is commonly used to define the translocation of animals of any origin into an area within their original range (Kleiman 1989). I prefer to use the term repatriation to define the process of restoring populations of animals into their original, unoccupied range (Reinert 1991).

Few bear repatriation efforts have occurred, fewer have been successful, and fewer still have been adequately documented. As a result, there are no clear protocols to follow. However, a review of the methods, successes, and failures associated with past repatriation and translocation attempts should increase the chances for success of future repatriation attempts. Most commonly, bear translocation efforts have been associated with the capture and subsequent relocation of nuisance bears to areas where they are less likely to resume problem behavior. Success of such programs is precarious and often results in increased mortality and decreased survival (Feis et al. 1986, Rogers 1986, Stiver 1991, Comly 1993, Riley et al. 1994, Blanchard and Knight 1995). The black bear has a powerful homing instinct and bears have been known to move great distances to return to their original home range following such relocations (Rogers 1973, 1987, Beeman and Pelton 1976). Physiographic barriers (McArthur 1981) and translocation

distances (Alt et al. 1977, Rogers 1986) have been found to influence the ability of bears to return to their place of origin. Numerous studies have identified an inverse relationship between the distance a bear is translocated and the probability the bear will return home (Beeman and Pelton 1976, Singer and Bratton 1980, McArthur 1981, Fies et al. 1987). Rogers (1986) suggested that a translocation distance >64 km was effective in reducing the homing ability of translocated bears. Brannon (1987) found that translocations of adult female grizzly bears with young were more successful than moving adult females without young in preventing further nuisance activity. Furthermore, he found that older bears were more likely to return than younger bears, and adults returned more than subadults. Also, regardless of nuisance history, male bears generally exhibit more widespread movements than females (Alt et al. 1980, Reynolds and Beecham 1980, Pelchat and Ruff 1986) and males typically demonstrate stronger homing ability than females (Fies et al. 1987, Comly 1993). Comly (1993) found that translocated nuisance female bears with cubs did not leave release areas and subsequently established home ranges in the new area.

Griffith et al. (1989) conducted a survey of bird and mammal translocations to determine factors associated with success and suggested guidelines for future efforts. Wolf et al. (1996) conducted a follow-up study to that of Griffith et al. (1989) to reassess the factors associated with successful translocation. Both found that translocations of native game species were more successful than those of threatened or endangered species, animals released into the core of their former range in excellent habitats were most successful, long-duration programs were more successful than those that were short in

duration, and wild-captured animal translocations were more successful than those of captive-raised animals. Whereas Griffith et al. (1989) predicted that omnivore (they included bears in this category) translocations were less successful than those of carnivores and herbivores, Wolf et al. (1996) found that translocations of species with omnivorous food habits were more successful than those of carnivores or herbivores. Based on theoretical considerations, Griffith et al. (1989) predicted that translocation success would be enhanced if the number of released individuals (founders) was high, there was high genetic variability, the rate of population increase is high with low variance, the effect of intraspecific competition is low, there is low environmental variation, and there are refugia. Unfortunately, bears fail on almost all counts: population growth is low with high variance, there is great environmental variation (e.g., annual fluctuations in acorn production), and they may have low genetic variability relative to their population size (Manlove et al. 1980, Wathen et al. 1985).

The most successful bear repatriation effort took place in Arkansas, where 254 black bears from Minnesota and Manitoba, Canada were stocked into unoccupied range within the Ozark and Ouachita mountains. This translocation project began in 1958 and continued through 1968, until high costs of translocation and public concern about the presence of bears made continued efforts impractical (Rogers 1973). The population increased to >2,500 animals in a 30-year period (Smith and Clark 1994). Factors that contributed to the success of that project include the use of wild-captured bears, the elimination of former extirpation factors, release into prime habitats within former range, multiple release sites, and release of sufficient numbers of animals over several years.

Although this effort resulted in a viable population of bears, it was performed clandestinely with little or no public input and little critical data were collected regarding the specifics of early releases (Smith and Clark 1994). Furthermore, post-release movements were extensive and mortality was high (Rogers 1974, Smith et al. 1990).

At the same time that Arkansas officials were repatriating bears to their state, Louisiana attempted to augment dwindling bear populations in the Tensas River area and the Atchafalaya Basin (Smith and Clark 1994). Louisiana translocated 161 bears from Minnesota. The failure or success of this augmentation effort has not been established. There is some concern that breeding took place between the Minnesota bears (*U. a. americanus*) and native Louisiana bears, thereby affecting the genetic integrity of native Louisiana bears (Pelton 1991). Consequently, it is not clear whether today's Louisiana bears are remnant native stock, repatriated Minnesota bears, or some mixture of the two. The U.S. Fish and Wildlife Service (USFWS) has since listed the Louisiana black bear (*U. a. luteolus*) as threatened (Fed. Register 1992).

Arkansas and Louisiana translocation techniques were both based on a hard release method whereby animals are captured, transported, and released at a new site without a period of acclimation (Griffith et al. 1989). Hard releases typically result in significant animal movements (Alt et al. 1977, Rogers 1973, McArthur 1981), as was the case in Arkansas and Louisiana.

Pennsylvania augmented a sparse population of black bears in the southwestern portion of that state. Their strategy involved closing the hunting season in the area between 1977 and 1984 and translocating 72 bears (22 adult females, 25 cubs, 1 yearling,

and 24 cubs born to females within 30 days of relocation; G. Alt, Penn. Game Comm., unpubl. rept.). A dramatic increase in average harvest by hunters was detected after completion of the restoration project. Prior to augmentation, harvests for the area averaged 4.0 bears/year; after augmentation, harvests averaged 111.0 bears/year. The success of this effort was influenced by the use of wild bears (no history of nuisance activity); closure of the hunting season for ≥5 years; and relocating hibernating, pregnant females or females with cubs. Furthermore, they discovered that separating cubs from mothers during translocation increased the chance of cub abandonment after relocation.

In summary, it appears that the success of a bear repatriation effort could be enhanced by removal of former extirpation factors, release into adequate habitat, the use of wild-captured bears, the use of adult females with cubs or subadult bears, increased translocation distance, better public awareness and involvement, and genetic considerations that prevent loss of genetic diversity and ensures the adaptability of released animals to the new area. Also, it is important to adequately monitor the repatriated animals to measure the success of population establishment, quantify factors that influence success, and assess or prevent conflicts (Stanley Price 1991, van Manen 1991).

History of the Big South Fork Project

Black bears were present in the Big South Fork area (BSFA) of Kentucky and Tennessee until the turn of this century, when the last one was reportedly killed in the vicinity of No Business Creek (Smith 1985). Like many other areas of the southeastern

United States, extirpation of bears in BSFA has been attributed to unregulated harvest of bears and habitat loss. Acquisition of much of the area by the U.S.D.A. Forest Service (USFS-Daniel Boone National Forest) and the U.S.D.I. National Park Service (NPS-Big South Fork National River and Recreation Area) has led to recovery of the habitat for bears.

In 1987, the Tennessee Bear and Boar Hunters Association approached the Tennessee Wildlife Resources Agency (TWRA) about investigating the possibility of reestablishing black bears to BSFA. TWRA contacted NPS and, based on its philosophy of restoring extirpated native species to their historic ranges and conserving genetic diversity (United States Department of the Interior 1990*a*), the NPS agreed to work with TWRA to explore the feasibility of such a proposal. A working group consisting of Kentucky Department of Fish and Wildlife Resources (KDFWR), USFS, TWRA, NPS, USFWS, and the University of Tennessee (UT) representatives was formed to address the reintroduction proposal. This working group decided that a habitat suitability study to evaluate bear habitat quality at BSFA be undertaken.

The habitat suitability study was performed by researchers from UT and completed in 1990. Researchers concluded that BSFA could support black bears (van Manen 1990). Summer and fall food production, although not optimal, appeared adequate to support a resident bear population. Furthermore, food production was expected to improve within the next 5-10 years as the second-growth forest matured and hard mast production increased. Also, escape and denning cover was found to be

adequate. Some concern remained about the potential for human-bear conflicts and road density on the area.

Whereas the habitat appeared to be adequate to support bears, many biological and social changes had taken place since bears last inhabited BSFA. As a result, the working group remained concerned about how black bears and the human inhabitants of the area would interact. These managers also needed information about how to restore bears from a logistical standpoint. The working group decided to consider an experimental repatriation under controlled conditions to determine whether reestablishing a black bear population is biologically and socially feasible. Furthermore, the question remained of how might repatriation be accomplished.

Technical Considerations

The black bear has a powerful homing ability (Rogers 1973, 1987, Beeman and Pelton 1976). Successful translocation into unoccupied areas cannot occur without the implementation of sound techniques that limit the homing ability of bears. Wildlife releases have been characterized as hard or soft. Soft releases are translocations to a new area followed by a short period of acclimation prior to release (Griffith et al. 1989). In contrast, hard release methods involve capturing, transporting, and releasing animals to a new site without a period of acclimation (Griffith et al. 1989). Hard releases have been the primary method applied in nuisance bear capture and release programs and typically result in significant animal movements (Alt et al. 1977, Rogers 1973, McArthur 1981). Therefore, hard release methods are not ideal for repatriation. It has been suggested that a

soft release, consisting of a short period of acclimation, may help curb the homing ability of bears. This theory has not been well tested or documented in bears; however, Rogers (1973) reported that food troughs were placed at some release sites in Arkansas and were used to some extent by bears. Benefits of soft versus hard releases are better documented for the red wolf (*Canis rufus*). Phillips and Parker (1988) attributed the success of red wolf repatriation in the southeastern U.S. to the use of a soft release involving a 6-month acclimation period of captive-bred wolves.

One variation of the soft release concept for bears is the capture, translocation, and subsequent release of hibernating bears during the winter. The technique was tested in Pennsylvania (G. Alt, Penn. Game Comm., unpubl. rept.). With this method, bears are trapped, radio collared, released on site in the summer and tracked to their winter dens. During winter, the bears are tranquilized, removed from the dens, transported to the new area, and placed in natural dens if possible. This technique is thought to be most effective for pregnant females or females with cubs. The premise of this technique is that the bear cannot immediately return to its place of origin because it must den to give birth and/or care for cubs. Upon den emergence in the spring, the bear's movements are restricted because of the presence of cubs, tender footpads, and limited availability of spring foods. Also, the time spent denning in the new area may serve as an acclimation period.

The working group limited the sample size for the experimental repatriation to 14 adult bears. I translocated only adult female bears into BSFA. As stated above, females and young bears are less predisposed to homing. Additionally, because bears are a polygamous species, the establishment of females into the area would increase the

population growth potential. Occasional bear sightings have been reported in and around BSFA. Because no sightings of females with cubs have been confirmed, these sightings, if accurate, are likely the result of subadult males dispersing from the mountains of Virginia and West Virginia and moving through the area. Therefore, there may be male bears in the area and the translocation of adult male bears could be unnecessary. Only wild-trapped bears with no history of nuisance behavior or human habituation were translocated to prevent occurrences of nuisance behavior. My objective was to compare 2 soft-release techniques at BSFA. The first was a winter-release technique involving the translocation of denning bears and the second was a summer-release technique involving an acclimation period whereby summer-captured bears are held in a pen and fed prior to on-site release.

To answer these and other questions, my study began in 1995 to experimentally release black bears into BSFA. Specifically, the objectives of this study were to:

1. Test the null hypothesis that release method has no effect on the homing ability, dispersal rates, or mortality rates of translocated bears;
2. Assess habitat use by bears based on the 1990 habitat study;
3. Evaluate the effects of bear-human interactions and document any damage to local landowners; and
4. Assess the feasibility, methodology, approach, and probability of success of releasing bears to establish a permanent, viable population at BSFA.

CHAPTER 2

STUDY AREA

The Big South Fork River basin includes the Big South Fork of the Cumberland River and 3 major tributaries: the Clear Fork, the New River, and the Little South Fork. The Big South Fork is formed by the confluence of the Clear Fork and the New River and is the third largest tributary to the Cumberland River. The river basin lies in the southeastern part of Kentucky and north-central Tennessee (Fig. 1).

The study area encompasses part of Stearns Ranger District of DBNF in Kentucky and the Big South Fork National River and Recreation Area (BISO) of Kentucky and Tennessee (Fig. 1), totaling around 780 km^2. The study area boundaries are defined by the BISO and that portion of DBNF southeast of the Little South Fork River. In Kentucky, Wayne and McCreary counties partially lay within the study area as do Fentress, Morgan, Pickett, and Scott counties in Tennessee.

Beyond the study area boundaries, extensive forest habitat lies at the northern (primarily DBNF) and partially at the western (Pickett State Park, Tennessee) part of the area. The areas to the east and south of BSFA mainly are used for agriculture. Many small towns and communities occur relatively close to the entire east and south boundaries. However, the 194-km^2 Royal Blue Wildlife Management Area in Tennessee lies 40 km east of BSFA and represents potential bear habitat.

The climate of the study area is influenced by moist air masses from the Gulf Coast Region, which are brought in by predominantly southerly and westerly winds

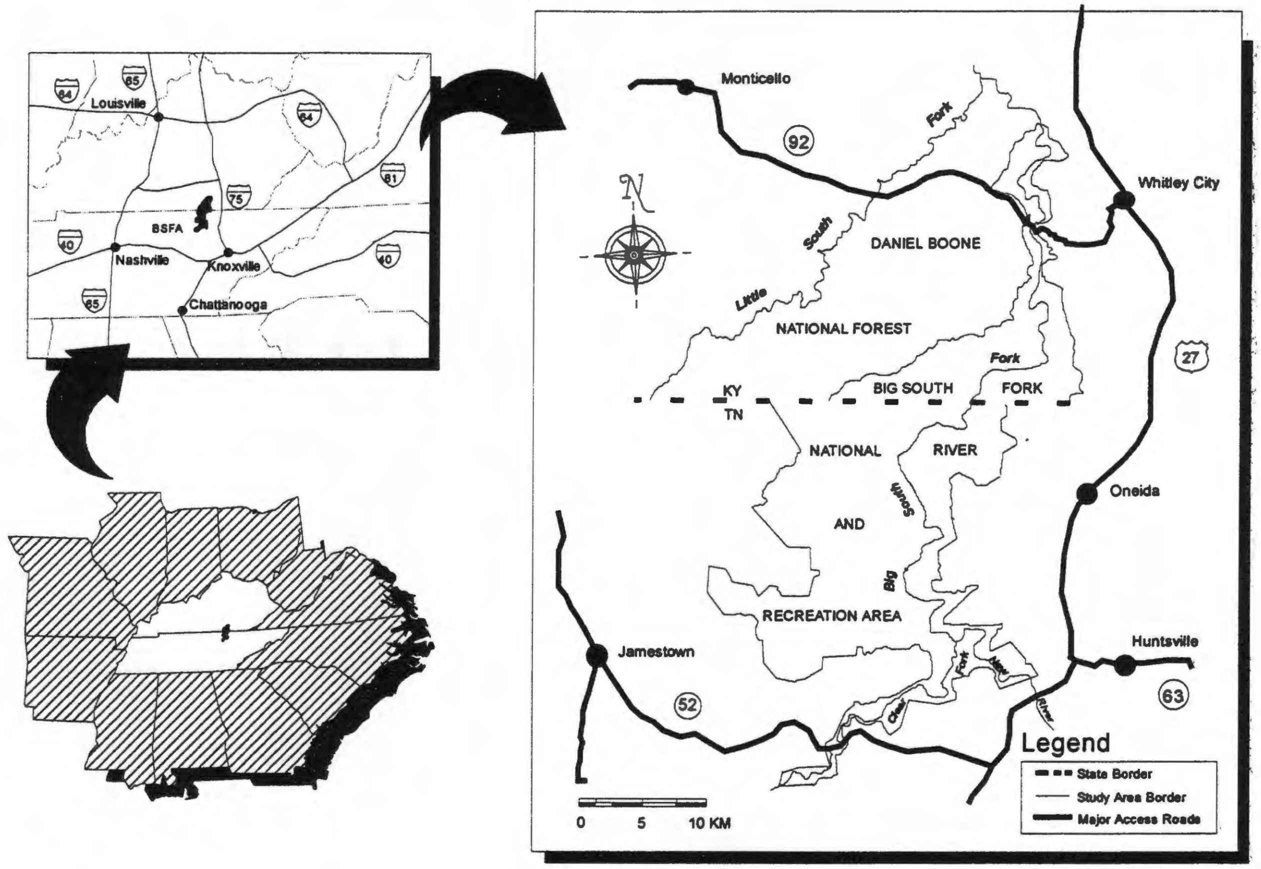

Fig. 1. The Big South Fork Area of Kentucky and Tennessee.

(USACE 1975). Long, moderately hot summers and short, mild to moderately cold winters describe the climate of the region (Smalley 1986). The climate of BSFA is classified as humid mesothermal with little or no water deficiency (Thornthwaite 1948). Annual precipitation is approximately 127 cm (National Oceanographic and Atmospheric Administration [NOAA] 1978). The fall generally is the driest season and spring the wettest. Mean temperatures may range from –1° C to 10° C in January and from 19° C to 32° C in July (NOAA 1978). The mean number of frost-free days is 179 (NOAA 1978). Locally, precipitation and temperature regimes may differ considerably due to topography (Smalley 1986). Snow mostly occurs between November and March averaging about 22.5 cm or 15 days annually (Clark 1985) and seldom remains on the ground for more than a few days.

The study area largely lies within the Mid and Northern Cumberland plateau regions of the Appalachian Plateau Physiographic Province that extends from New York to northern Alabama (Thornbury 1965, Smalley 1986). As a result, some topographic differences occur between the southern and the northern part of the study area. The rock formations are elevated and dissected such that the landforms are in large part mountainous.

The topography of the study area is characterized by long, narrow to moderately broad ridgetops, steep sideslopes and narrow to moderately broad valleys; ridges appear to be more broad and gently rolling in the southern part of the study area (Smalley 1986). Average elevation is approximately 460-520 m in the south and southeastern part of the study area and gradually decreases to 365-425 m in the northern part. Relief also

gradually changes from approximately 180 m in the south to 150 m in the northern part of the study area. Average elevation of the major streams within the area is approximately 215-245 m. The highest point in the River Basin is 1077 m; the lowest point, 205 m, is where the river empties into Lake Cumberland (USACE 1975).

BSFA is mainly underlain by sedimentary rocks of the Pennsylvanian and Mississippian periods consisting of alternating beds of sandstones, conglomerates, clayey to sandy shales, coals, and siltstones (Wilson et al. 1956, Swingle et al. 1966). Arches, bluffs, caves, and various other rock formations are common. Major mineral resources of the BSF basin are coal, petroleum, and natural gas which are primarily found in the Mississippian Rocks (USACE 1975).

The great diversity of environmental conditions in BSFA creates a variety of habitats which is reflected in the relatively high plant diversity. Cold air currents and high moisture availability on the north-facing coves and slopes is a contrast to conditions on warmer, arid plateau tops (USACE 1975). Several rare, threatened, and endangered plant species can be found within the area (USACE 1975, Knowles et al. 1990). More than 525 species of vascular plants were found in BISO (USACE 1975).

Braun (1950) classified the forests of this area within the mixed mesophytic forest region. Recent studies, however, suggested that the mixed mesophytic forest classification only applies to protected sites on the rich soils of the escarpment slopes, coves, and deeper ravines (Hinkle 1989). Safley (1970) described 22 different forest types within BSFA with white oak (*Quercus alba*) as the most frequent species.

Forest management differs greatly between the DBNF and BISO. The forest vegetation in DBNF is actively managed for multiple use and there is relatively high flexibility in the overall management scheme (USFS 1985). Forest management to benefit wildlife resources is implemented through the use of Management Indicator Species (USFS 1985). In contrast, NPS management policies only allow minimal forest management on BISO; the removal of timber is only permitted for development or maintenance of historic, public use, and administrative sites (USDI 1990*b*). Although not specifically stated, vegetation management to benefit wildlife on the BISO essentially is restricted to maintenance of the open character of historic sites.

The high diversity of vegetation and habitat components form the basis of high faunal diversity. The terrestrial fauna of the area also shows a mixture of northern and southern species (Knowles et al. 1990). Game species include: white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), feral hog (*Sus scrofa*), gray squirrel (*Sciurus carolinensis*), ruffed grouse (*Bonasa umbellus*), mourning dove (*Zenaida macroura*), bobwhite quail (*Colinus virginianus*), woodcock (*Philohela minor*), and turkey (*Meleagus gallopavo*). The feral hog population is increasing and is mainly found on the west side of the river (Clark 1985). Open abandoned mine shafts throughout the study area provide excellent habitat for many species of bats (USACE 1983). The significance of the area for nongame animals is high; 47 species of amphibians, 41 species of reptiles, 253 species of birds, and 59 species of mammals are found in BISO alone (USACE 1975). Federally endangered species inhabiting or regularly visiting the

area are red-cockaded woodpecker (*Picoides borealis*) and Indiana bat (*Myotis sodalis*) (Knowles et al. 1990).

Locally, the aquatic fauna has been severely affected by acid drainage from abandoned coal mines; approximately 37 such mines have been located (USDI 1990). Several endemic mollusc and fish populations have been found in the Cumberland River and the Little South Fork of the Cumberland River (Knowles et at. 1990). Sixty-two species of fish have been reported within the BISO waters (USACE 1975).

Recreational opportunities in BSFA are diverse and plentiful. The combination of extensive forests, mountains, scenic views, deep river gorges, waterfalls, rock shelters, caves, and the wide variety of flora and fauna creates exceptional recreational opportunities. An increasing number of people visit the area for sight-seeing, hiking, bicycling, camping, picknicking, canoeing, rafting, hunting, fishing, and nature observation (Peine et al. 1995).

CHAPTER 3

MATERIALS AND METHODS

Public Support

Local support for repatriation efforts is central to success (Mech 1979, Reading and Kellert 1993). Prior to the initiation of this experimental release, TWRA and NPS conducted a series of public meetings for the purpose of informing and educating the public about the experimental release and to disseminate factual information regarding bear biology and behavior (Clarence Coffey, TWRA, pers. comm.). Furthermore, before any bears were translocated to BSFA, an environmental assessment was prepared and additional meetings were held to update the public about the status of the project and to address public concerns. Peine et al. (1995) conducted an exit survey of 1,556 visitors to BISO. Results of that survey indicated that 76.9% of participants were in favor of bear restoration to the area; 8.3% were opposed. Among local visitors, 60.6% were in favor of bear restoration in BISO; 17.0% were opposed. Of the non-local visitors, 80.8% were in favor of bear restoration and 5.8% were opposed.

Capture and Handling

Griffith et al. (1989) found that animals from a source population that is stable or expanding are more likely to become successfully reestablished. Source populations should be genetically similar to the extirpated population to ensure adaptability to the new area and to prevent loss of genetic diversity (Fellers and Drost 1995). Considering the

above criteria, the Great Smoky Mountains National Park (GRSM) was chosen as the source population.

Black bears were trapped in GRSM using spring-activated foot snares as described by Johnson and Pelton (1980). Foot snares were equipped with swivels and automobile hood springs to prevent injury to bears. Trapping was conducted from May through August in 1995 and 1996 to obtain a sample of bears for potential repatriation in winter. Trapping was conducted from May through August 1996 to obtain the summer-released bears.

Bears were immobilized with a mixture of ketamine hydrochloride (Ketaset, Bristol Lab., Syracuse, N.Y.), xylazine hydrochloride (Rompun, Haver-Lockhart, Inc., Shawnee, Ks.), and mepivicaine hydrochloride (Carbocaine V, Winthrop Lab., New York, N.Y.) (KRC). Concentrations of each drug were as follows: ketamine hydrochloride at 400 mg/kg; xylazine hydrochloride at 200 mg/kg; and mepivicaine hydrochloride at 20 mg/kg. The drug was delivered intramuscularly at a dosage of 1 ml/22.7 kg (50 lb) of estimated body weight. KRC was administered to the bear by push pole or dart pistol (Palmer Chemical Co., Douglasville, Ga.).

While immobilized, an optical wetting solution (Akwa Tears, Bausch & Lomb Pharmaceuticals Inc., Tampa, Fl.) was applied and a cloth was placed over the eyes to reduce stress and prevent ocular damage from debris. All captured bears were ear tagged, tattooed in the lip and groin area, sexed, weighed, and measured. A premolar tooth was extracted from each bear for age determination. Teeth were sectioned, prepared, and

stained according to techniques described by Eagle and Pelton (1978). Age was determined from cementum annuli counts (Willey 1974).

Bears that showed vaginal swelling or pinkish vaginal discharge were classified as being in estrus (Wathen 1983). Bears that were in estrus or not lactating during the summer trapping were prospective candidates for winter translocation and were fitted with MOD-500 radiocollars (Telonics Inc., Mesa, Az.) equipped with break-away spacers.

Translocation Techniques

I tested 2 techniques designed to limit post-release movements of translocated bears. Both techniques are based on the concept of a soft release.

The first technique involved removing pregnant bears or females with cubs from their winter dens in GRSM, transporting them to BSFA, and placing them in pre-selected den sites, lined with straw. To accomplish this, female bears were trapped during summer, fitted with radiocollars, and released on site in GRSM. Bears that were likely pregnant were then tracked to their winter dens. Accessible bears were tranquilized and removed from their dens. Because motorized vehicle access is prohibited in backcountry areas of GRSM, tranquilized bears were carried from backcountry den sites in a Ferno 71-S plastic basket stretcher with tire (Ferno Washington Inc., Wilmington OH) to the nearest paved road. While in the stretcher, bears were wrapped in a sleeping bag to maintain adequate body temperature. Bears were placed in a straw-lined transport cage and transported to BISO by a camper-topped truck. If cubs were present, the cubs were

carried from the backcountry to the transport cage and placed in the cage with the mother. Mentholated salve was applied to cub's bodies and to the adult bear's nose to hide human scent; this was done to prevent cub abandonment by the mother. Upon arrival at BISO, bears were re-immobilized and transported to backcountry sites using the same techniques as during extraction from GRSM. Bears were placed in remote rock shelter dens lined with straw. Again, mentholated salve was applied to bears to prevent cub abandonment.

The second technique involved trapping additional bears during the summer in GRSM and transporting them to BISO. Bears were trapped in remote back-country areas of GRSM and hand-carried with a stretcher, as described above, to the nearest paved road. Bears were loaded into a transport cage on a truck and transported to BISO. Two 5-m (18 ft) diameter, circular, steel acclimation pens were constructed at a remote site in BISO. Bears were held in each of the 2 cages for an acclimation period of 2 weeks. Pens were modified corn cribs (Behlen Mfg. Inc., Omaha, NE) and are commonly used to house bears and other animals. While the bears were held in the pens, they were fed and watered by humans. I attempted to minimize the possibility that the bears would become habituated to humans by minimizing contact and through negative reinforcement by periodic tranquilization and work-up procedures. Bears were fed commercial dog food during acclimation. After acclimation, each bear was released by opening the door to the pen. Food was left at the release site for 3-4 days to increase site affinity.

Radiotelemetry

Translocated bears were radio located approximately once each day for the first 2 weeks post-release for summer-released bears and upon den emergence for winter-released bears. Telemetry was performed using a Telonics TR-2 receiver (Telonics, Mesa, Arizona). Radiolocations were gradually reduced to approximately 2 locations per week for each bear.

The rugged, inaccessible terrain, coupled with extensive movements of some translocated bears, required most locations be obtained by airplane. H-antennas (Telonics, Mesa, Arizona) were attached to each wing strut and connected with a cable through the cabin to a switch box and radio receiver. Locations were obtained by flying circles around the animal and decreasing the diameter of the circle by flying toward the loudest signal. When the aircraft was directly over the bear, the position was recorded with a global positioning system (GPS). Locations were plotted on 1:24,000 U.S. Geological Survey quadrangle maps using the Universal Transverse Mercator (UTM) grid system.

Ground telemetry was accomplished with 5-element Yagi antennas (Wildlife Materials Inc., Carbondale, Il.) using triangulation and the loudest signal method (Springer 1979). Three azimuths for each location were obtained and plotted on 1:24,000 U.S. Geological Survey quadrangle maps. Only azimuths that formed angles between 30° and 150° were utilized and a time interval between first and third azimuths of <50 min was maintained. If triangles formed by the 3 azimuths were >2 ha in size, those azimuths were rejected. These procedures helped identify spurious azimuths and significant animal

movement between observations (Schmutz and White 1990). For each estimated animal location, bear identification number, date, time (Eastern Standard Time), distance (m) from estimated location to observer, and UTM grid system coordinates were recorded.

Telemetry Error Analysis

To test the accuracy of estimated bear locations, radio collars were placed in locations that were topographically similar to conditions found at actual bear locations. The location of each test radiocollar was unknown to the observer being tested. Test locations were obtained throughout the study in 1996 and 1997. Test collars were located using the same procedures described above. Actual locations of test collars were obtained with a GPS and differentially corrected. The distance from the actual location to the estimated location was calculated to obtain an error distribution (Schmutz and White 1990, Clark 1991).

Movements

Because of the importance of post-release movements, I intensively monitored the distance moved immediately after each bear was released or emerged from the den. Den emergence was determined by radio telemetry. Denning bears were checked for activity or movements 3-5 times/week to determine date of emergence. Mean daily movement was calculated by dividing the total movement by the number of days the bear required to move that distance. Net movement was determined by calculating the straight line distance between the starting point and the ending point. I determined circuity by

dividing the net movement by the total movement. Circuity is a measure of the linearity of an animal's movement with values ranging from 0 and 1. A value of 0 indicates the animal returned to its starting point, or never left it; a value of 1 indicates the animal moved directly away from its starting point. Total distance moved was calculated with the MOVEMENT module (Hooge et al. 1999) in ArcView (Environmental Systems Research Institute, Inc., Redlands, Ca.). I compared movement parameters for each release method using the Wilcoxon signed-rank test.

I performed a site fidelity test with the post-release movements of translocated bears with the MOVEMENT module in ArcView. The site fidelity test compares the observed movement pattern against a random distribution of movement angles. This test uses a Monte Carlo simulation and parameters from the original data to determine if the observed movement pattern belongs to 1 of 3 categories: more site fidelity than would occur randomly (constrained movements), represents a random pattern, or is more dispersed than random. I applied the test to bear post-release movements after the first 2 weeks, the first 6 months, and first year. I chose these time intervals in an effort to determine when, or if, site fidelity would occur among translocated bears and between release techniques.

I applied the multi-response permutation procedure (MRPP) to the movements of bears that established themselves in BSFA, regardless of release technique, to determine if movements became more concentrated as they adjusted to the release area. The concentration of movements over time could indicate a shift from exploratory movements to home range establishment. Movement data for each bear was divided into 3-month

periods. Comparisons were made between the 0- to 3-month set of movements and the 3- to 6-month set of movements for each resident bear. Then, I compared the 3- to 6-month movements to the 6- to 9-month movements for each resident bear. MRPP tests were performed with program BLOSSOM (Midcontinent Ecological Science Center, USGS/BRD). MRPP is a distribution free statistical procedure that tests the null hypothesis (H_o= no difference between groups) based on permutations of the data instead of an assumed population distribution. Permutation procedures make efficient use of small sample sizes because probabilities are calculated exactly and there is no reduction in degrees of freedom because no parameters are estimated.

Survival

Because bears were added to the population at BISO at different times within a year, I estimated survival using the Kaplan-Meier staggered entry procedure (Pollock et al. 1989). Survival was estimated by

$$\hat{S}(t) = \Pi(1 - d_j/r_j)$$

$$j/a_j < t,$$

where $\hat{S}$ is estimated survival, a_j is the time of death, d_j is the number of bears that died at time a_j, r_j is the number of bears at risk at time a_j, and t is the time interval. I considered the product of all j terms for which a_j<the time t. An estimate of variance (var) is

$$\text{var}(\hat{S}[t]) = [\hat{S}(t)]^2[1 - \hat{S}(t)] / r(t).$$

Assumptions of the Kaplan-Meier procedure are that all bears monitored for survival were randomly sampled, survival times were independent among bears, capturing or radio-collaring did not influence survival, censoring mechanisms were random, and newly radio-collared bears had the same survival function as previously radio-collared bears (Pollock et al. 1989). Although I targeted female bears for translocation, my sample was randomly drawn from all female bears in the northwestern quadrant of GRSM.

I compared survival between the 2 release methods for the first year post-release using the means and variance of the 2 survival rates by calculating a *Z* statistic (Pollock et al. 1989). I considered all tests significant at $P \geq 0.05$. I also estimated overall survival for all translocated bears for the duration of the study.

Some bears were not monitored for the duration of the study because of dropped radio-collars or loss of radio contact; therefore, they were censored at the time contact was lost (Pollock et al. 1989). Bears that permanently left the area were treated as mortalities for the purpose of this analysis because they did not become established at BSFA.

Bait-Station Survey

I initiated a bait-station survey in BISO after bears were translocated to the area. Bait-station routes at BISO were mostly limited to ridgetops with roads or trails (Fig. 2). Nine routes consisting of 101 bait sites were established along 80.8 km (50.5 mi) of roads

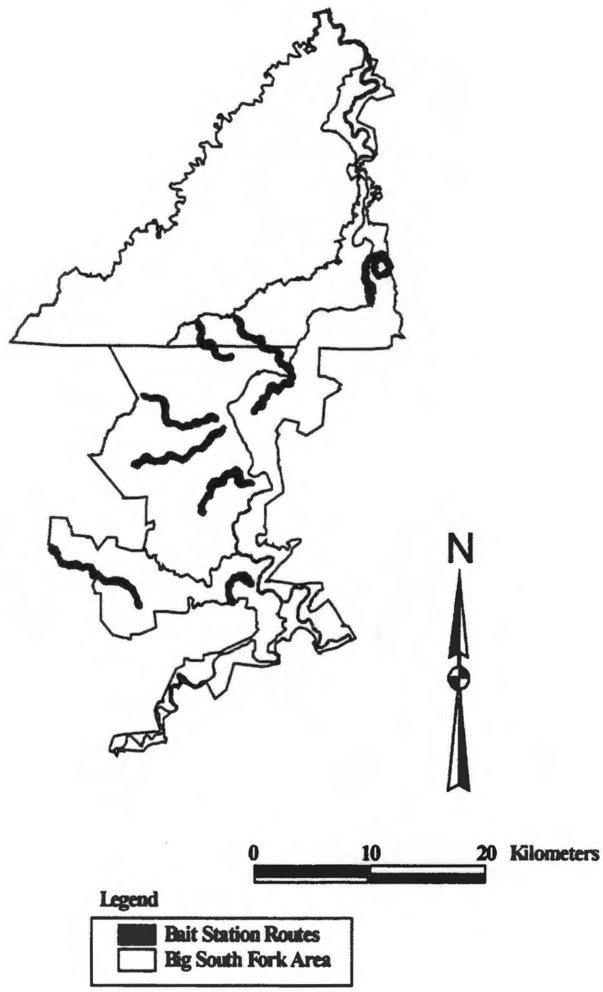

Fig. 2. Bait station routes in the Big South Fork National River and Recreation Area, Kentucky and Tennessee.

or trails in BISO according to protocols established by Johnson (1992). Baits were placed at approximately 0.8-km (0.5-mi) intervals. Distance between bait stations was determined by odometer on vehicles or by stopwatch when horses or all terrain vehicles (ATV) were used. The rate for ATV was 2-3 minutes/0.8 km, depending on the severity of the terrain. The rate on horseback was 4.5 minutes/0.8 km. Individual baits consisted of 3 partially opened cans of sardines placed approximately 3 m (10 feet) above the ground with string. Baits were placed into the forest away from the road or trail. Bait sites were marked at the road or trail with flagging to aid in bait recovery. At the site, data regarding overstory vegetation, understory vegetation, elevation, and topography was recorded.

Baits were checked 5 days after establishment. Evidence of a bear visit was determined by tooth marks on sardine cans, presence of bear scat, or claw marks on trees. I recorded whether the baits were visited by bears, other animals, or untouched.

While bait sites were established, I monitored the locations of radio-collared bears. Confirmation of bears other than those translocated to BISO could be attained if a bait had been visited by a bear in an area where radio-collared bears were known not to be present.

Den Visits

Translocated bears that remained in the study area were visited during February and March of 1997 and 1998 in their winter dens. The objective was to determine the condition of the translocated bears, determine yearling survival, determine if any natural

reproduction had occurred, and obtain cub counts. Natural reproduction would confirm the presence of adult male bears in the area. I immobilized adult females in the den, weighed them, and repaired or replaced radio collars.

Sightings and Human-Bear Interactions

Interactions between humans and bears were documented by NPS personnel. Incidences of nuisance bear behavior, property damage reported by local landowners, and sightings of bears by local citizens and visitors was recorded.

Population Modeling

I used a population model developed for polar bears (*U. maritimus;* Taylor et al. 1987*a*, 1987*b*) and adapted for black bears to estimate population growth and probability of extinction of translocated bears. The model is a mathematical simulation of black bear life history which incorporates age-specific survival and recruitment rates, population size, stable or standing age distributions, harvest rates (if applicable), and can be run deterministically or stochastically. The model was based on the following population parameters: cub survival, litter survival, subadult male and female survival, adult male and female survival, litter production rate, and the probability of producing 1-, 2-, 3-, and 4-cub litters. I used the adult female survival estimate from this study in the model. I estimated the remaining parameters based on black bear population studies in GRSM (Coley 1995) and Arkansas (Clark 1991). I increased the population parameters during the second year of the simulation to achieve stable population growth (i.e., growth rate

≥1.0). I did this to represent the probable increase in survival and reproduction that likely would occur as bears become more established in the colonizing population. I performed simulations under 8 different stocking scenarios, all starting with the 1998 standing age distribution. I added 6 adult female bears with a total of 12 cubs for 1999 (a standard stocking based on past experience) to provide the model with a sufficient standing age distribution to perform the simulations. I examined the various scenarios to determine the most efficient and timely way to establish a population of bears in BSFA. I performed one deterministic simulation for each scenario to estimate mean population growth. I then ran 50 stochastic simulations for each scenario to estimate variability in growth based on the variability of my population parameter estimates. I determined the probability of extinction with each scenario by the determining the percentage of the 50 stochastic simulations that resulted in extinction. The standard deviation for each scenario was calculated in Excel 5.0 from the 50 stochastic simulations. I then calculated the 95% confidence interval for each year of each scenario. I did not include density-dependent effects into the model.

Habitat Analysis

Johnson (1980) described the hierarchical nature of habitat selection. First-order selection was defined as the selection of the physical or geographic range by a species. Second-order selection pertains to the choice of a home range within the geographic

range. Finally, third-order selection involves the use of habitat components within the home range.

van Manen (1990) partitioned the BSFA into 5 sections and assigned a Habitat Suitability Index (HSI) value to each section to evaluate the habitat suitability for bears (Fig. 3). I investigated the effect of habitat quality, as determined by van Manen (1990), on second- and third-order selection by translocated bears. I used compositional analysis (Aebischer et al. 1993) to test the hypothesis that bears would disproportionally utilize the section or sections with the highest HSI values. Compositional analysis uses log ratios of use versus availability with a multivariate analysis of variance to compare sections. Sections are ranked relative to each other. I excluded all UTM locations that were within 3 months post-release to exclude exploratory movements. I then used the remaining UTM locations of all bears that established residence in BSFA. The widest portion of BSFA is approximately 25 km; the length of BSFA is approximately 45 km. Some translocated bears made movements >100 km in length immediately after release. Because of extensive movements by some translocated bears, I assumed that the entire BSFA was available to all bears. I determined the proportion of the study area that each of the 5 sections occupied to determine availability. I then determined the percentage of bear locations that occupied each of the 5 sections and performed the compositional analysis.

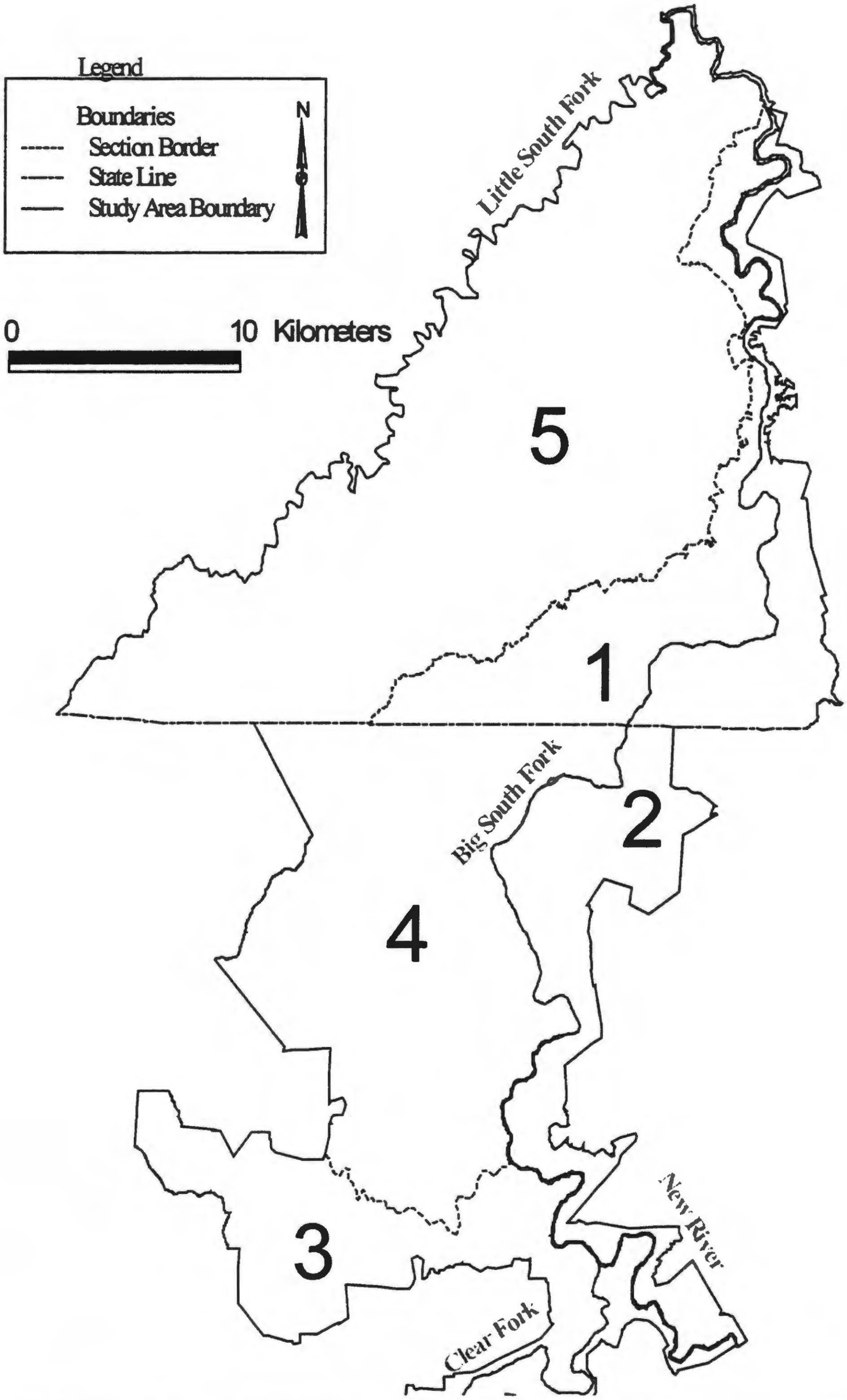

Fig. 3. Habitat study area sections of the Big South Fork Area, Kentucky and Tennessee as described by van Manen and Pelton (1997).

CHAPTER 4

RESULTS

Translocations

I translocated 14 adult female black bears approximately 160 km from GRSM to BISO (Fig. 4). Eight bears were translocated with the winter technique and 6 bears with the summer technique. Three adult female bears without cubs were translocated to BISO in January 1996. These 3 bears were assumed to be pregnant. In March 1996, 3 additional adult female bears with a cumulative total of 8 cubs were translocated to BISO. Two additional bears with a total of 5 cubs were translocated to BISO in winter 1997. From June-August 1996, 6 female bears were trapped in GRSM and transported to BISO and held for 2 weeks in the acclimation pens.

Telemetry Error

Two project personnel obtained 84 locations of test radiocollars from August 1996 through December 1997. Proportions of test locations by each observer approximated the proportion of bear locations each observer collected during the study. The mean distance between the estimated location and the actual location was 291 m (Fig. 5). Distance between estimated locations and actual locations ranged from 2–1,590 m. Ninety-five percent of the estimated locations were within 826 m of the actual location but 92% were <600 m from the actual location.

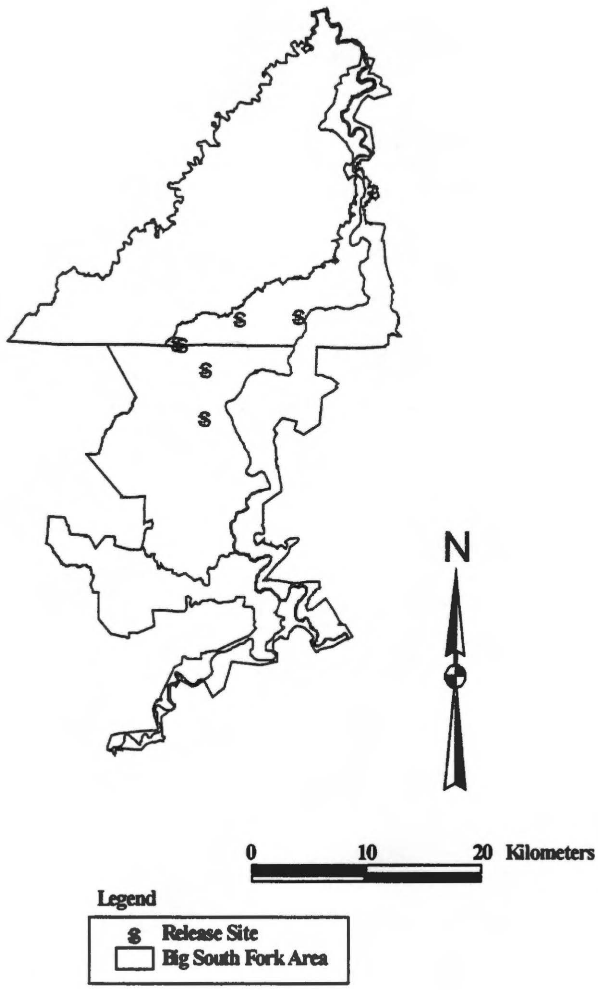

Fig. 4. Release sites of translocated bears in the Big South Fork Area, Kentucky and Tennessee, 1996-1997.

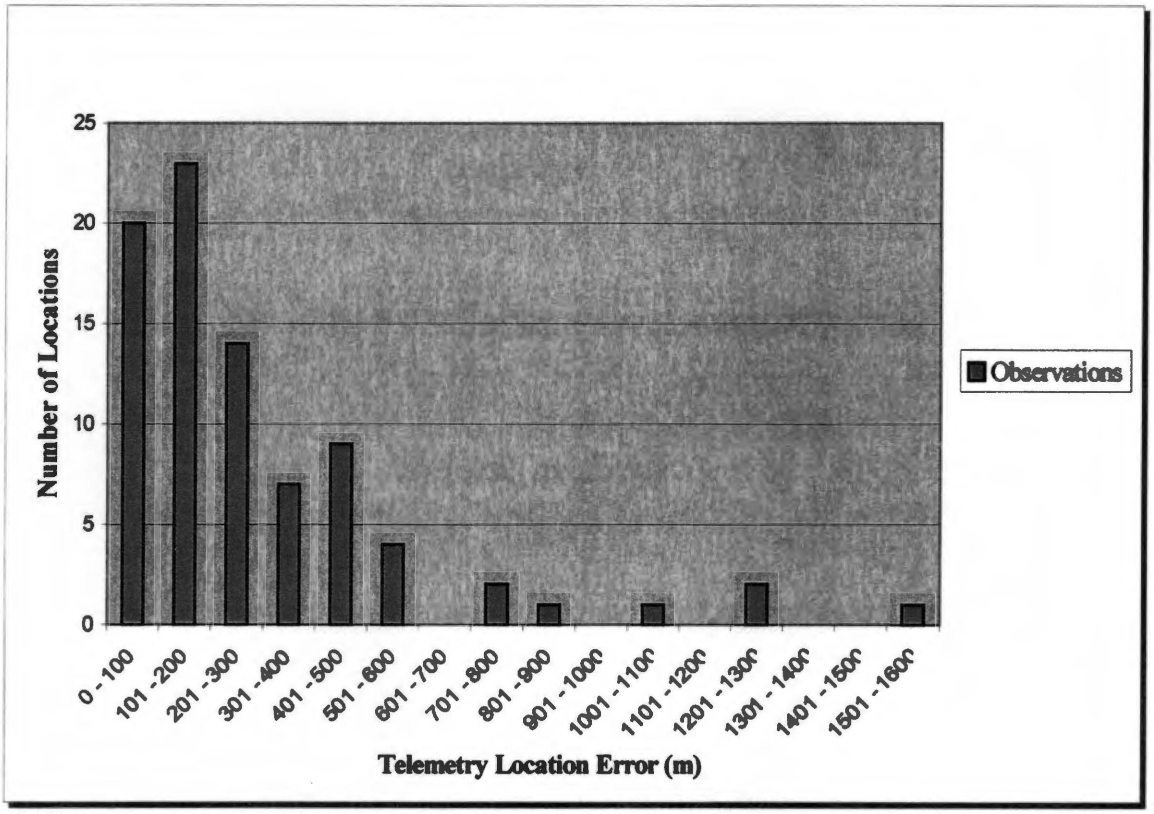

Fig. 5. Telemetry error distribution of 2 project personnel, Big South Fork Area, Kentucky and Tennessee, 1996-1997.

Movements

I monitored the fates and reproductive success of all repatriated bears (Table 1) and compared movements for the first 2 weeks post-release between 7 winter-released and 6 summer-released bears (Table 2). I confirmed that at least 1 of the 3 bears translocated in January gave birth to 3 cubs after translocation. One bear released in January died in the den. A necropsy performed at the University of Tennessee College of Veterinary Medicine revealed the cause of death to be a uterine infection, which was said to be unrelated to the winter translocation. All 7 remaining winter-released bears established home ranges within the study area (BISO and DBNF). However, 1 winter-released female attempted to return to GRSM after remaining in the area for >1 year. This female was placed in a den in BISO with her 3 cubs in 1996. She remained in the area until after the 1997 denning period. Soon after den emergence, she left BISO with her 3 yearlings, apparently in an effort to return to GRSM. The bear was allowed to travel until she was "treed" with her yearlings in a rural area north of Knoxville, Tennessee. She was subsequently "treed" again in a residential area of Knoxville without her yearlings. She was captured and relocated to a remote area of Cocke County, Tennessee by TWRA personnel. The fate of the yearlings was not confirmed; however, there were reports of the yearlings being killed while crossing railroad tracks.

Interestingly, the 3 pre-parturient bears that were translocated to BISO left the den sites where they were placed. All 3 bears re-denned within 1600 m of the release site in dens of their own choosing. In contrast, the 5 post-parturient bears remained in the dens we chose for them. In contrast to the winter bears, 5 of the 6 summer-released bears left

Table 1. Fates of black bears translocated to the Big South Fork Area, 1996-1997.

Bear	Release Date	Age at Release	No of Cubs	Fate as of November 1999
W-170	January 1996	14	0	Collar failed
W-910	January 1996	10	0	Died in den
W-790	January 1996	17	3	Dropped collar
W-780	March 1996	8	3	Dropped collar
W-030	March 1996	8	2	BISO resident
W-610	March 1996	12	3	Cocke Co. TN
W-130	March 1997	6	2	Dropped collar
W-990	March 1997	8	3	Collar failed
S-210	July 1996	7	0	Died
S-090	July 1996	6	0	Dropped collar
S-010	July 1996	14	0	GRSM
S-050	July 1996	3	0	Died
S-190	August 1996	8	0	BISO resident
S-110	August 1996	8	0	Died

Table 2. Two week post-release movements of black bears translocated to the Big South Fork Area, 1996-1997.

Bear	Total Movement (m)	Net Movement (m)	Average Daily Movement (m)	Circuity
W-170	15,857	7,900	1,133	0.19
W-790	4,262	1,662	304	0.39
W-780	42,577	13,588	3,041	0.32
W-030	24,183	13,183	1,860	0.55
W-610	17,834	949	1,274	0.05
W-130	2,039	369	185	0.19
W-990	21,105	11,696	1,919	0.55
S-210	86,992	79,116	66,992	0.91
S-090	10,367	7,266	3,456	0.70
S-010	128,014	113,966	4,267	0.89
S-050	12,305	1,079	947	0.09
S-190	24,702	21,055	4,117	0.85
S-110	163,286	158,063	10,886	0.97

the study area. However, 2 bears that left the area returned and established home ranges within BSFA.

The total movement during the first 2 weeks post-release for winter-released bears ranged from 2-43 km with a mean of 18 km (Figs. 6-12). The total movement during the first 2 weeks post-release for summer-released bears ranged from 10-163 km and the mean was 71 km (Figs. 13-18). I found no statistical difference ($Z = 1.357$, $P = 0.1747$) in total movements between the 2 groups. Two summer-released bears (S-090, S-190) left the study area within days of release and I lost contact with them (Figs. 16, 18). Therefore, the above test could be misleading because it is based on incomplete data for those 2 bears within their first 2 weeks post-release movements. To account for this, I substituted the highest total movement displayed by a summer-released bear (163,286 m) for the total movement of S-090 and S-190 and found a difference ($Z = 2.227$, $P = 0.013$) in total movements between the groups. I then substituted the mean total movement of summer-released bears (97,650 m) for the total movement of S-090 and S-190 and again found a difference ($Z = 2.217$, $P = 0.013$) in total movements between the groups.

The average daily movement for summer-released bears ranged from 947-10,886 m with a mean of 5,061 m. The average daily movement for winter-released bears ranged from 185-3,041 m and the mean was 1,388 m. A difference in average daily movements was detected between the 2 groups ($Z = 2.214$, $P = 0.0268$).

The net movement for summer-released bears ranged from 1,079-158,063 m and the mean net movement was 63,424 m. The net movement for winter bears ranged from 396 m to 13,588 m and averaged 7,053 m. No difference was detected ($Z = 1.2143$, $P =$

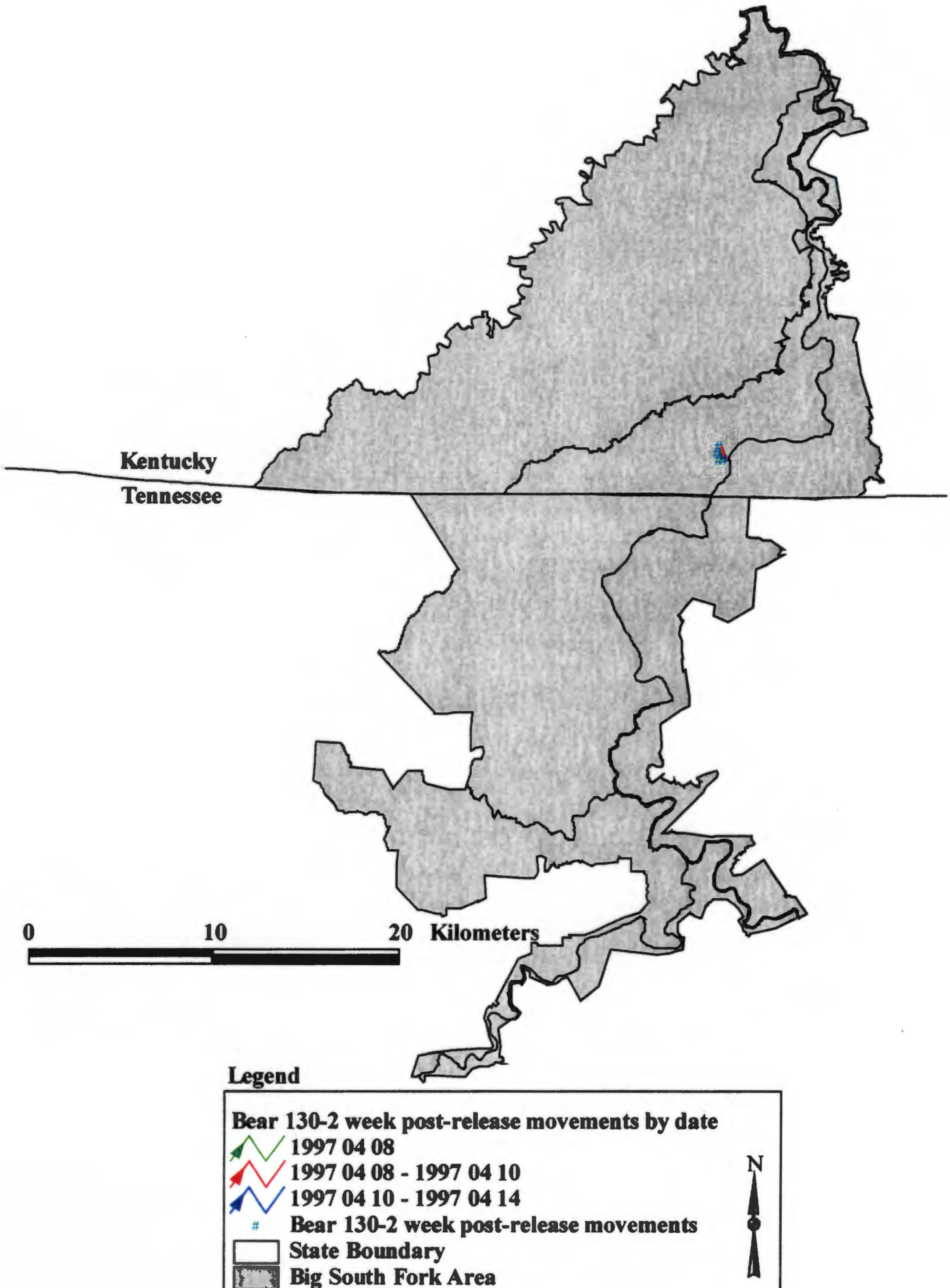

Fig. 6. First 2 weeks post-release movements of winter-released bear 130, Big South Fork Area, Kentucky and Tennessee, 1997.

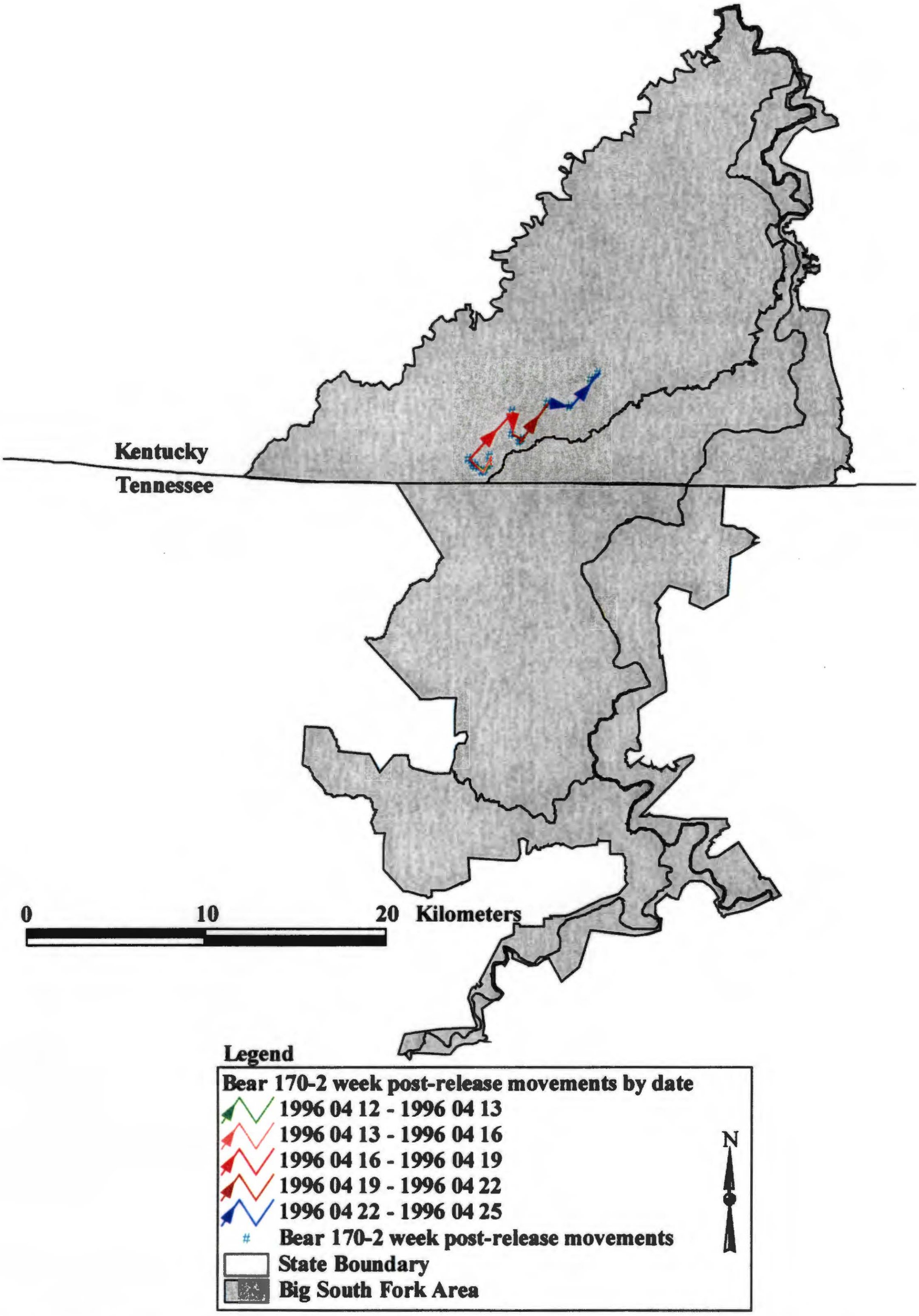

Fig. 7. First 2 weeks post-release movements of winter-released bear 170, Big South Fork Area,1996.

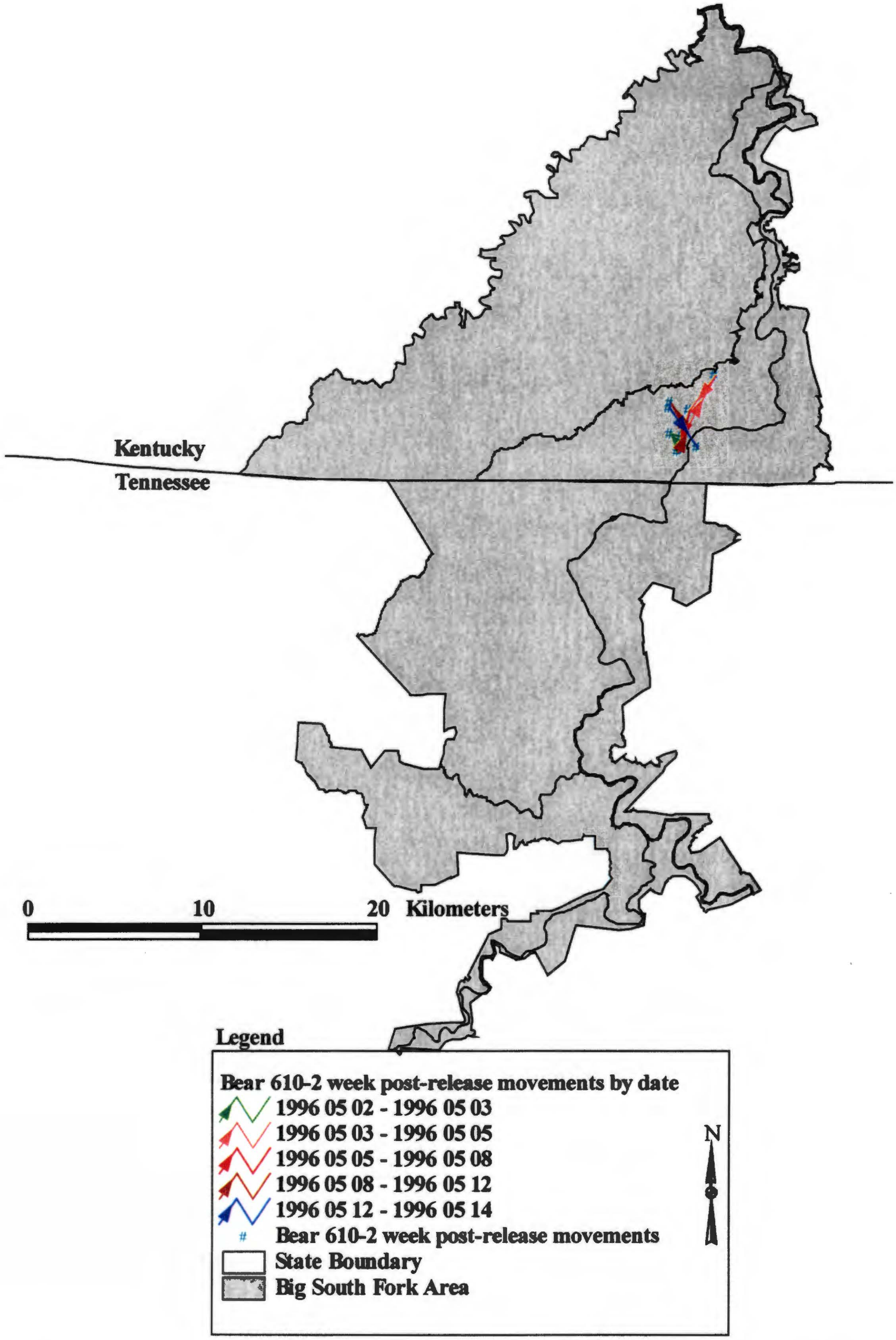

Fig. 8. First 2 weeks post-release movements of winter-released bear 610, Big South Fork Area, Kentucky and Tennessee, 1996.

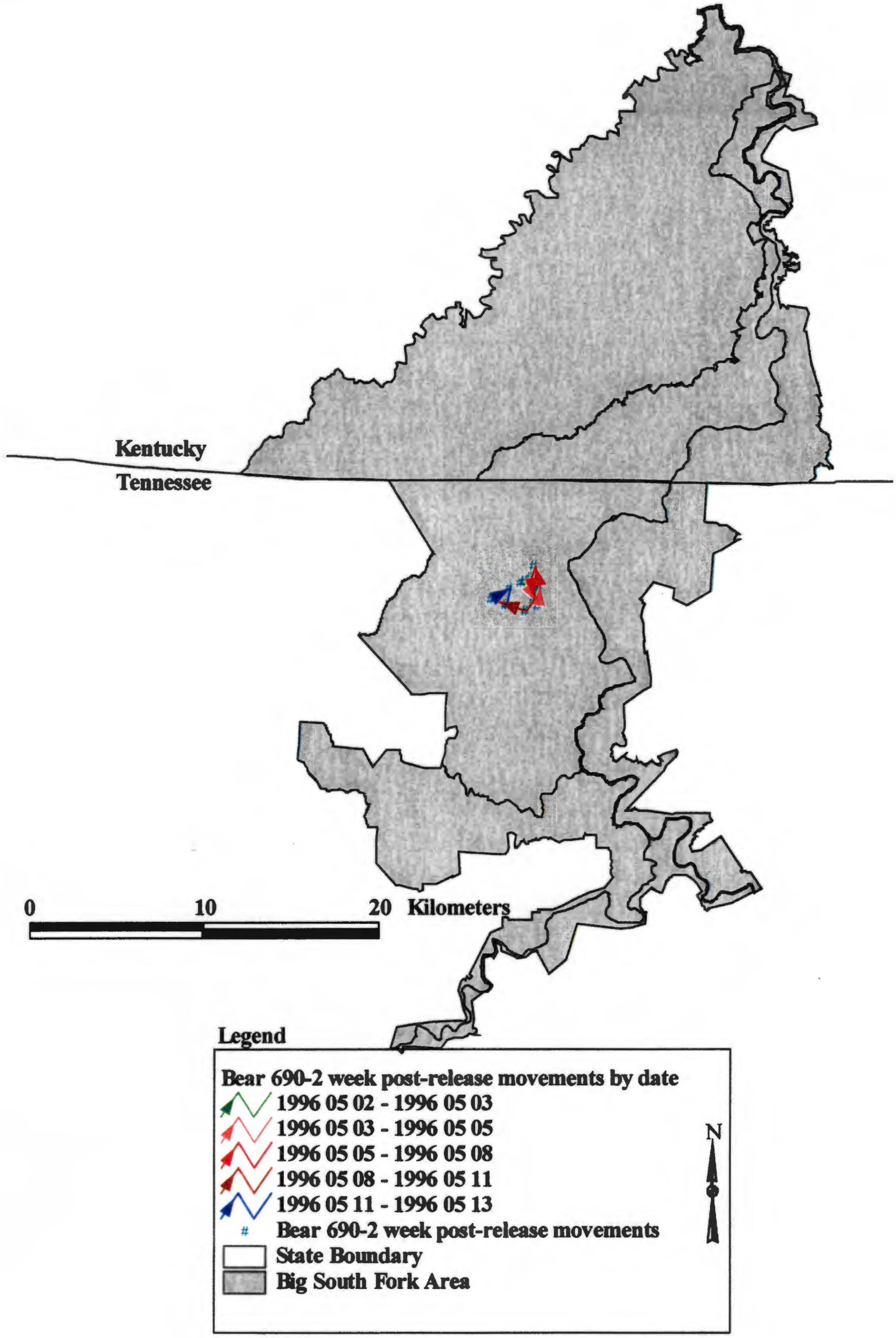

Fig. 9. First 2 weeks post-release movements of winter-released bear 690, Big South Fork Area, Kentucky and Tennessee, 1996.

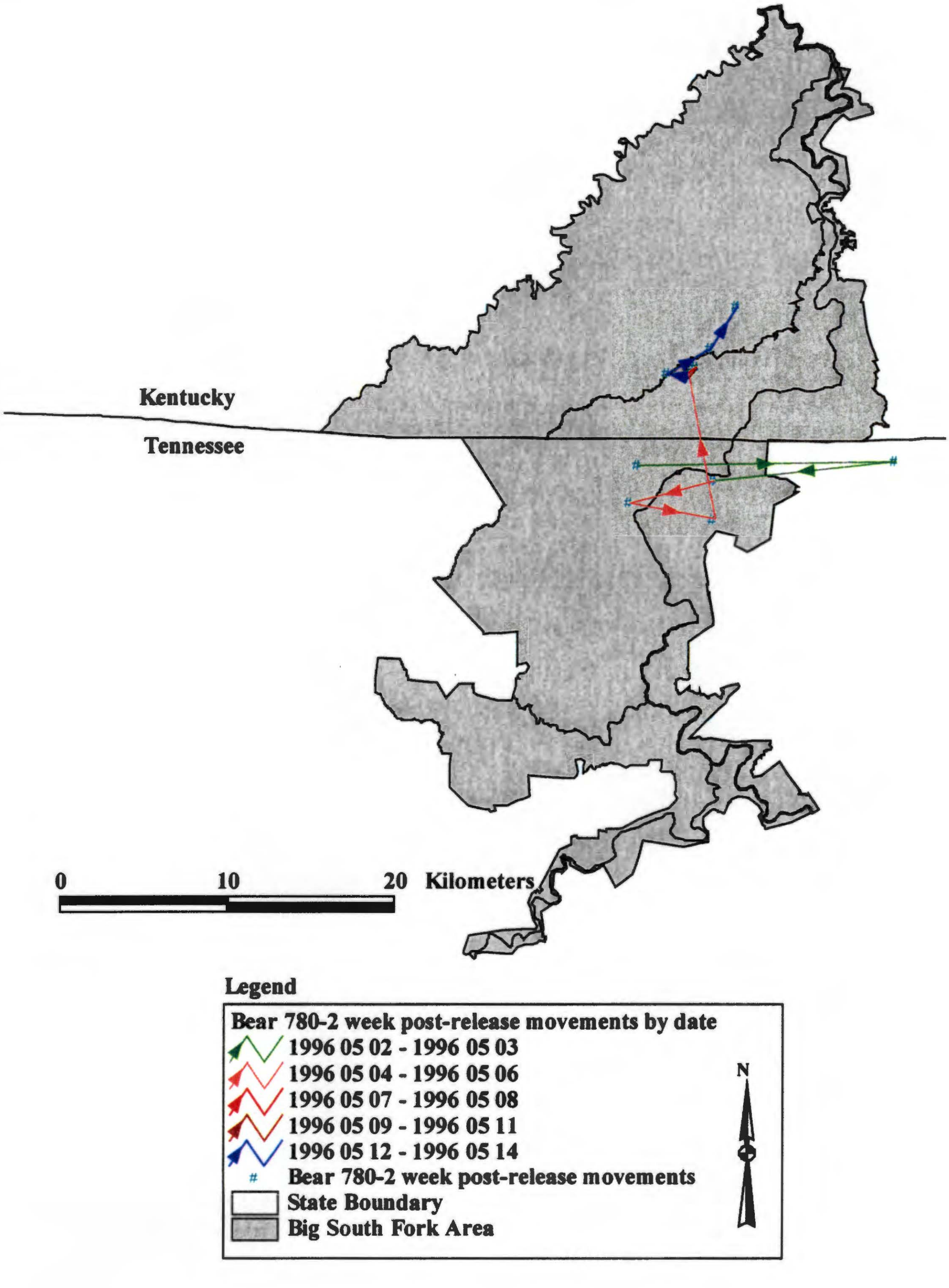

Fig. 10. First 2 weeks post-release movements of winter-released bear 780, Big South Fork Area, Kentucky and Tennessee, 1996.

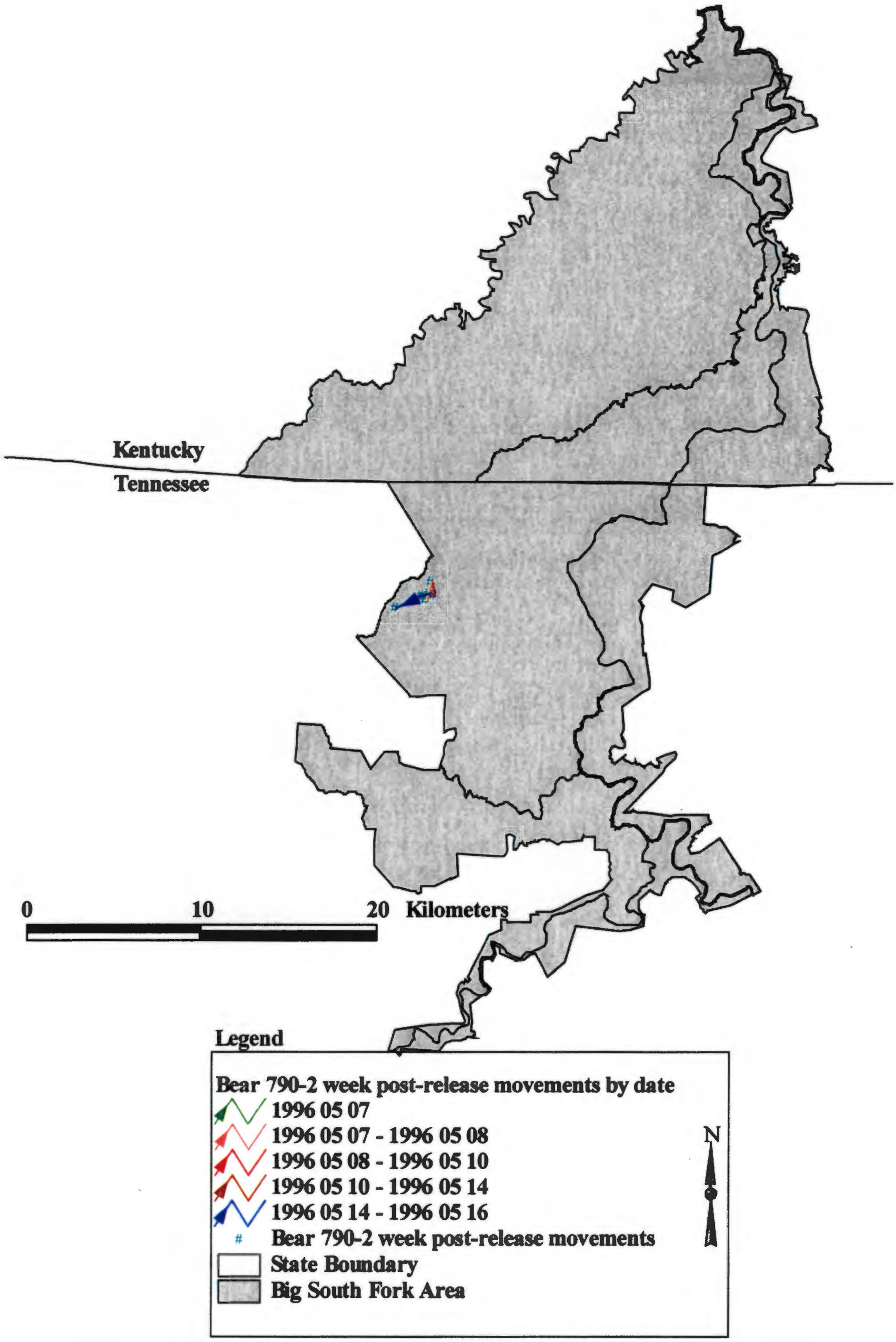

Fig. 11. First 2 weeks post-release movements of winter-released bear 790, Big South Fork Area, Kentucky and Tennessee, 1996.

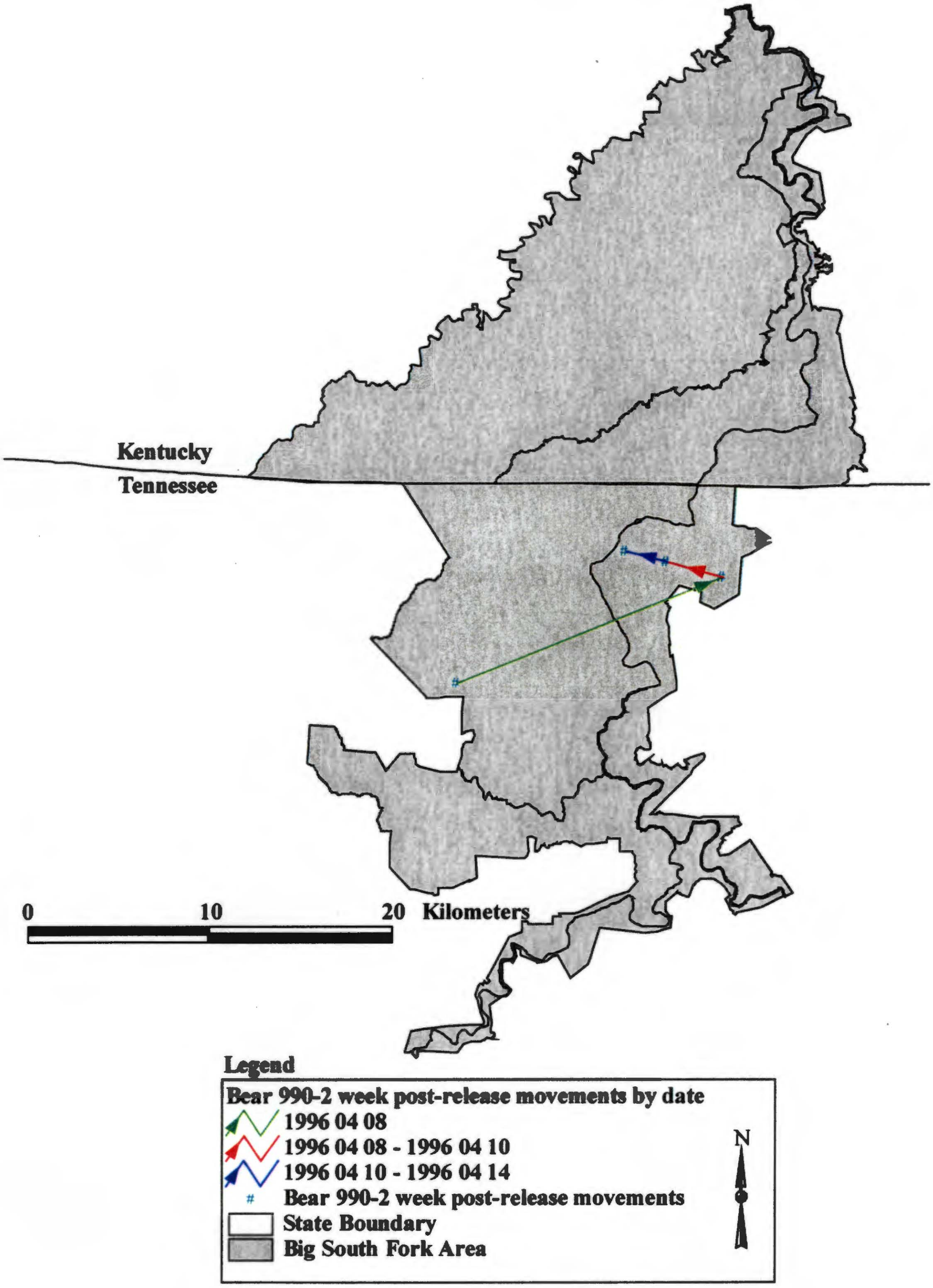

Fig. 12. First 2 weeks post-release movements of winter-released bear 990, Big South Fork Area, Kentucky and Tennessee, 1997.

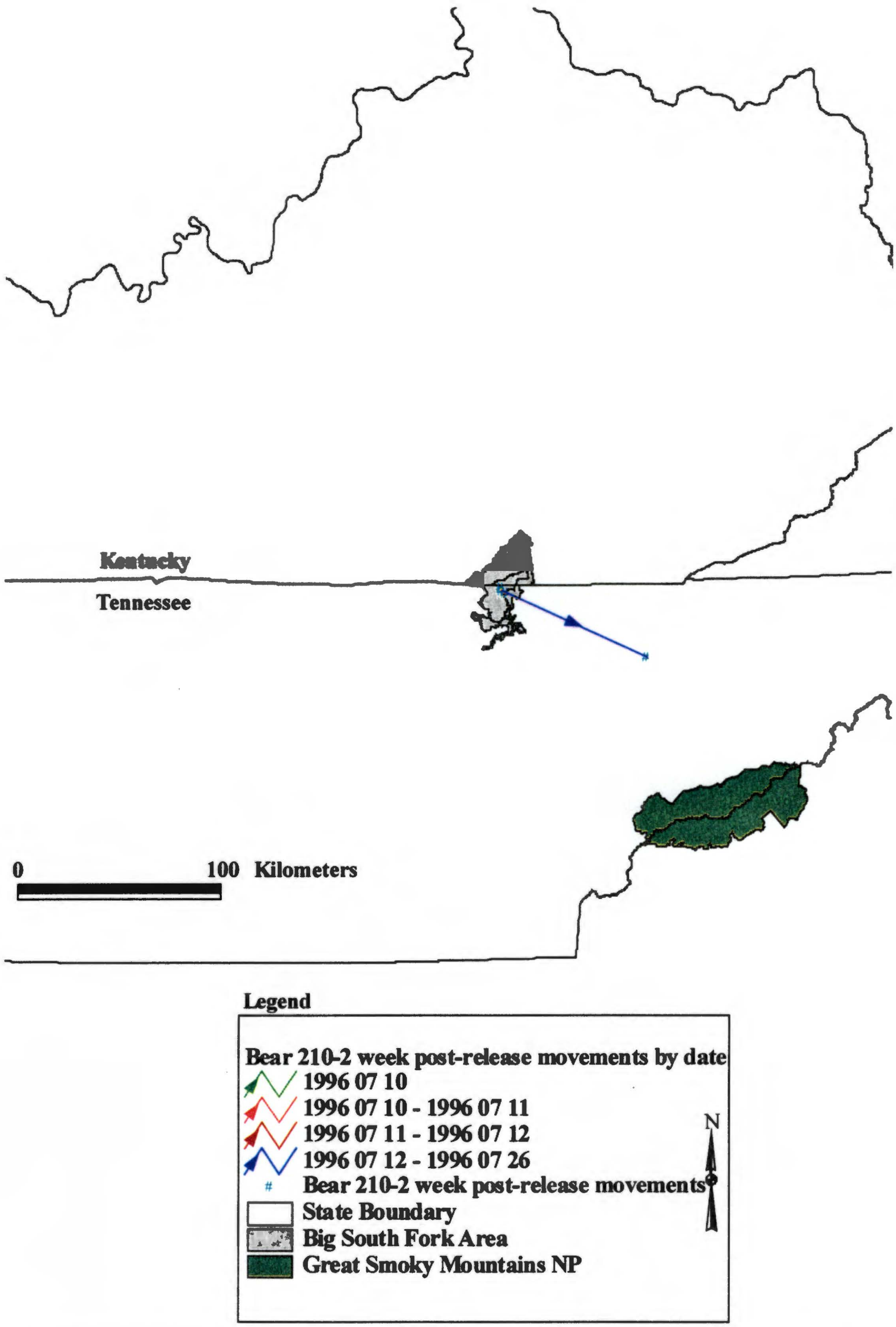

Fig. 13. First 2 weeks post-release movements of summer-released bear 210, Big South Fork Area, Kentucky and Tennessee, 1996.

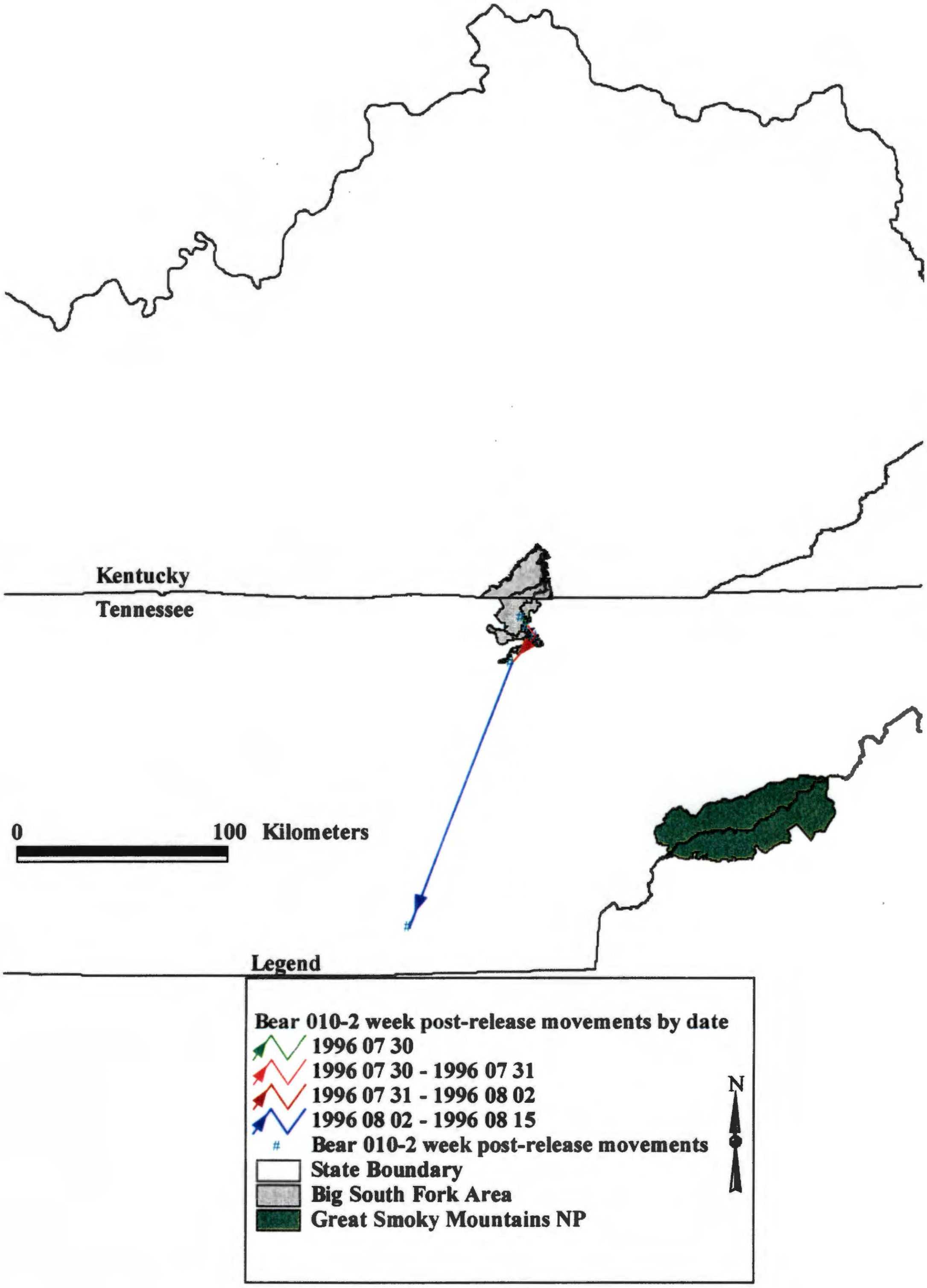

Fig. 14. First 2 weeks post-release movements of summer-released bear 010, Big South Fork Area, Kentucky and Tennessee, 1996.

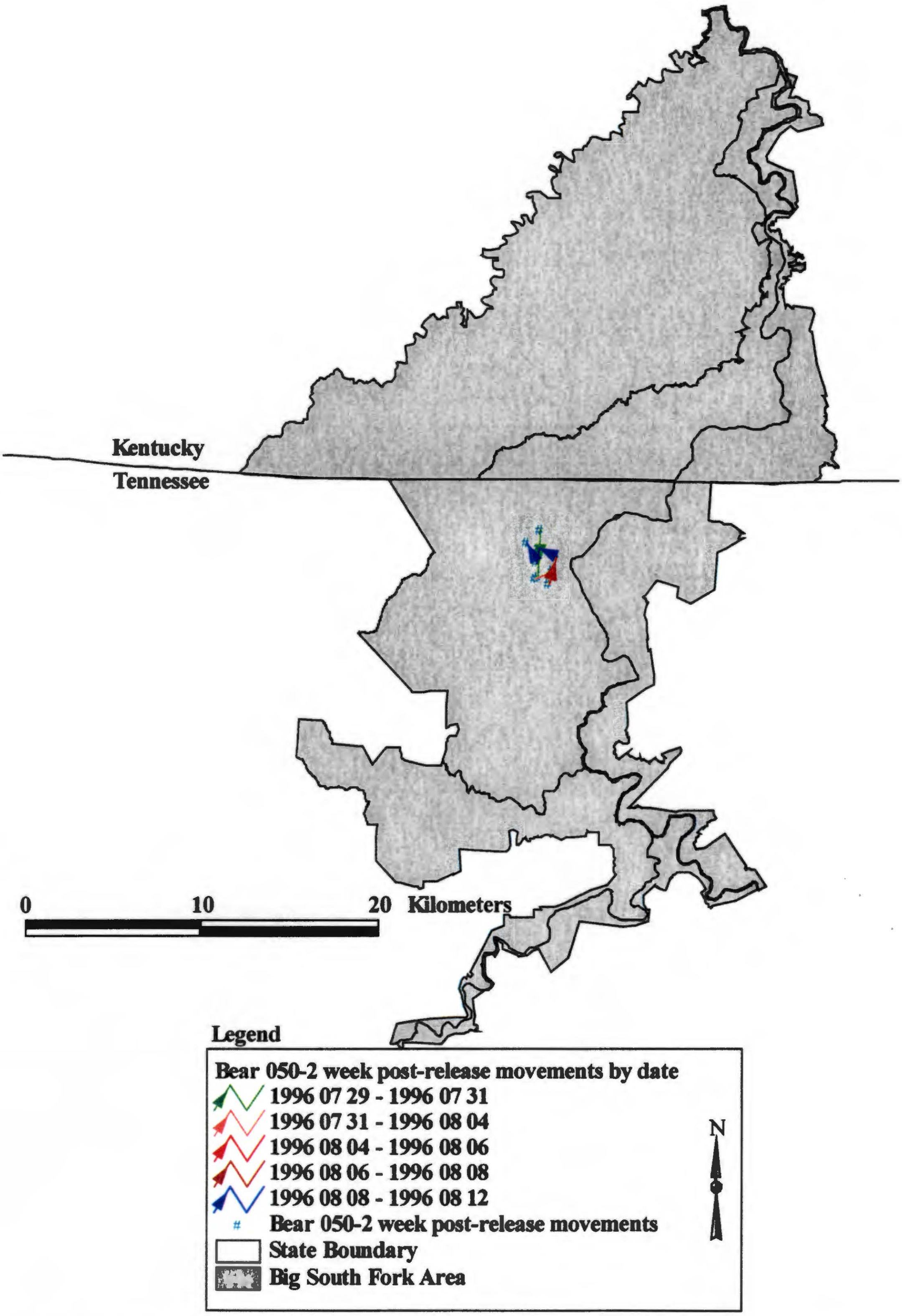

Fig. 15. First 2 weeks post-release movements of summer-released bear 050, Big South Fork Area, Kentucky and Tennessee, 1996.

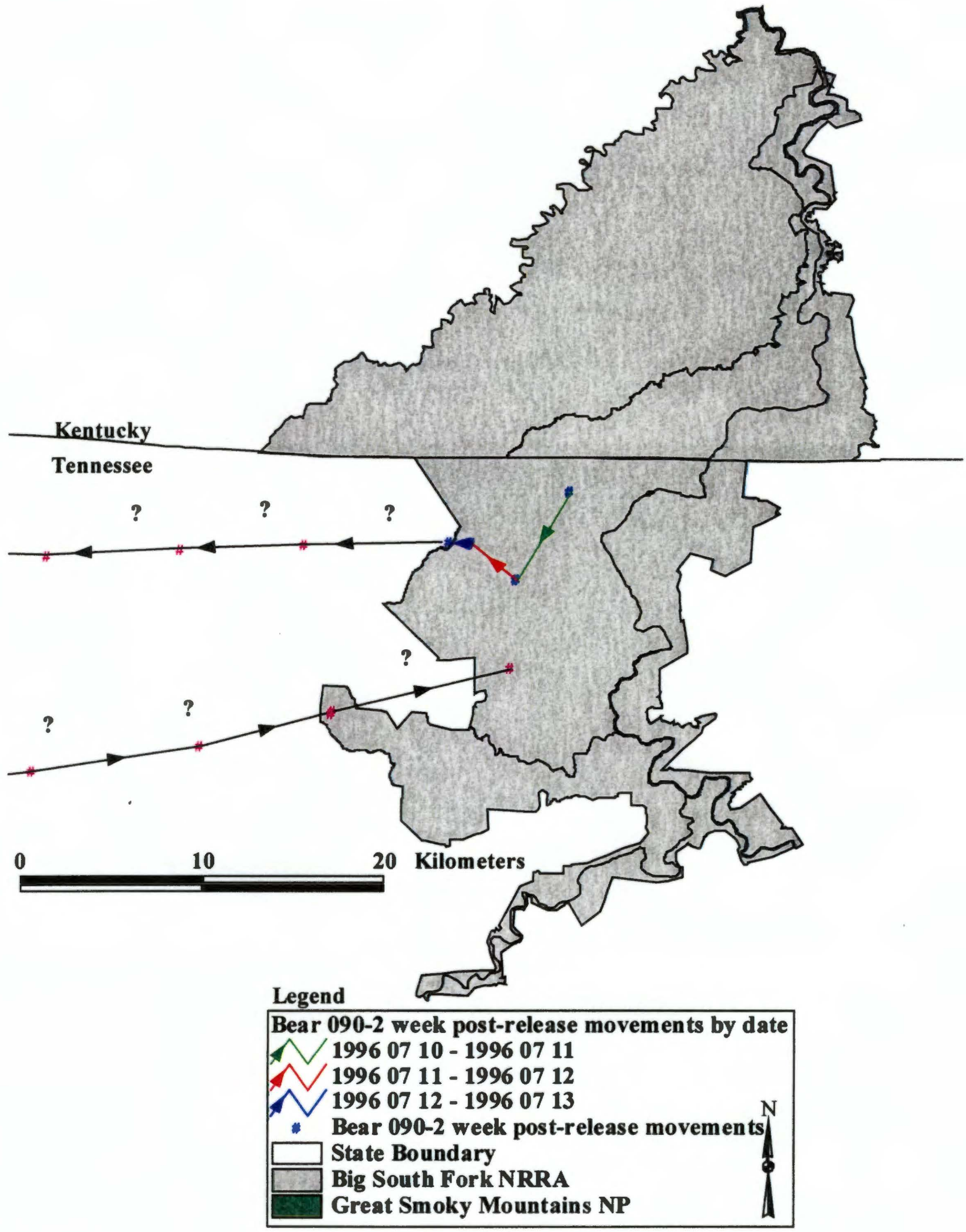

Fig. 16. First 2 weeks movements of summer-released bear 090, Big South Fork Area, Kentucky and Tennessee, 1996. The sequence was not complete because radio-contact with the bear was lost 4 days after release and was regained until 1 month later. The bear was presumably making exploratory movements far from the study area.

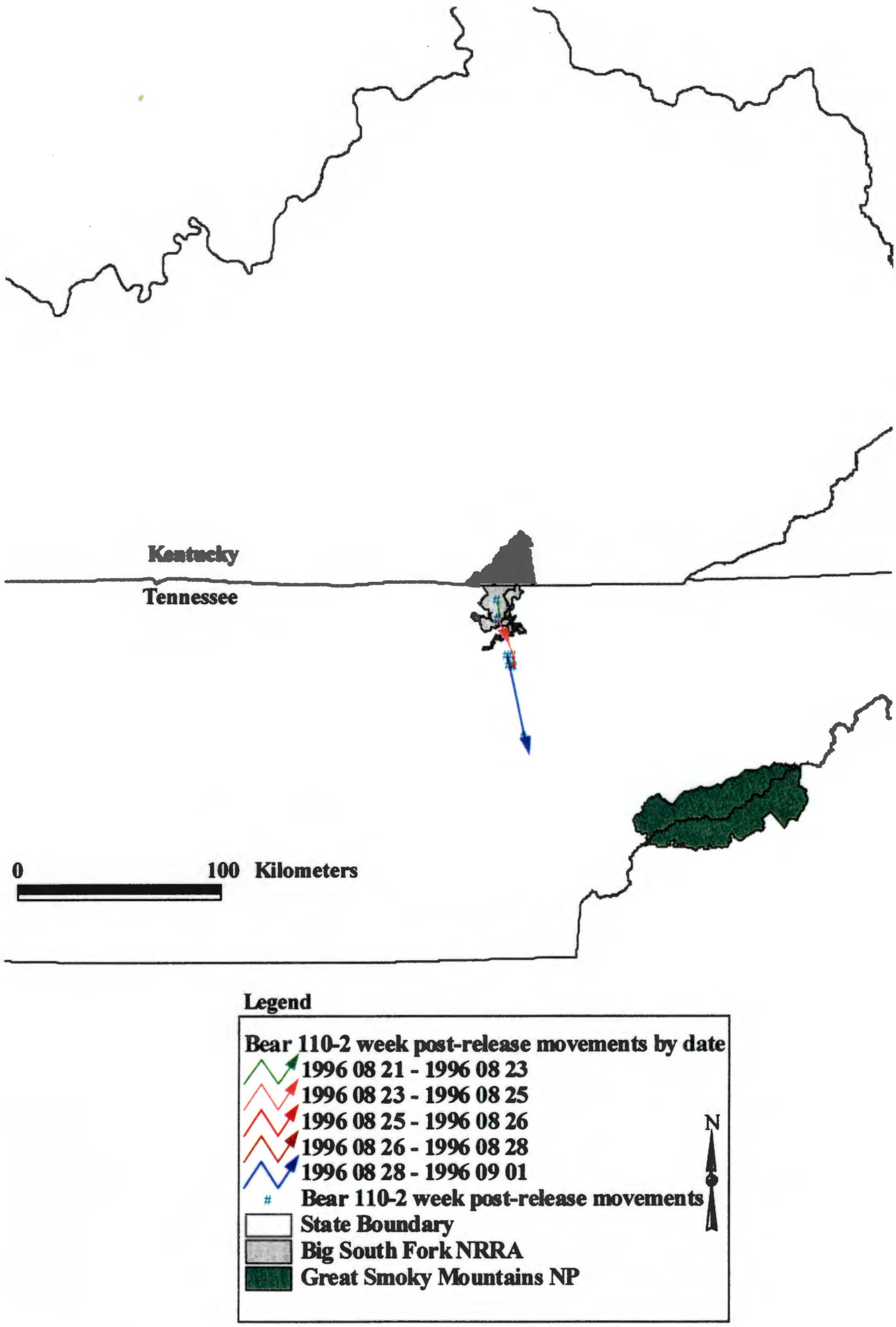

Fig. 17. First 2 weeks post-release movements of summer-released bear 110, Big South Fork Area, Kentucky and Tennessee, 1996.

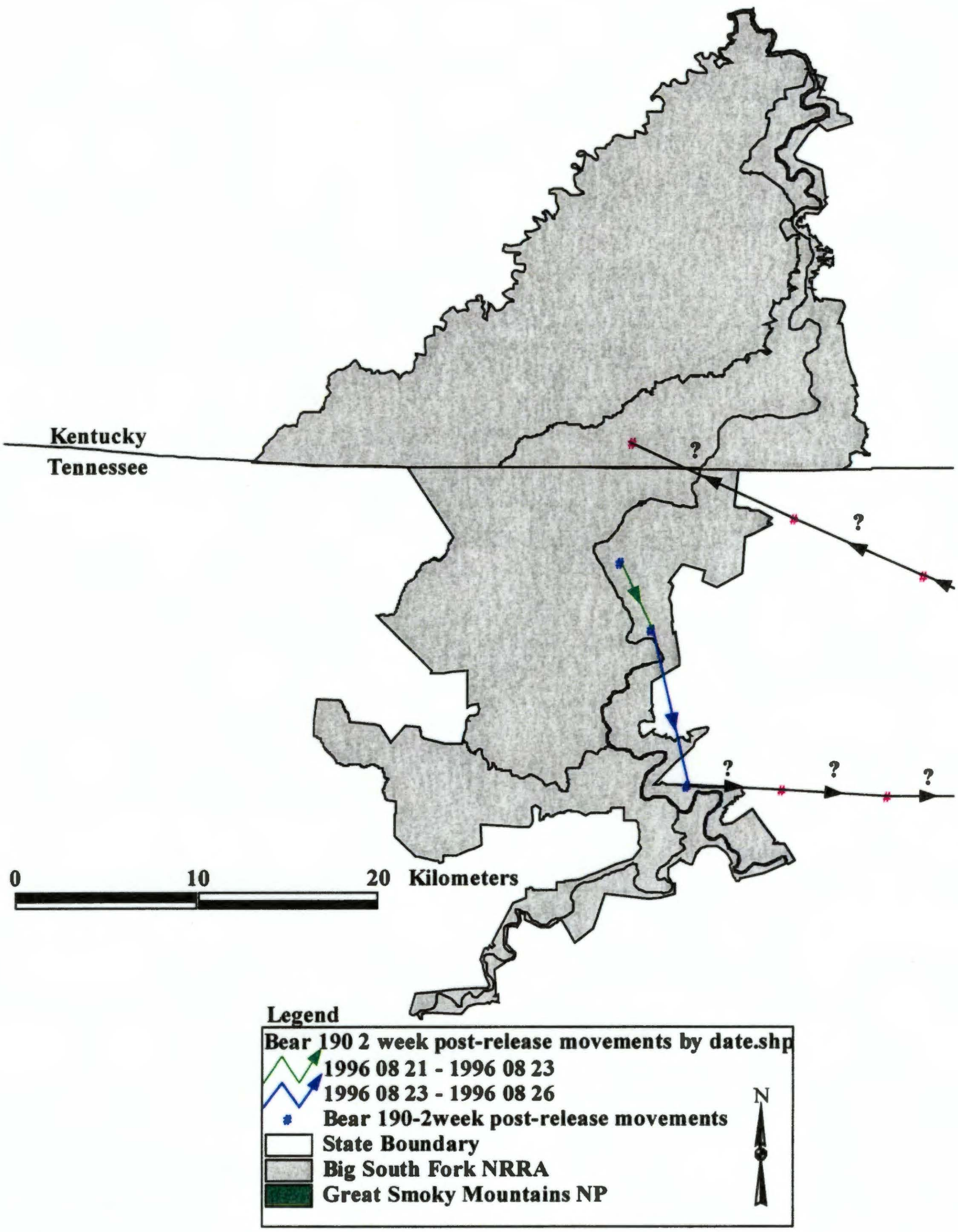

Fig. 18. First 2 weeks movements of summer-released bear 190, Big South Fork Area, Kentucky and Tennessee, 1996. The sequence was not complete because radio contact with the bear was lost 3 days after release and was not regained until 1 month later; The bear presumably was making exploratory movements far from the study area.

0.1004). Again, the incomplete movement data for S-090 and S-190 could produce misleading results. So, I substituted the highest net movement displayed by a summer-released bear (158,063 m) for the net movements of S-090 and S-190 and found a difference (Z = 2.227, $P = 0.013$). I also substituted the mean net movement of summer-released bears (88,056 m) for the net movement of these 2 bears and again found a difference (Z = 2.217, $P = 0.013$).

Circuity for summer-released bears ranged from 0.09-1.0 and the mean was 0.735. Circuity for winter-released bears was greater than that of summer-released bears ($Z = 2.0743$, $P = 0.0381$) and ranged from 0.05-0.55 with a mean of 0.364.

Site fidelity was determined for 7 winter-released bears and 6 summer-released bears (Figs. 19-29). Within 1 year after release, movements were determined to be too constrained to be random for all winter-released bears. Most (5 of 7) were too constrained to be random within 6 months after release for winter-released bears (Table 3). Within the first 2 weeks post-release, most (4 of 7 winter-released, 3 of 4 summer-released) bears showed random movements (Table 3).

Two summer-released bears that left BSFA and returned (S-090 and S-190) displayed constrained movements within 6 months of release (Table 3). However, I was unable to collect complete movement data for S-190 and S-090 while they were outside BSFA within 2 weeks post-release. The remaining summer-released bear that remained in BSFA (S-050) displayed random movements throughout the 9 months before death (Fig. 15, Table 3). Movements for 2 of the summer-released bears (S-010 and S-110) that left the area were determined to be random within 2 weeks post-release (Figs. 14, 17).

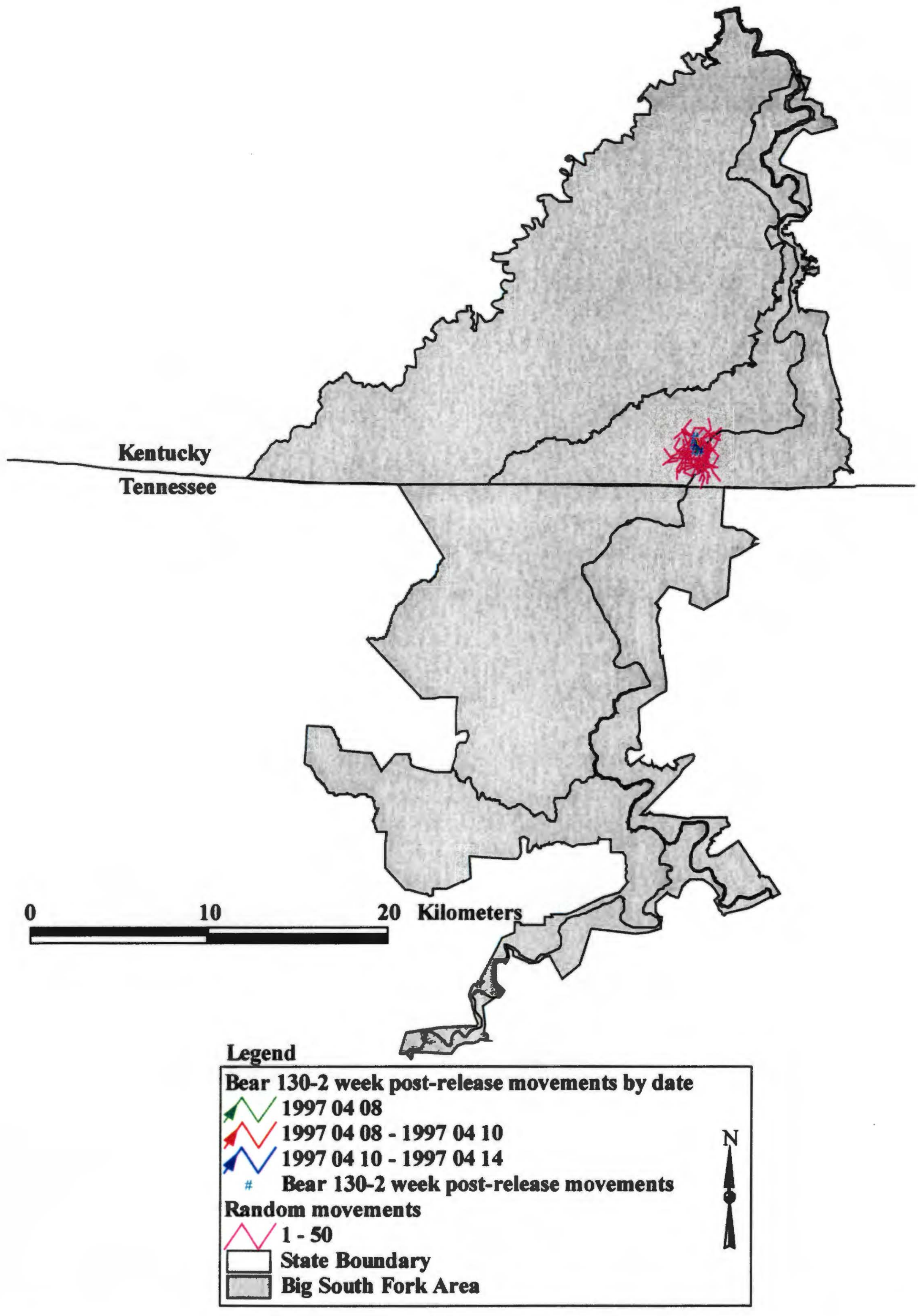

Fig. 19. First 2 weeks post-release movements of winter-released bear 130 compared to 50 random movements paths, Big South Fork Area, Kentucky and Tennessee, 1997. The observed bear movements are more constrained than random movement paths (p > 98.1).

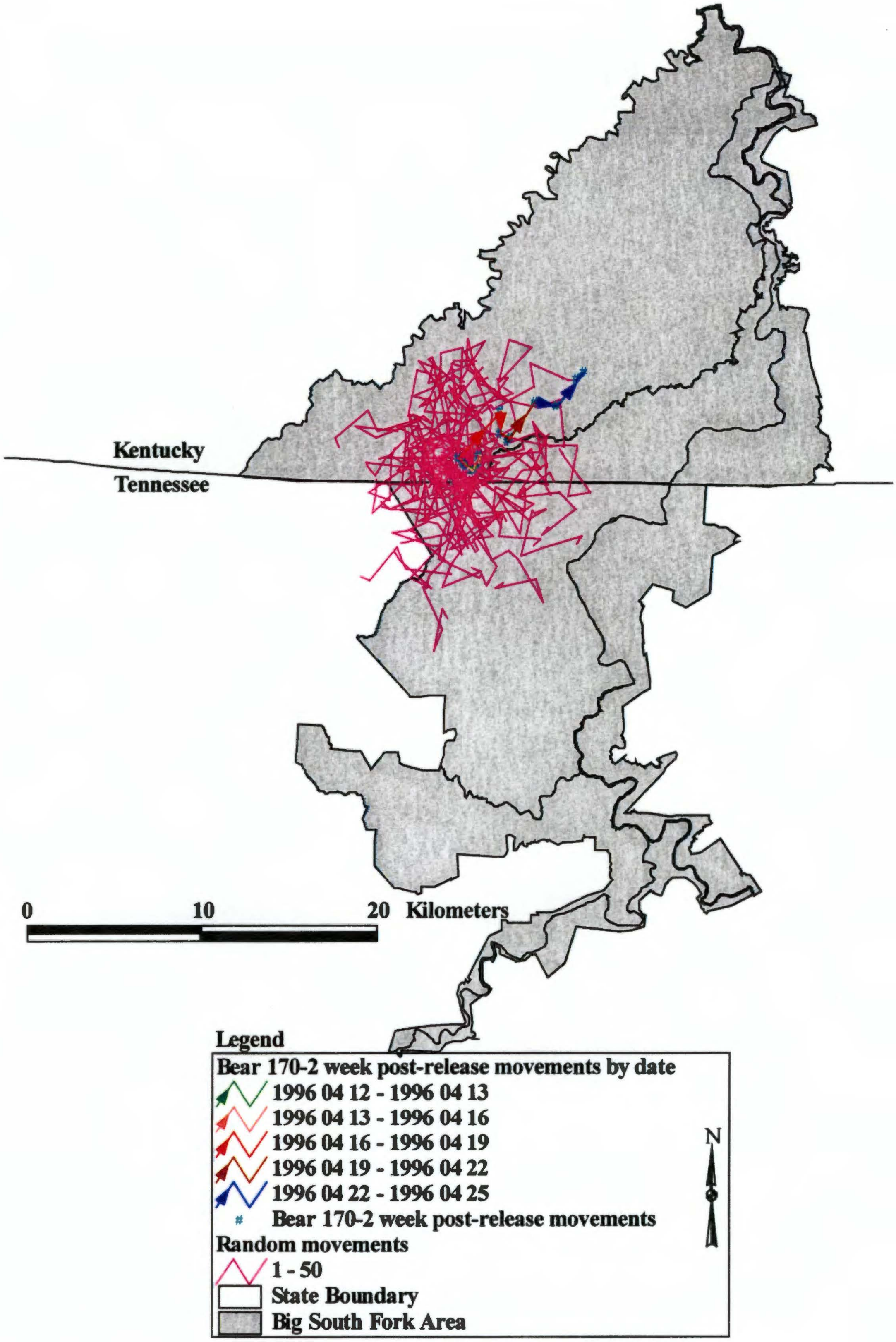

Figure 20. First 2 weeks post-release movements of winter-released bear 170 compared to 50 random movement paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements did not differ from random movements ($p > 21.6$).

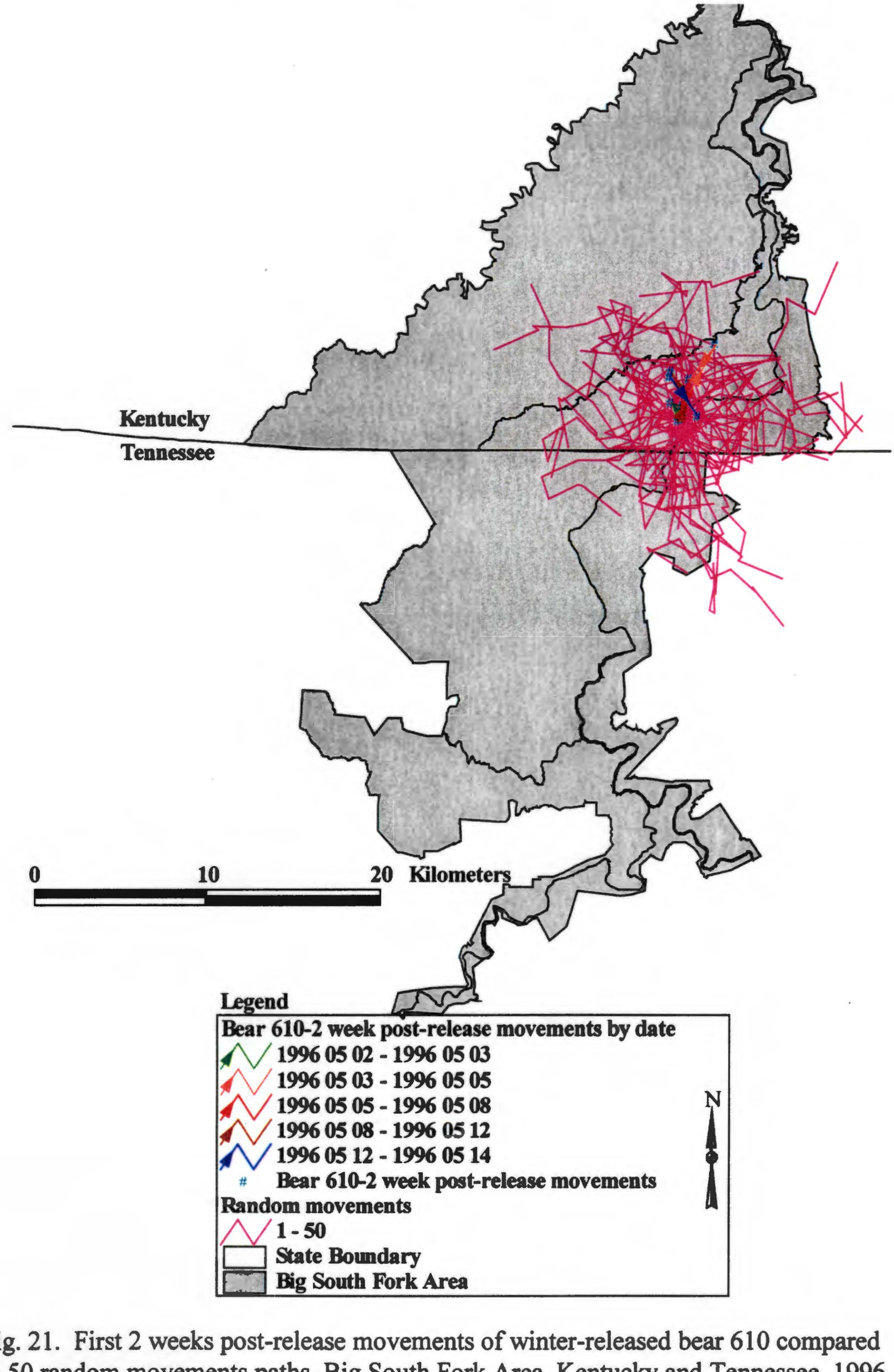

Fig. 21. First 2 weeks post-release movements of winter-released bear 610 compared to 50 random movements paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements were more constrained than random movement paths (p > 98.0).

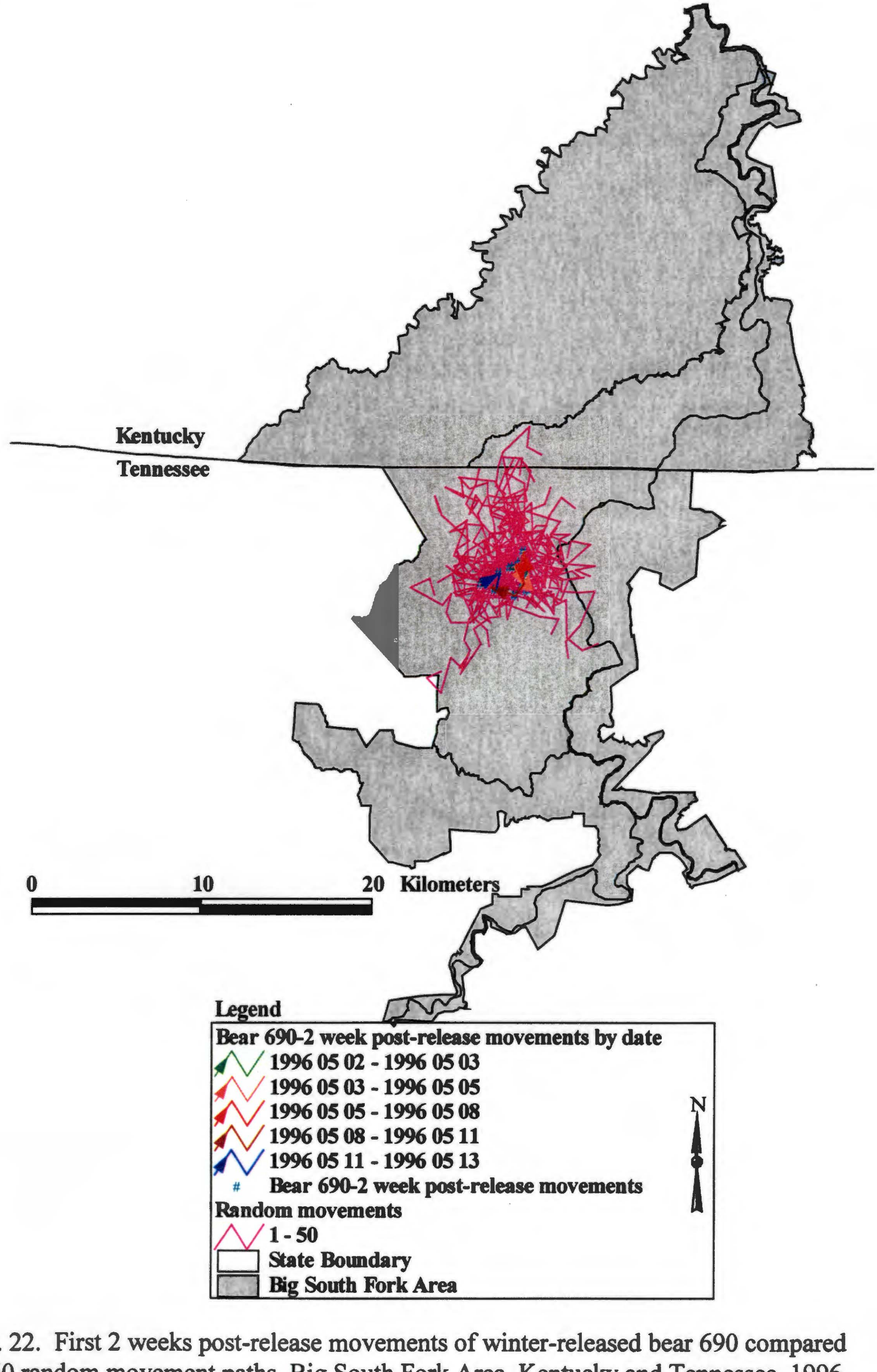

Fig. 22. First 2 weeks post-release movements of winter-released bear 690 compared to 50 random movement paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements did not differ from random movements (p > 92.2).

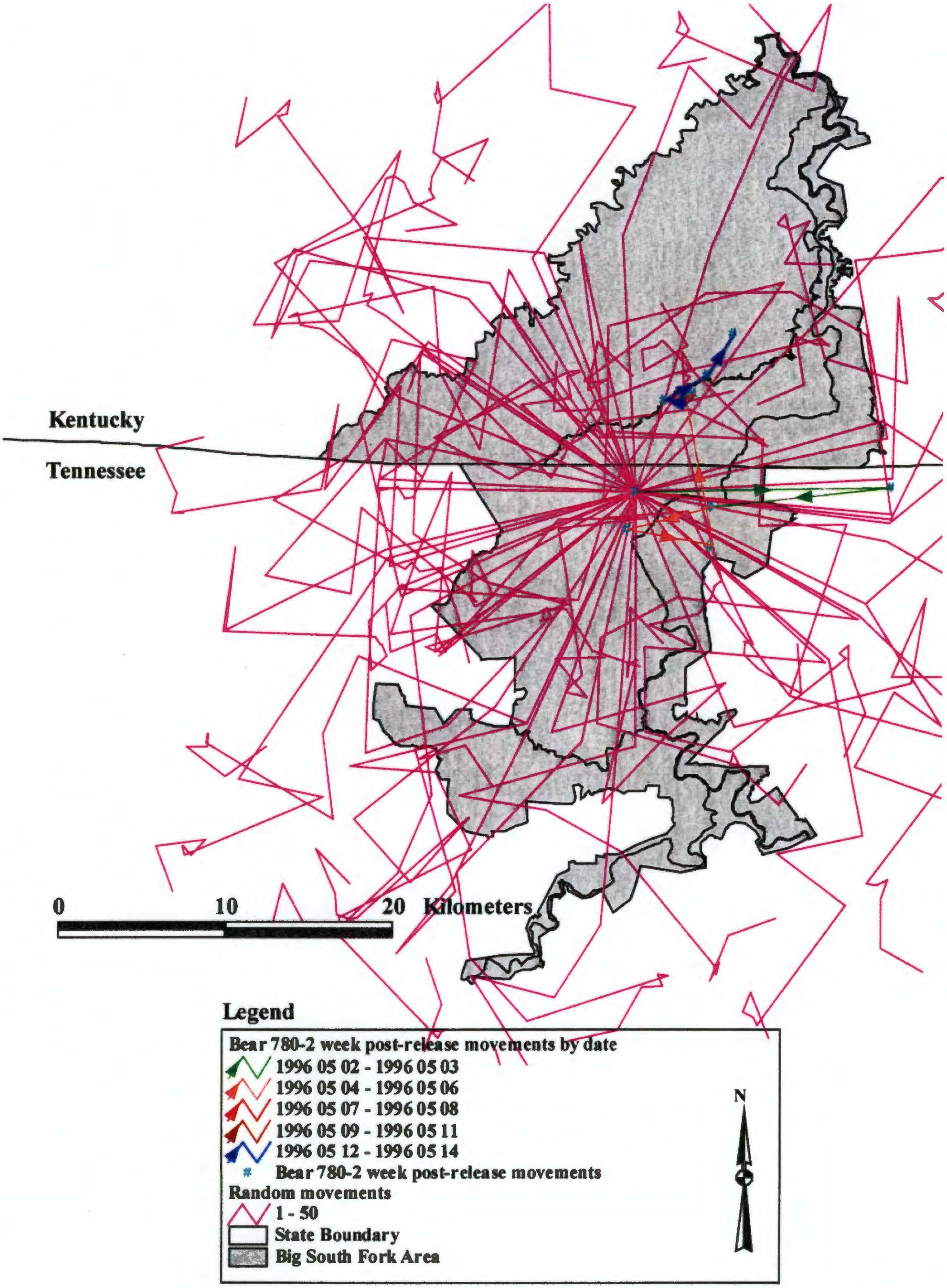

Fig. 23. First 2 weeks post-release movements of winter-released bear 780 compared to 50 random movement paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements did not differ from random movement paths (p > 47.1).

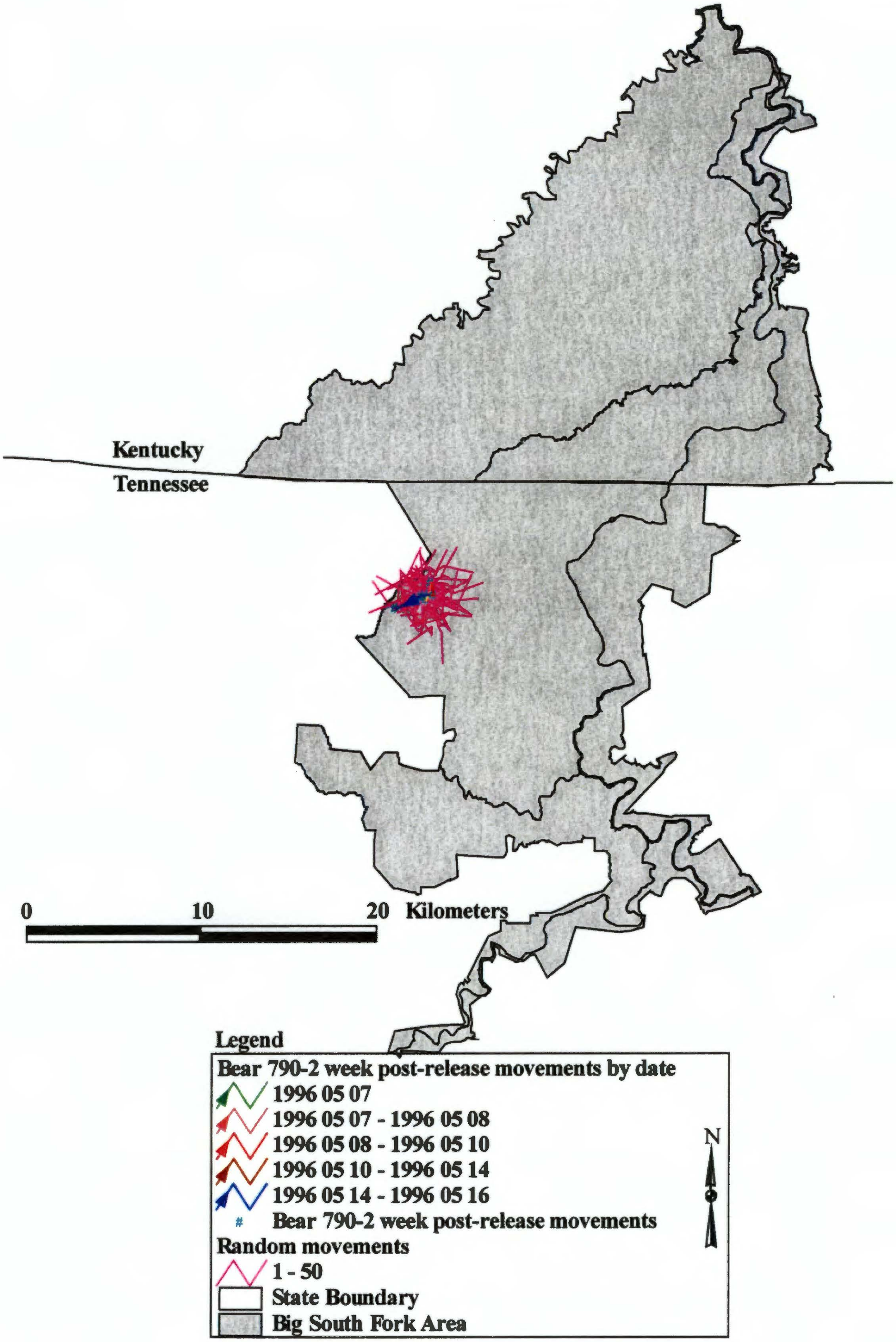

Fig. 24. First 2 weeks post-release movements of winter-released bear 790 compared to 50 random movement paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements did not differ from random movement paths (p > 64.7).

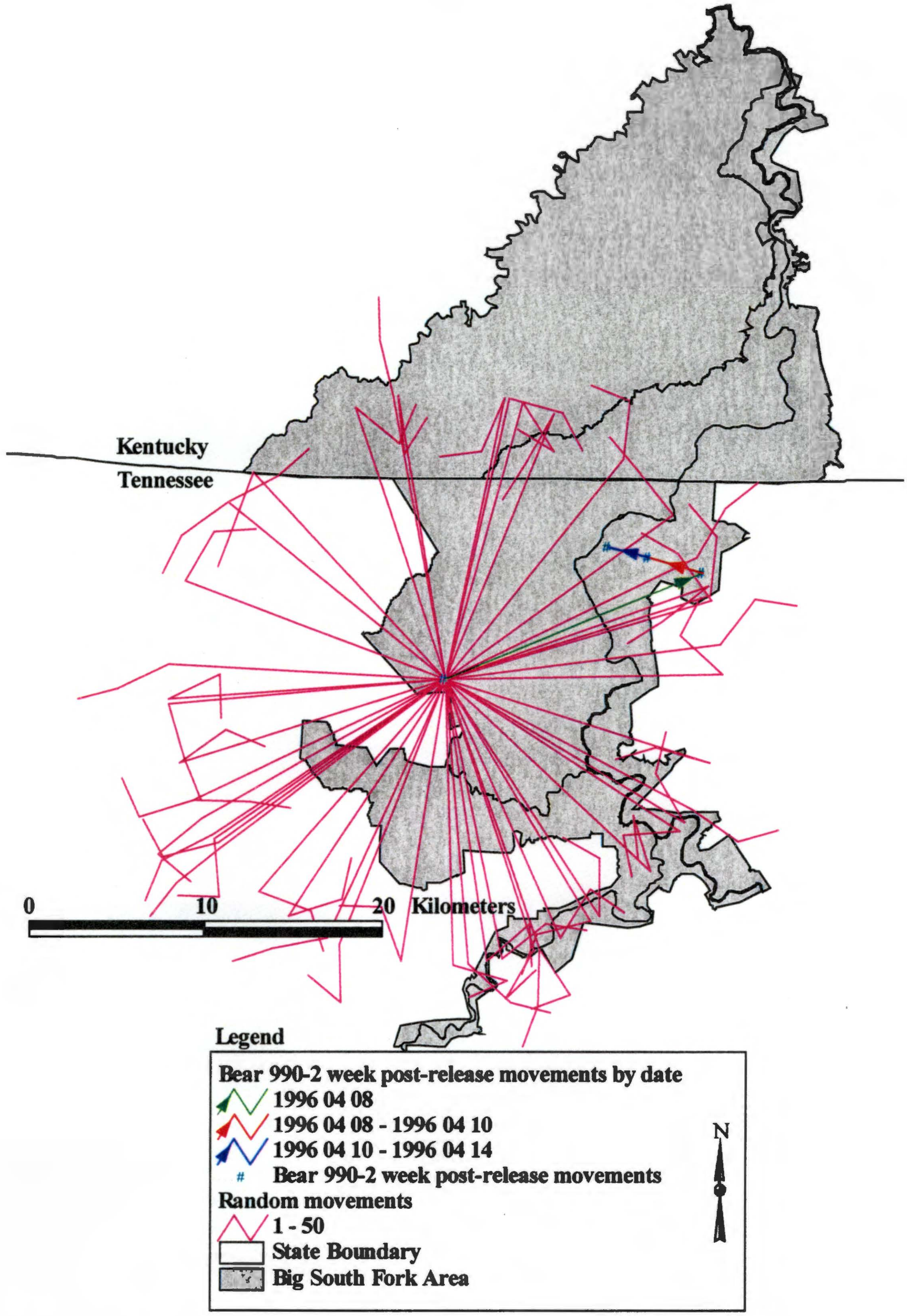

Fig. 25. First 2 weeks post-release movements of winter-released bear 990 compared to 50 random movement paths, Big South Fork Area, Kentucky and Tennessee, 1997. The observed bear movements were more dispersed than random movement paths (p > 100).

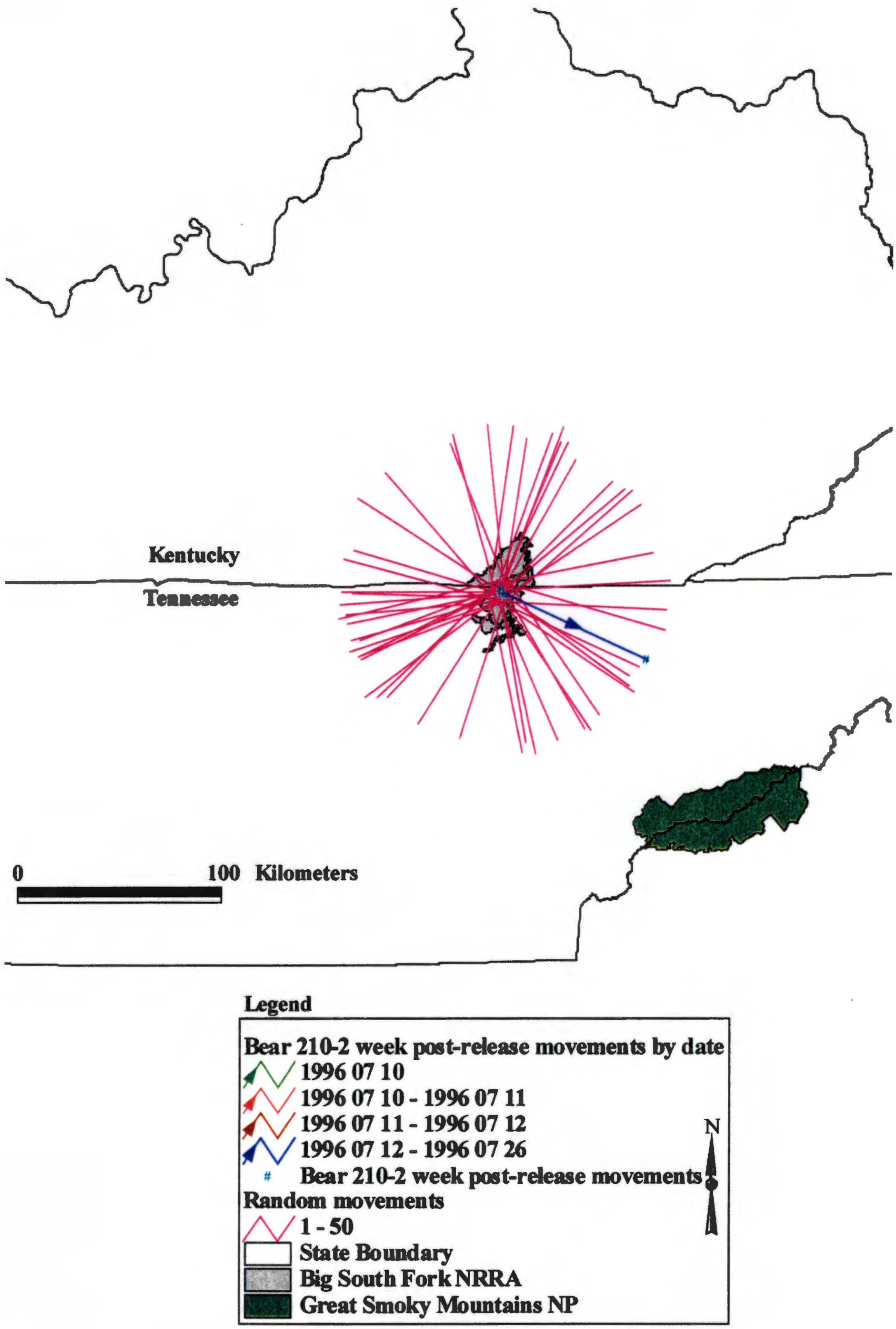

Fig. 26. First 2 weeks post-release movements of summer-released bear 210 compared to 50 random movement paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements were determined to be more constrained than random movements ($p > 98.4$).

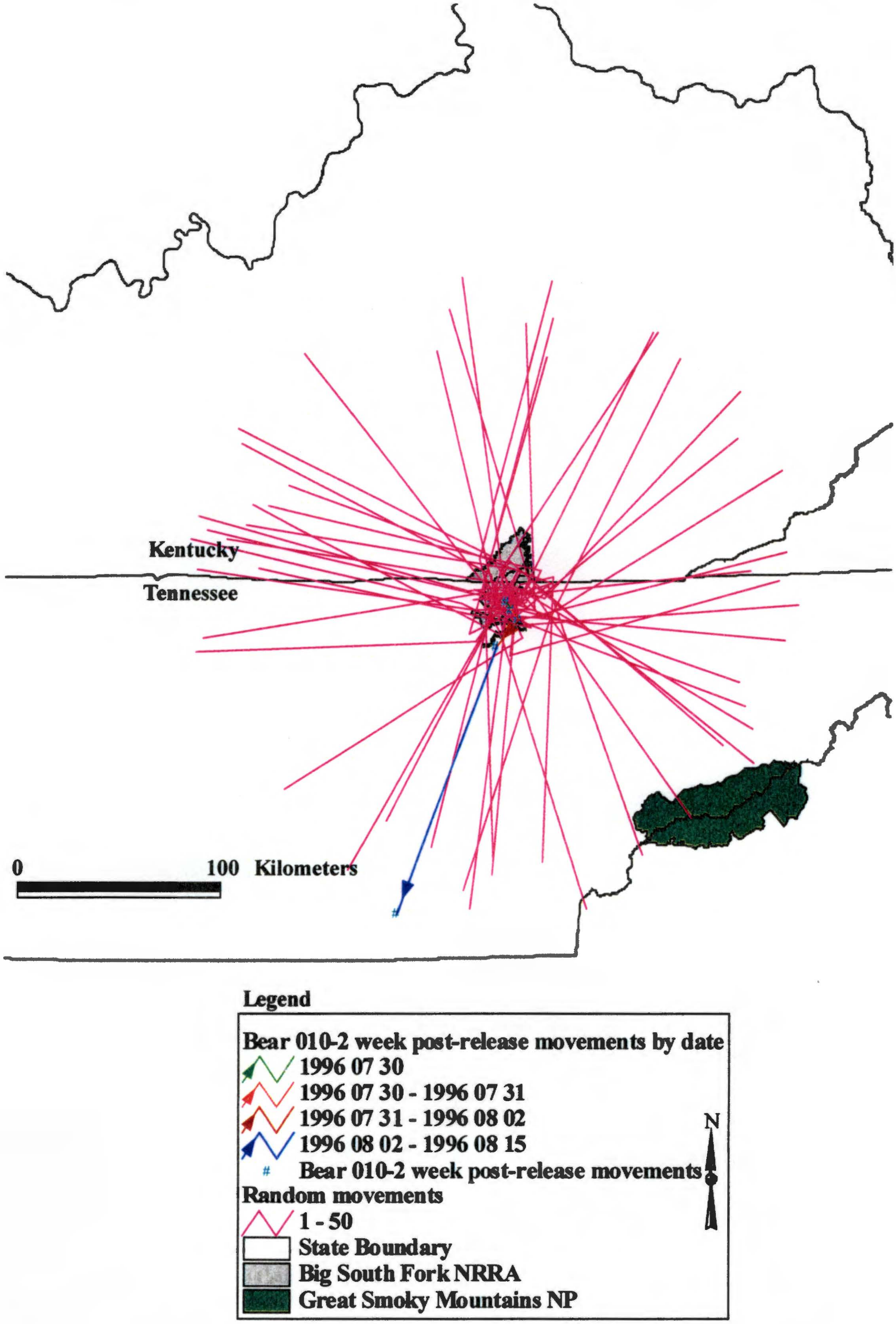

Fig. 27. First 2 weeks post-release movements of bear 010 compared to 50 random movements paths, Big South Fork Area, Kentucky and Tennessee, 1996. The observed bear movements did not differ from random (p > 54.9).

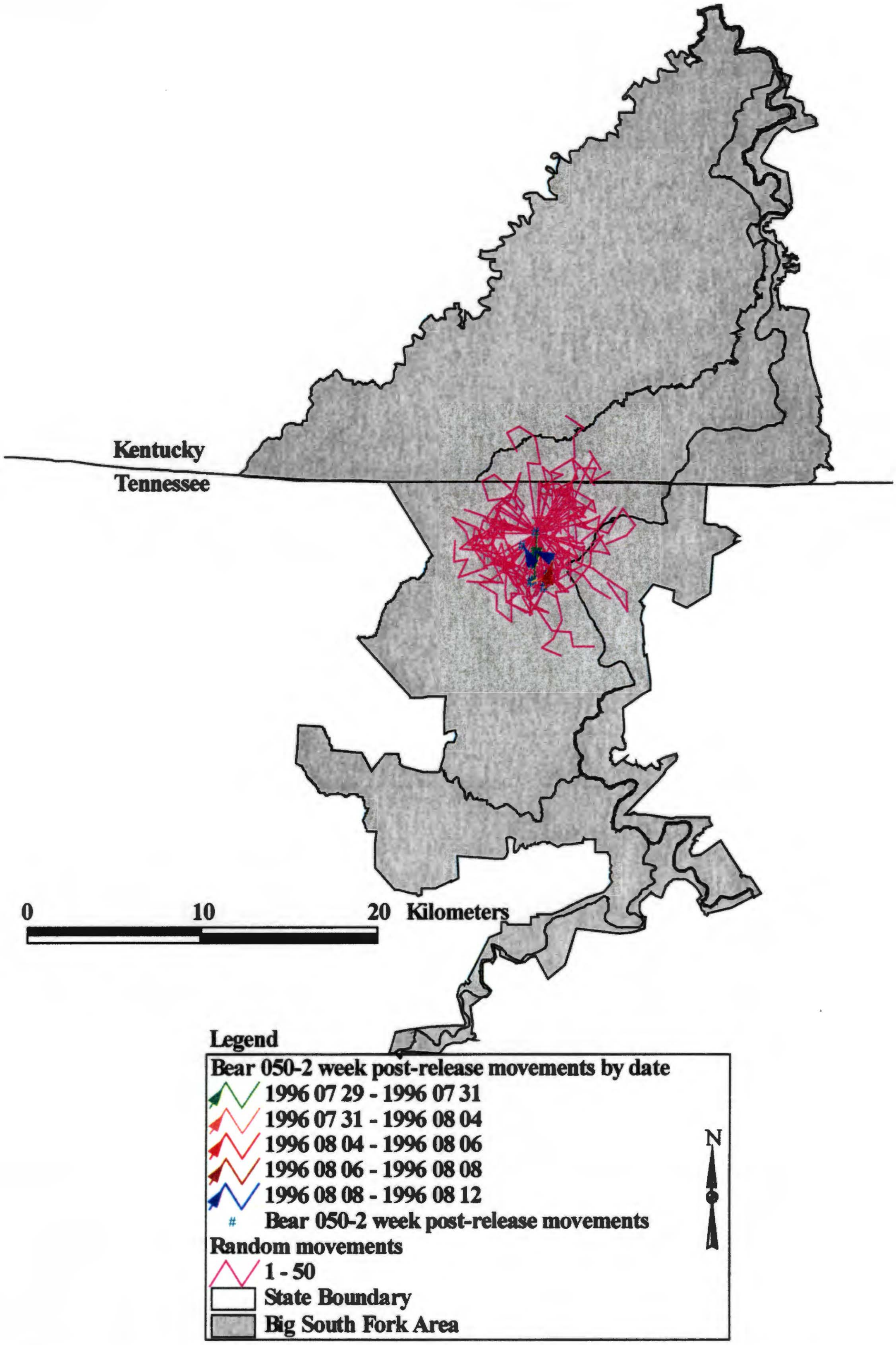

Fig. 28. First 2 weeks post-release movements of summer-released bear 050 compared to 50 random movement paths, Big South Fork Area, 1996. The observed bear movements did not differ from random movement paths (p > 45.1).

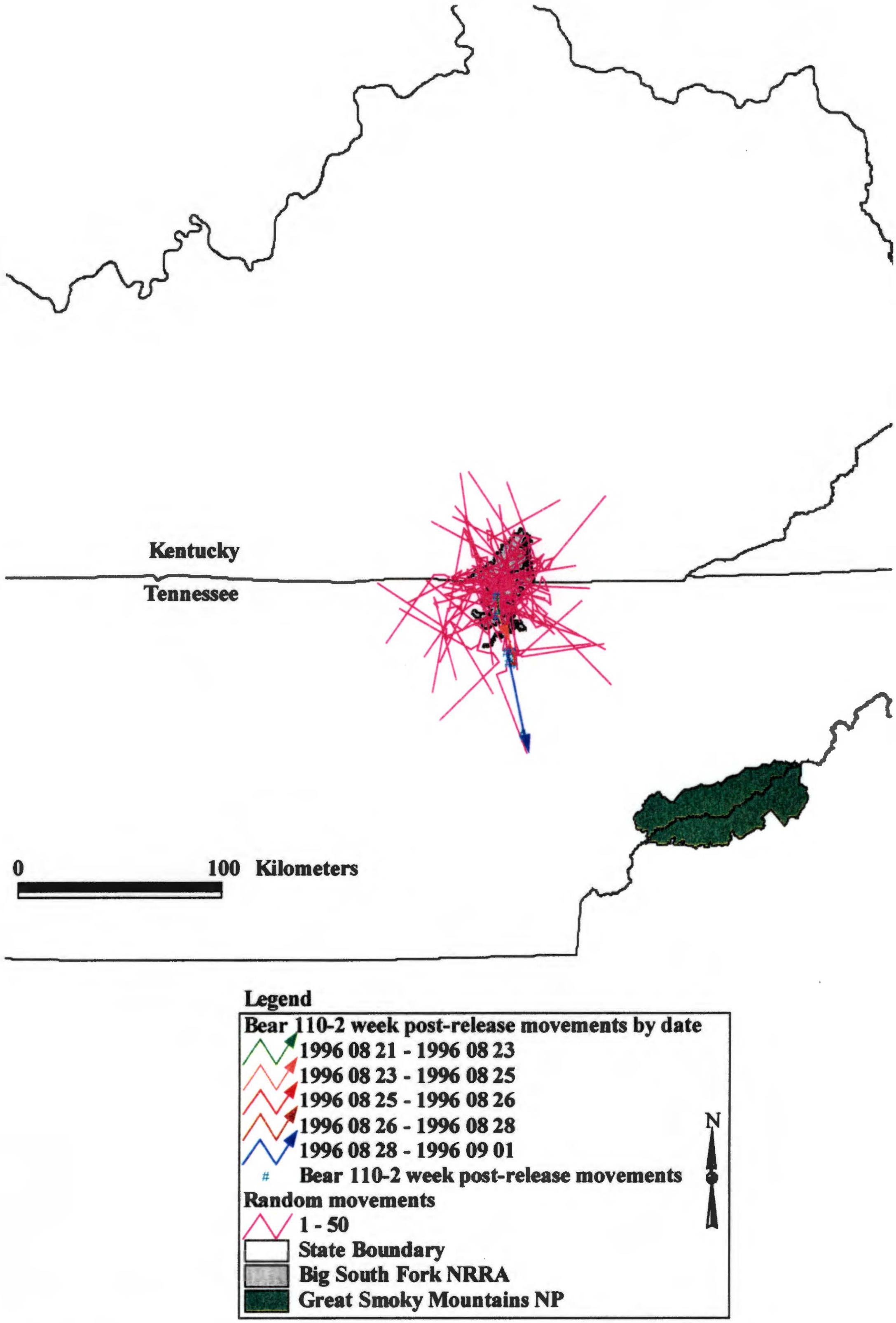

Fig. 29. First 2 weeks post-release movements of summer-released bear 110 compared to 50 random movement paths, Big South Fork Area, 1996. The observed bear movements did not differ from random movement paths ($p > 48.1$).

Table 3. Results of the site fidelity test for translocated bears at 2weeks, 6 months, and 1 year post-release, Big South Fork Area, Kentucky and Tennessee, 1996-1997.

Bear	Release Method	2 weeks	6 months	1 year
130	Winter	constrained	constrained	constrained
170	Winter	random	random	constrained
610	Winter	constrained	constrained	constrained
690	Winter	random	constrained	constrained
780	Winter	random	constrained	N/A
790	Winter	random	constrained	N/A
990	Winter	dispersed	constrained	constrained
010	Summer	random	N/A	N/A
050	Summer	random	random	random
090	Summer	N/A	constrained	constrained
110	Summer	random	N/A	N/A
190	Summer	N/A	constrained	constrained
210	Summer	constrained	random	constrained

Additional movement data were not collected because of mortalities. The remaining summer-released bear that left the area (S-210) displayed constrained movements within the first 2 weeks post release (Fig. 13). The movements of this bear became random at 6 months (Table 3) but became constrained within 1 year as she established a new range well outside BSFA (Table 3).

I performed the MRPP on 5 winter-released bears and 3 summer-released bears that established themselves in BSFA for ∃6 months. No comparisons were made between release methods because this test was designed to determine at what time a translocated bear would restrict its movements into a definable home range, given that the bear remained in the area ∃6 months, regardless of release technique. A difference was found between successive periods of movements; in all cases but 1, movements decreased over time (Table 4). A difference was detected between the 3-month set of movements and the 6-month set of movements in 6 of the 8 bears (Table 4). The movements of the remaining 2 bears decreased from the 6-month set to the 9-month set. However, the movements of 1 bear decreased from 3 months to 6 months but increased from 6 months to 9 months.

Survival

I monitored 14 adult female bears (6 summer-released, 8 winter-released) between December 1996 and October 1998. Among the 14 bears, 5 bears dropped their radio collars (2 summer-released, 3 winter-released), collar failure occurred with 2 winter-

Table 4. Movements of translocated black bears in the Big South Fork Area 1996-1997.

Bear	Interval (months)	Test Statistic	P-value	Trend
W-130	0-3 compared to 3-6	12.3	0.000002	Increase
W-130	3-6 compared to 6-9	1.2	0.11	None
W-170	0-3 compared to 3-6	18.1	0.00000006	Decrease
W-170	3-6 compared to 6-9	5.3	0.0007	Decrease
W-610	0-3 compared to 3-6	8.5	0.0001	Decrease
W-610	3-6 compared to 6-9	1.1	0.12	None
W-690	0-3 compared to 3-6	1.9	0.05	Decrease
W-690	3-6 compared to 6-9	6.9	0.0002	Decrease
W-990	0-3 compared to 3-6	1.4	0.90	None
W-990	3-6 compared to 6-9	2.2	0.04	Decrease
S-050	0-3 compared to 3-6	13.8	0.000002	Decreased
S-090	0-3 compared to 3-6	0.4	0.22	None
S-090	3-6 compared to 6-9	2.9	0.02	Decrease
S-190	0-3 compared to 3-6	2.4	0.03	Decrease
S-190	3-6 compared to 6-9	6.4	0.007	Increase

released bears, 5 bears died or left the area (3 summer-released, 2 winter-released), and 2 radiocollared bears remained in BISO (Table 1).

Cumulative annual survival over the duration of the study was 0.659 (95% CI = 0.4314-0.8862) for all translocated bears (Fig. 30). A difference ($Z = 3.084$; $P = 0.001$) was detected between annual survival of winter-released bears (S = 0.875, 95% CI = 0.525-1.0) and summer-released bears (S = 0.200, 95% CI = 0.000-0.448) during the first year after release (Figs. 31, 32).

Bait-Station Survey

I conducted bait-station surveys in 1996, 1997, and 1998. No bear visits were recorded. As a result, I could not confirm the presence of bears other than those translocated to BSFA.

Den Visits

I immobilized 4 bears in their dens at BSFA during winter 1997; 1 other bear did not den. Although I documented no natural reproduction at that time, considerable weight gain in 2 bears was recorded. One 30-kg (66-lb) bear that was released in summer 1996 weighed 65 kg (143 lb) in winter 1997. One 74-kg (163-lb) summer-released bear weighed 114 kg (250 lb) in winter 1997. I was unable to immobilize any bears in their dens during winter 1998 because most appeared to be winter active.

BISO, UT, and U.S. Geological Survey personnel continued den work at BISO during winter 1999 and confirmed natural reproduction. Researchers found that S-190

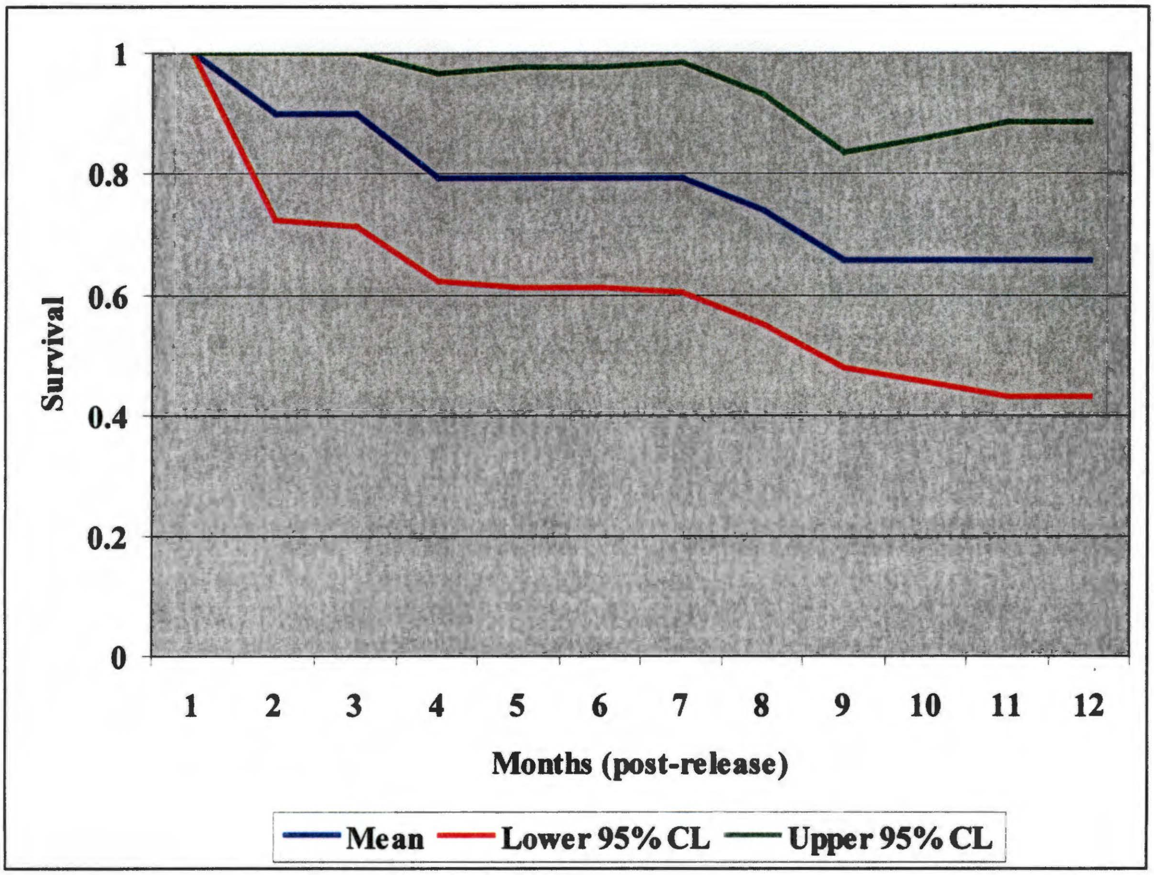

Fig. 30. First year post-release survival of all translocated bears in the Big South Fork Area, Kentucky and Tennessee, 1996.

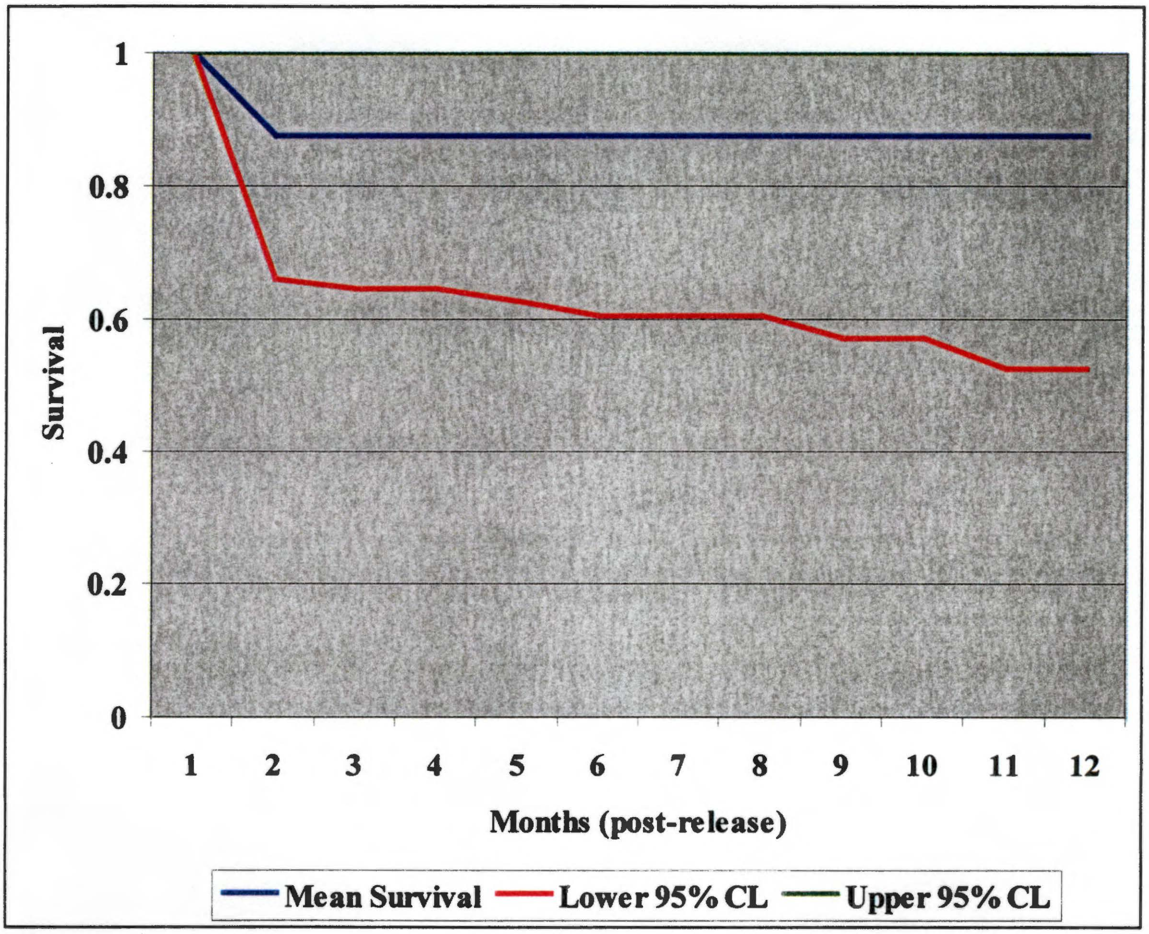

Fig. 31. First year post-release survival of winter-released bears in the Big South Fork Area, Kentucky and Tennessee, 1996.

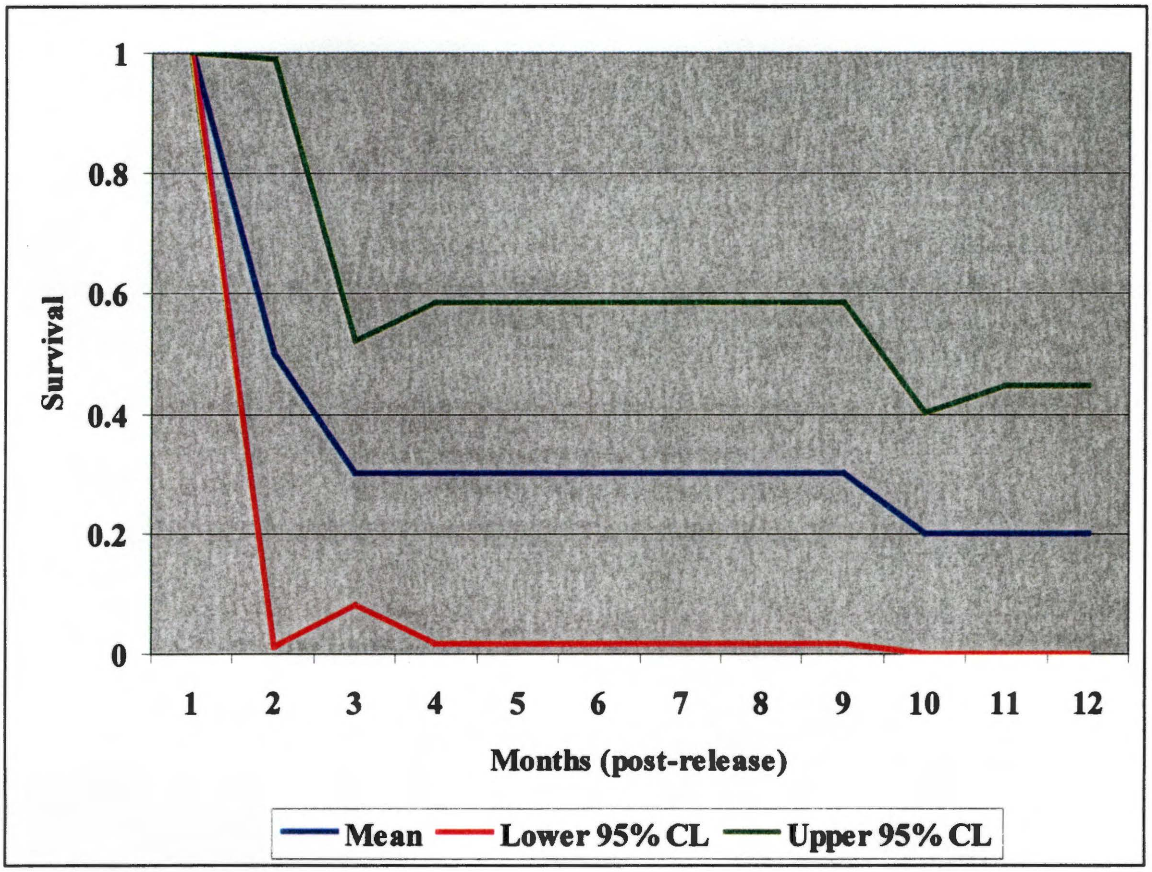

Fig. 32. First year post-release survival of summer-released bears in the Big South Fork Area, Kentucky and Tennessee, 1996.

and W-030, the 2 remaining radio-collared bears, had given birth to 2 and 3 cubs, respectively.

Sightings and Human-Bear Interactions

Fifty-three bear sightings were documented by BISO personnel from April 1996 through November 1999. No incidences of property damage or "panhandling" behavior by translocated bears were documented.

Population Modeling

Population growth simulations with only the bears that presently exist in BSFA resulted in a 56% probability of extinction; mean population growth was 129 bears in 20 years (range = 0-304 bears). Therefore, it is reasonable to assume that without further additions to BSFA, a viable population will not result. Consequently, I ran subsequent simulations assuming additional bears would be necessary.

For scenario 1, I increased the population parameters slightly after the first year of supplemental stocking (Table 5). This was done after the first supplemental stocking and was used for all the other stocking scenarios. In scenario 2, I added 6 adult females and 12 cubs to the population for 2 consecutive years. With scenario 3, I added the standard stocking of 6 adult female bears and 12 cubs for 3 consecutive years. In scenario 4, I added the standard stocking of bears each year for 4 years. I continued the process of adding an additional standard stocking for each subsequent scenario until I completed 8 scenarios. Based on reports of black bear densities in upland habitats in the southeastern

Table 5. Black bear population parameter estimates used for population simulations, BSFA.

Parameter	1999		2000+	
	$\bar{x}$	SE	$\bar{x}$	SE
Cub-of-the-year (COY) survival	0.70	0.15	0.80	0.05
Litter COY survival	0.80	0.15	0.90	0.05
Subadult (1-3) survival (M)	0.87	0.05	0.87	0.05
Subadult (1-3) survival (F)	0.93	0.03	0.93	0.03
Adult (4+) survival (M)	0.85	0.19	0.88	0.19
Adult (4+) survival (F)	0.73	0.10	0.85	0.05
Litter production rate (age 3)	0.02	0.04	0.03	0.01
Litter production rate (age 4+)	0.85	0.05	0.90	0.05
Probability of COY litter = 1	0.15	0.27	0.15	0.27
Probability of COY litter = 2	0.49	0.27	0.49	0.27
Probability of COY litter = 3	0.34	0.27	0.34	0.27
Probability of COY litter = 4	0.03	0.03	0.03	0.03

United States (Warburton 1984, Carney 1986, Clark 1991, Coley 1995), it is reasonable to assume BSFA can support 1 bear/0.26 km^2. Therefore, BSFA could theoretically support approximately 200 bears. I ceased developing scenarios at 8 because by the time I introduced 8 stockings, I had surpassed the theoretical carrying capacity of the area of 200 bears.

Thirty-five bears were released from 1996-1999 with scenario 1; not including density effects, a population size of 200 bears was reached in 20 years (Fig. 33). However, stochastic simulations resulted in extinction within 8 years and possibly 200 bears in 11 years (Fig. 33). With scenario 2, 53 bears were released from 1996-2000 resulting in a population size of 200 bears in 17 years on average; at best, 200 bears was attained in 9 years and, at worst it was projected that the population could become extinct in 21 years (Fig. 34). The release of 75 bears with scenario 3 resulted in 200 bears in 13 years; at worst, extinction resulted in 45 years and at best, a population size of 200 bears was reached in 8 years (Fig. 35). Ninety-six bears were released with scenario 4 and on average, carrying capacity was reached in 11 years; extinction was not projected with this scenario within 50 years (Fig. 36). A total of 124 bears were released with scenario 5, resulting in a population size of 200 bears in 10 years (Fig. 37). The release of 152 bears with scenario 6 resulted in 200 bears in 9 years (range = 6-17 years) (Fig. 38). One hundred and eighty-three bears were released with scenario 7 (Fig. 39). A total of 216 bears were released with scenario 8 (Fig. 40). Common among all the scenarios is tendency for variation to increase over time. This is evident from the way the population growth curves widen as these estimates are projected into the future.

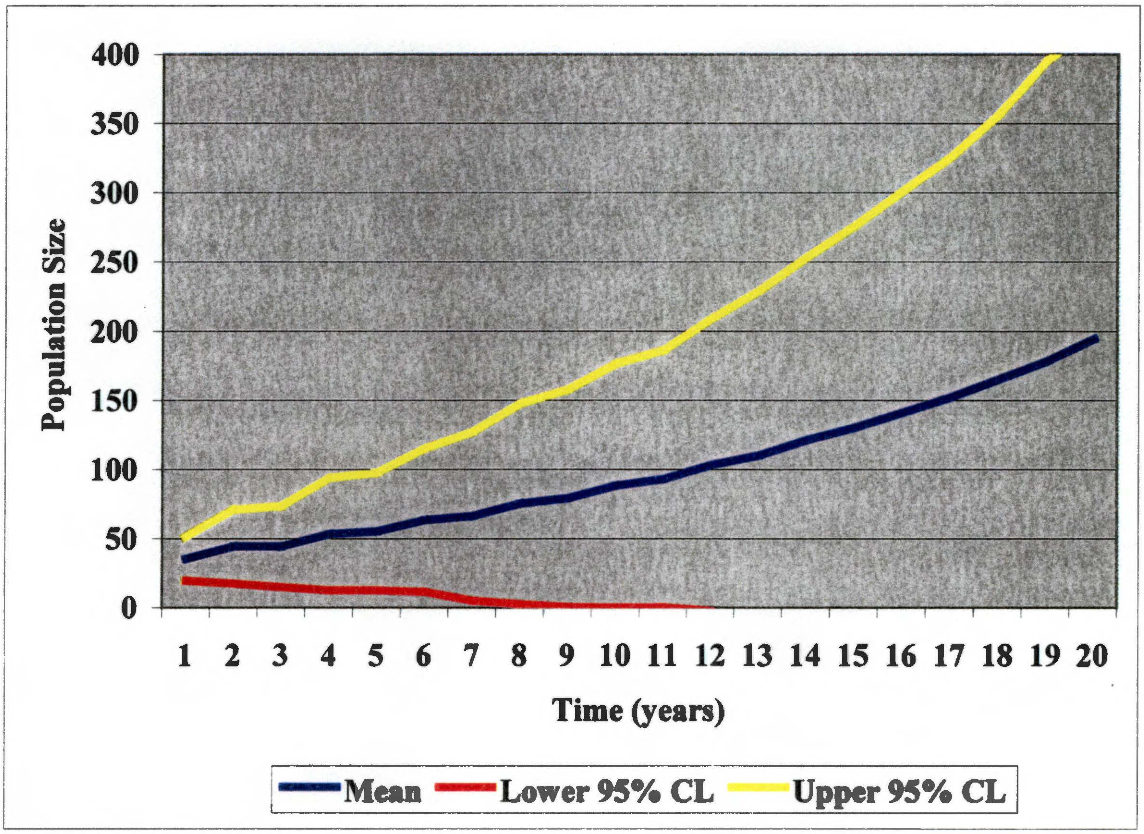

Fig. 33. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 1.

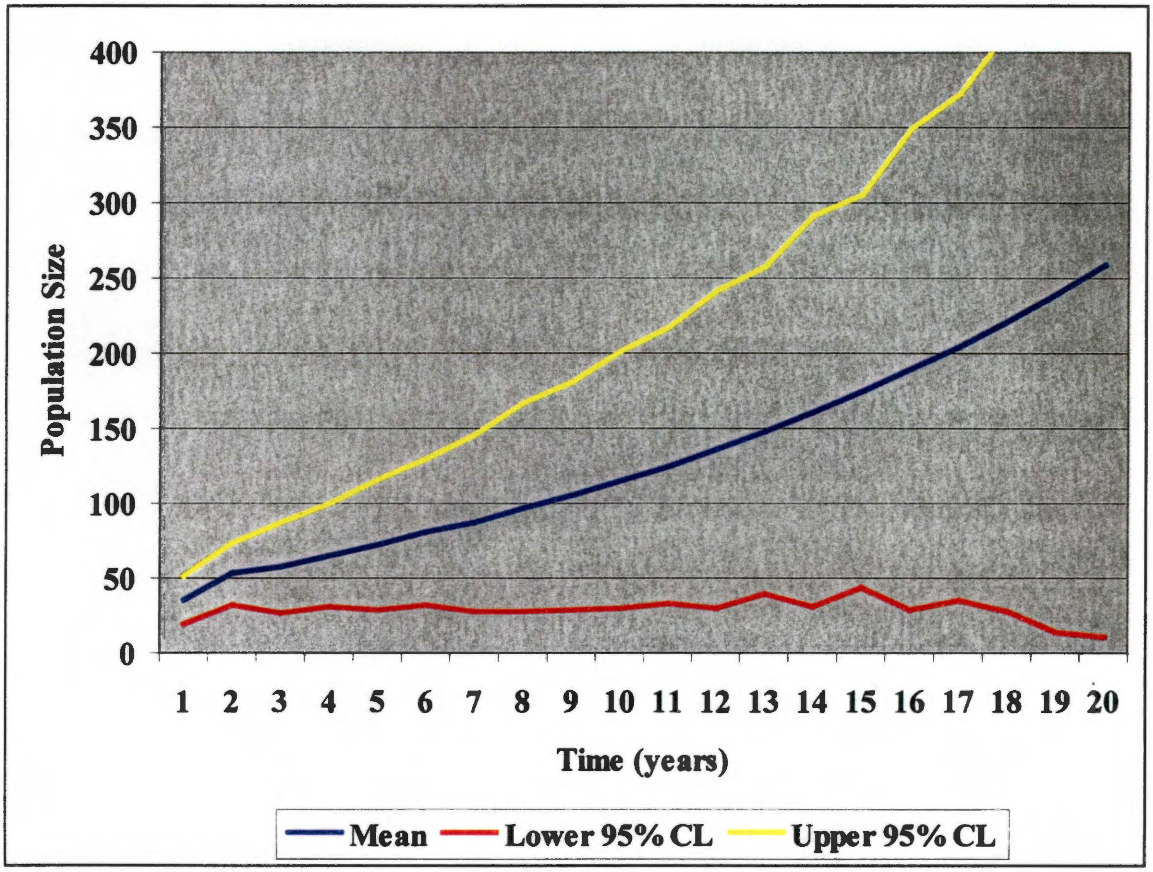

Fig. 34. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 2.

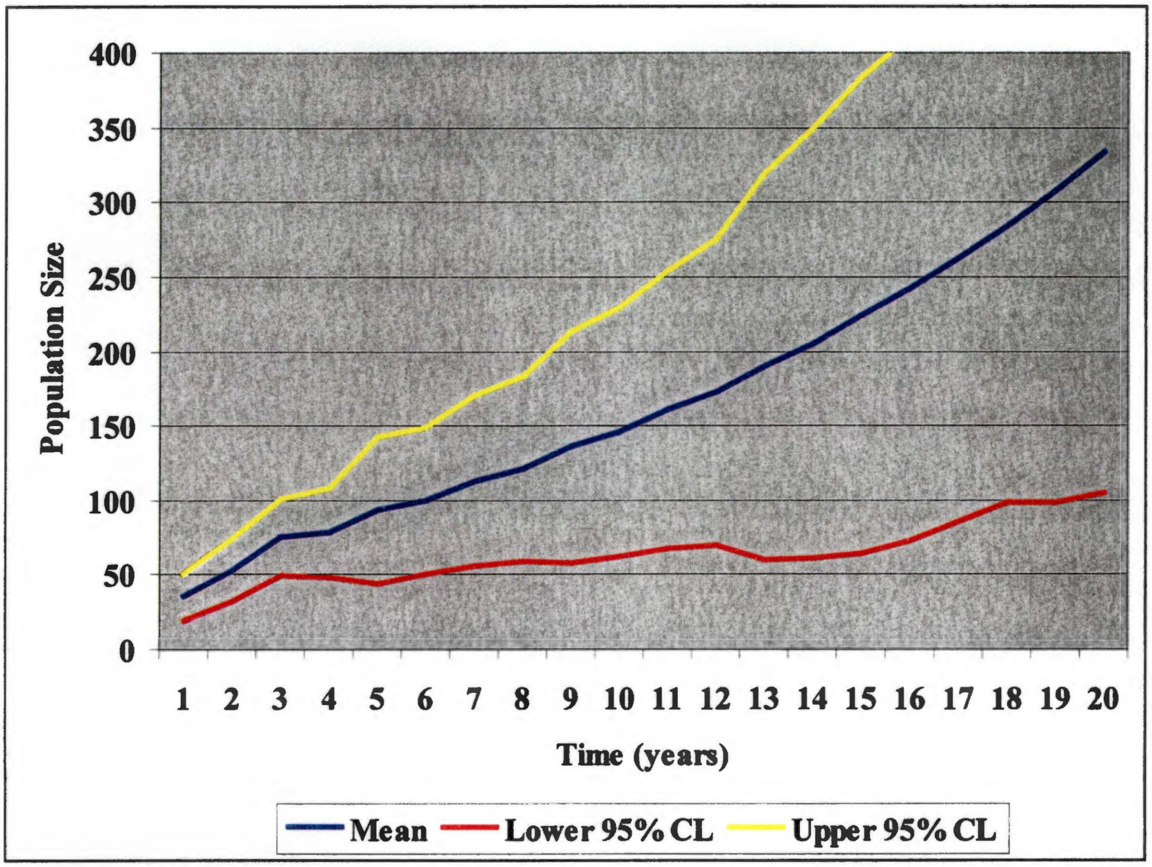

Fig. 35. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 3.

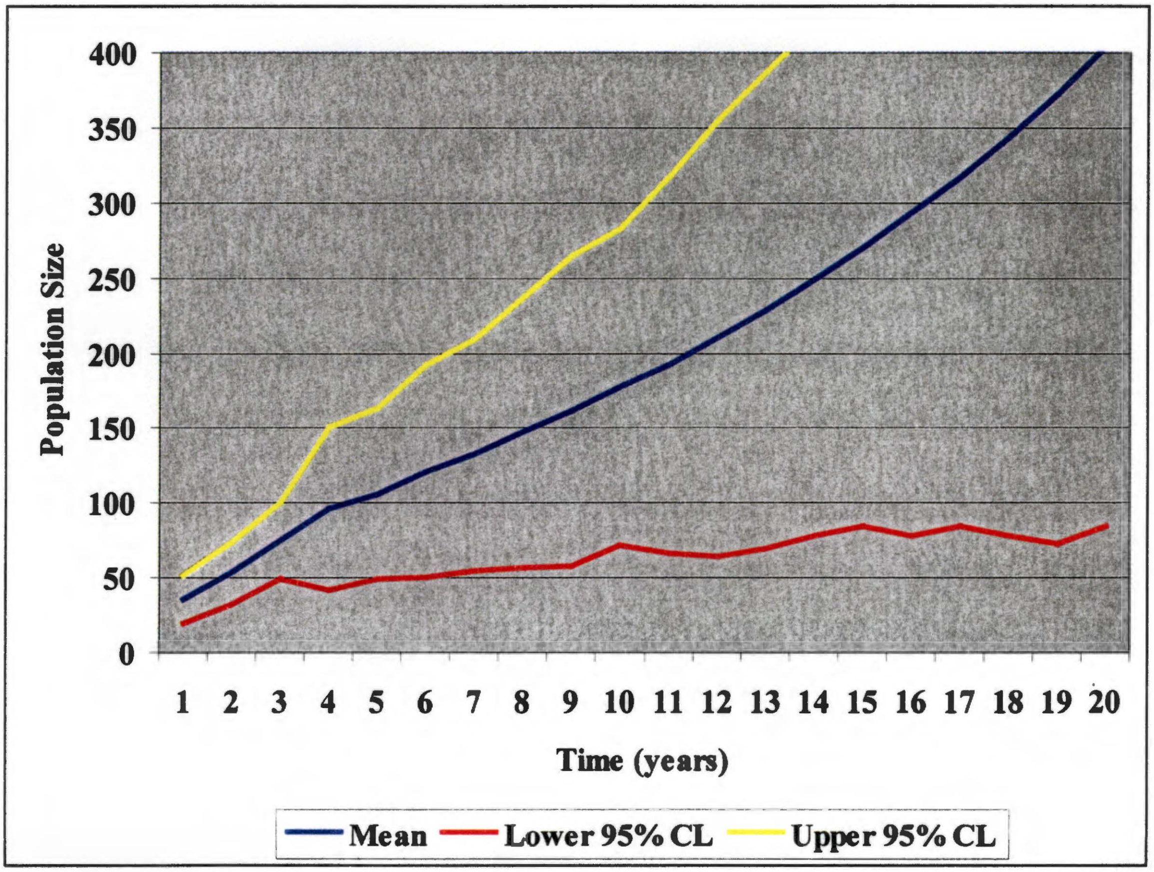

Fig. 36. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 4.

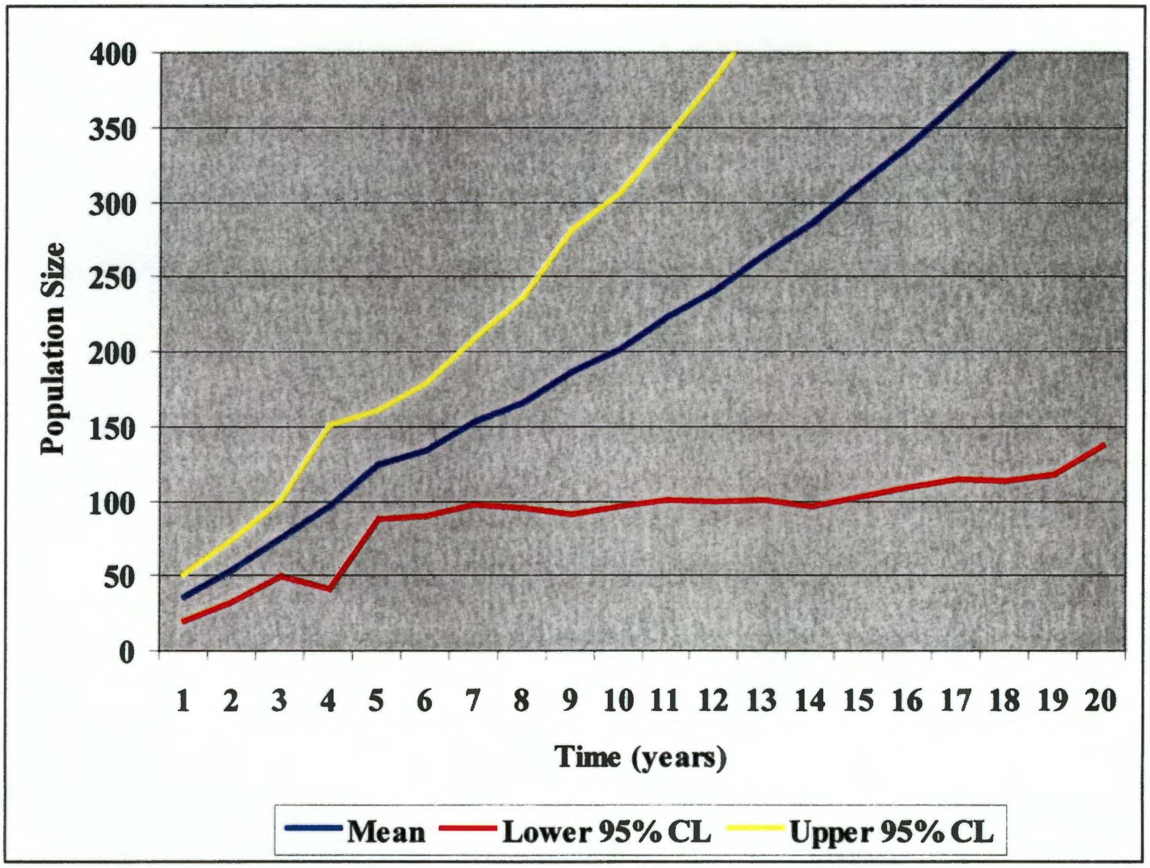

Fig. 37. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 5.

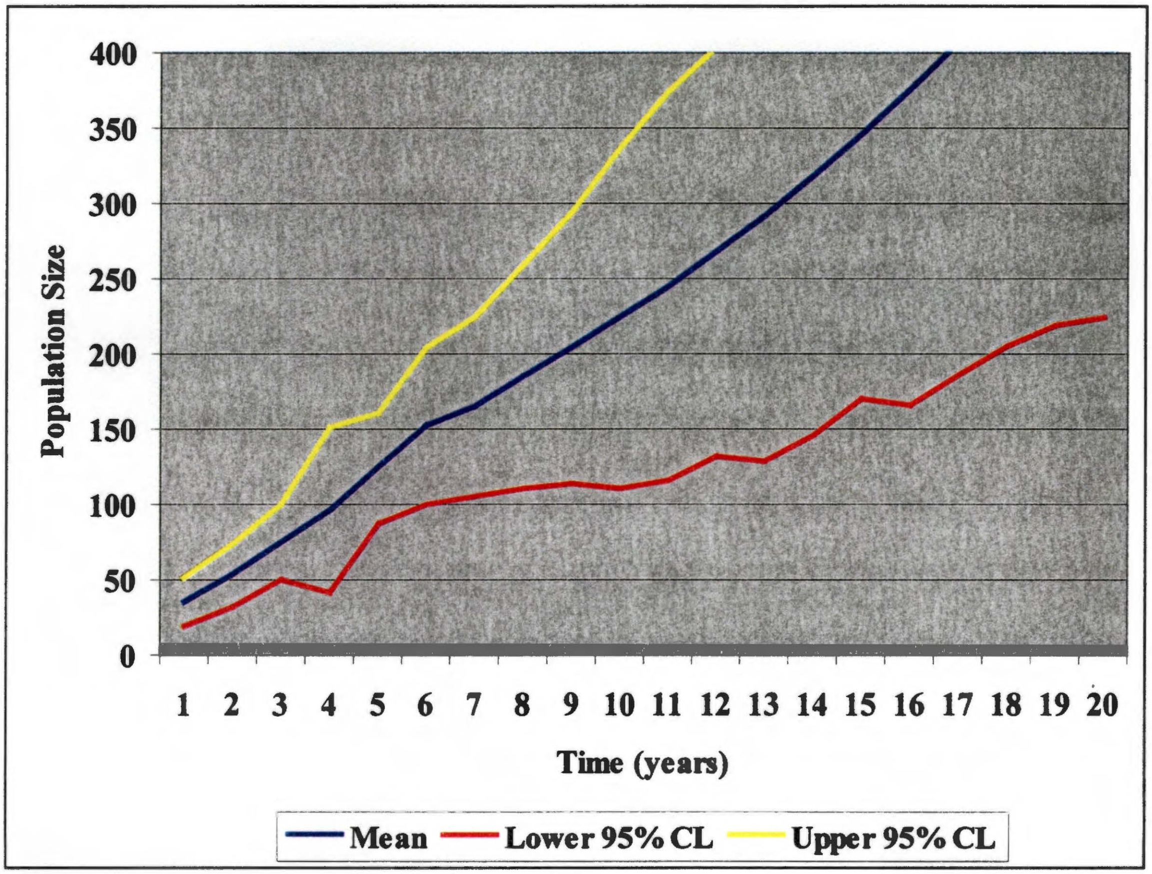

Fig. 38. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 6.

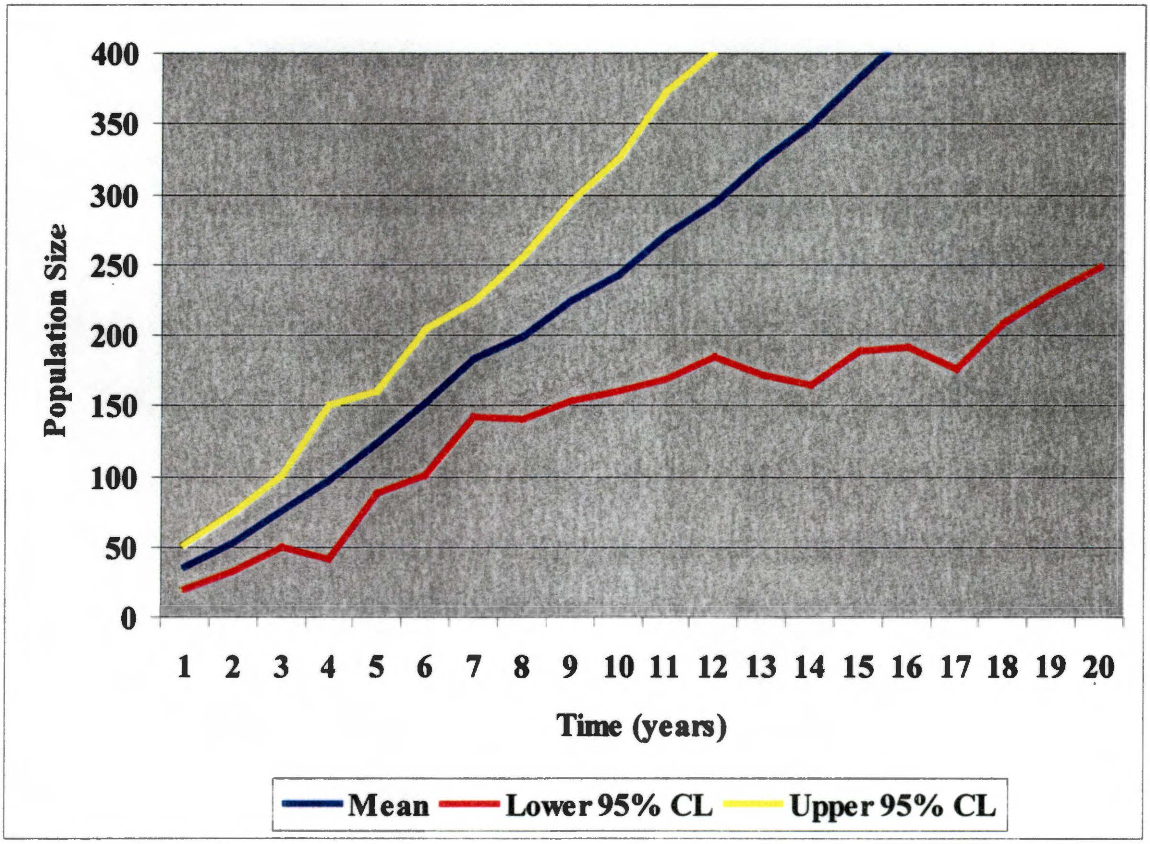

Fig. 39. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 7.

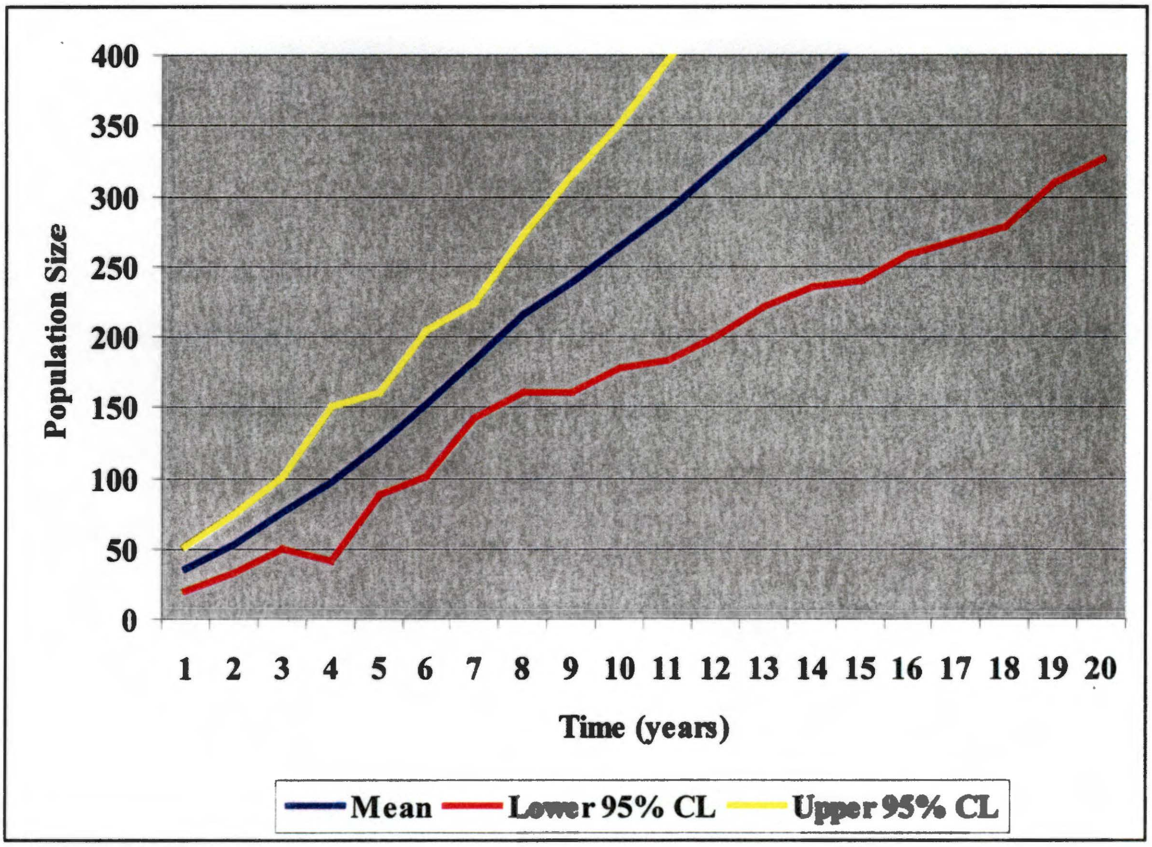

Fig. 40. Estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee with scenario 8.

This occurs because the variation in growth for each successive year is dependent on all previous years; therefore, variation and confidence limits increase with time. The value of the population model is in the ability to compare the relative value of 1 stocking scenario to others to determine the most efficient and timely way to reestablish bears to BSFA (Fig. 41). In general, each successive scenario produces a more steeply sloped growth curve than previous scenarios, with decreased variation. However, the magnitude of increase begins to subside with each new scenario (Fig. 41). For example, because of increased growth rates from additional bears, carrying capacity was reached 4 years earlier with scenario 2 than with scenario 1. However, carrying capacity was reached only 1 year earlier with scenario 6 as compared to scenario 5; hence, diminishing returns are attained. Diminishing returns are such that by scenario 8, the translocation of additional bears has virtually no effect.

Under scenarios 1, 2, and 3, in spite of additional stockings, the probability of extinction was 20% (10 of 50 simulations), 4% (2 of 50 simulations), and 2% (1 of 50 simulations) of the time, respectively. Conversely, the probability of extinction for scenarios 4-8 was 0%.

Habitat Analysis

Habitat sections 4 and 5 contained most of the bear locations (Table 6). The data did not differ from normal ($W = 0.967$, $P = 0.479$) and the MANOVA indicated an overall effect (Wilks' Lamda = 0.048, $F = 20.052$, $df = 4$, $P = 0.007$) in the analysis of

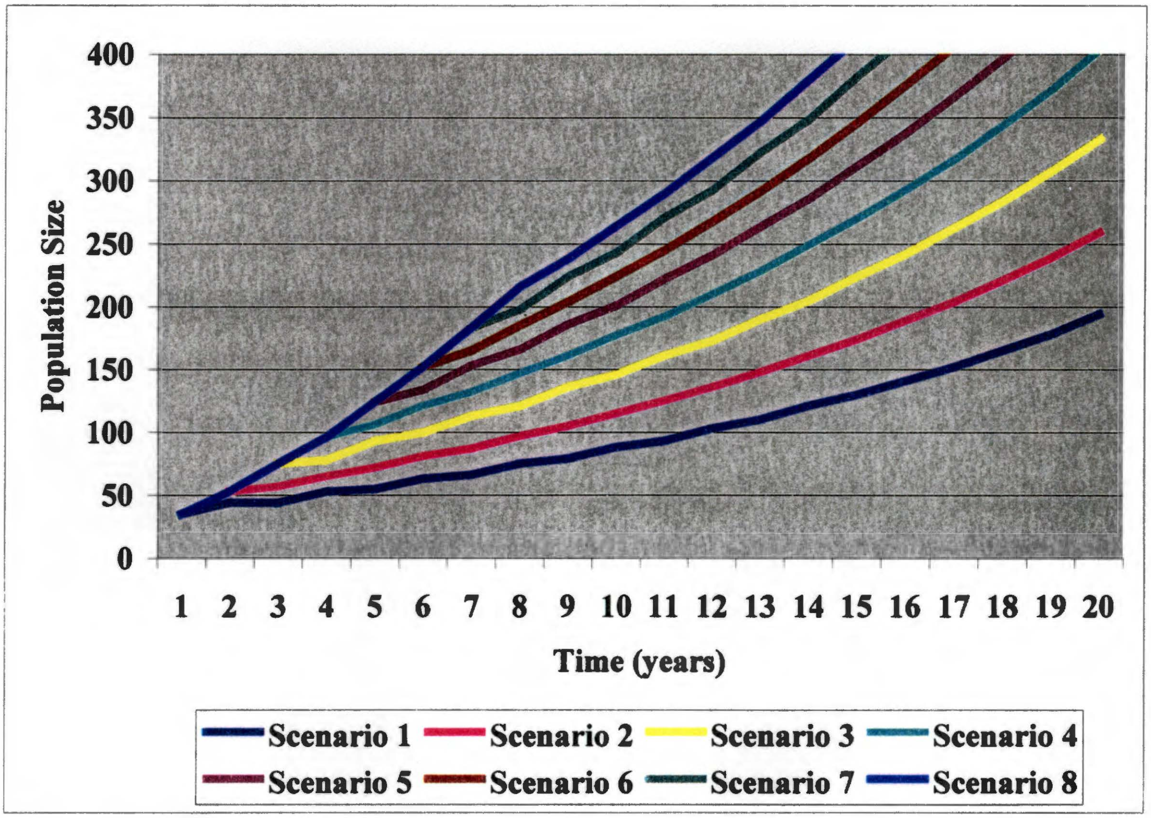

Fig. 41. Comparison of estimated population growth of translocated bears in the Big South Fork Area, Kentucky and Tennessee among 8 stocking scenarios.

Table 6. Locations of black bears within each habitat section of the Big South Fork National River and Recreation Area, Kentucky and Tennessee, 1996-1997.

Habitat Section	Number of Locations	% of Total Locations
1	66	18.8
2	28	8.0
3	1	0.3
4	127	36.3
5	128	36.6
Total	350	100.0

habitat use at the landscape level (second-order selection). Section 3 was used less than all other sections for the second-order selection. For analysis of habitat use of the sections within the home range (third-order selection), the MANOVA indicated no effect (Wilks' Lamda = 0.182, F = 4.49, df = 4, P = 0.873). Therefore, no section was used more than another within a bears range of movements.

CHAPTER 5

DISCUSSION

Movements

No statistical differences in total movement or net movement were detected between the 2 release groups (winter- versus summer-release); however, the power of the statistical tests was weakened by small sample sizes. Also, there was considerable variation introduced by certain individuals. For example, 1 summer-released bear (S-050) that was 2.5 years of age when released never left the area and maintained very restricted movements during the first month post-release. This was atypical behavior compared to the other summer-released bears I monitored (Table 2). Alt et al. (1977) suggested that young bears demonstrate stronger site affinity to the release area compared to adult bears after translocation. Miller and Ballard (1982) found that, among non-nuisance translocated brown bears, non-returning bears of both sexes were younger than returning bears. Subadult female grizzly bears were found to be the best candidates for translocation for population augmentation purposes because of their small home range sizes and because they were the age and sex class with the lowest probability of leaving the target area (Servheen et al. 1987). In a study of translocated nuisance bears in Virginia, Comly (1993), found that subadult male bears moved less and were less likely to move in a homeward direction than adult male bears. Subadult bears possibly demonstrate less proclivity to return to their area of origin because they have less time invested in their original range than adult bears. Therefore, it is understandable that this

summer-released subadult bear showed such affinity to the release area. I believe that stronger statistical differences in movements between the winter and summer technique would have resulted if only adult bears had been compared. On the other hand, translocation of subadult females during summer may help increase site affinity to the new area.

Another confounding factor is that 2 summer-released bears (S-090 and S-190) left the area after release and moved so rapidly that I could not maintain radio contact. These bears returned to the area; however, I could not collect complete movement data for these 2 bears during the crucial first 2 weeks post release. So, the movement rates of these 2 bears likely were underestimated. Therefore, to estimate post-release movements during the time that contact was lost, I substituted total and net movements that were typical of most summer-released bears. After doing so, I found a difference in both cases; total and net movements were smaller for winter-released bears than for summer-released bears.

I believe the most important criterion of the movements of translocated bears is circuity because it is a measure of site affinity. If it were true that there were no differences in the net and total movements of winter- and summer-released bears, it would not be so important when one considers the circuity of each group. When winter bears moved after den emergence, they demonstrated a tendency to move in and around the release area. In contrast, the summer-released bears tended to move directly away from the release area. It is common for translocated bears to leave release sites within a few days of release and move widely regardless of whether they return to their place of

origin or not (Alt et al. 1977, Massopust and Anderson 1984). All but 1 of the summer-released bears moved directly away from BSFA after release (Figs. 13-18). However, this was not the case for winter-released bears (Figs. 6-12). Two winter-released bears without cubs moved widely within the release area where they subsequently restricted their movements. So, the length of total movement of winter-released bears was not problematic because their movements were restricted to BSFA and not homeward.

All winter-released bears demonstrated movements too constrained to be random within 1 year post-release and most did so within 6 months. Summer-released bears did not demonstrate the same trend. Three of the 6 summer-released bears continually demonstrated random movements until 2 were killed crossing roads and the other was returned to GRSM because of extensive movements. Two summer-released bears displayed movements too constrained to be random within 6 months of release but, because they immediately left BSFA upon release, I did not record complete data on these early movements. Therefore, I missed the most critical post-release movement data for those 2 bears. I suspect that immediate post-release movements would not be constrained for these 2 bears if those data had been available.

One summer-released bear (S-210) demonstrated movements too constrained to be random within the first 2 weeks post-release (Fig. 26). However, this occurred because she made a constrained movement homeward; it was not a result of site fidelity. This demonstrates an important aspect of the site fidelity test in the MOVEMENT module of ArcView; constrained movements do not always indicate site fidelity. The post-release movement data for this bear indicated a direct path that did not meander

across the landscape. It is probable that these movements were not random; however, this bear demonstrated no site fidelity. Likewise, 5 of the 7 winter-released bears demonstrated immediate post-release movements that either did not differ from random or were too dispersed than random; however, these bears remained in the area and demonstrated site fidelity. Therefore, circuity may be a better measure of site fidelity.

The MRPP test detected a shift in the movements of non-returning bears over time. All non-returning bears restricted their movements within 9 months and most did so within 6 months. This suggests that non-returning translocated bears can move extensively immediately after release but generally restrict their movements inside the release area within 9 months or less. The random movements detected by the site fidelity test of many non-returning bears support this observation. These extensive post-release movements are probably exploratory; as the bears learn the landscape they settle into a definable home range.

All bears were translocated a minimum distance of 160 km from GRSM to BSFA with physiographic barriers such as the Big South Fork River, the Cumberland Mountains, Interstate 75, and Interstate 40 in between. Rogers (1986) suggested that a distance >64 km was adequate for preventing homing in translocated bears; however, a distance more than twice that was ineffective in deterring homing by most summer-released bears. Also, McArthur (1981) found that physiographic barriers were correlated with the success of transplants; however, barriers such as a major river, a mountain range, and 2 Interstate highways were ineffective in preventing homing by most summer-released bears.

Survival

The cumulative (winter- and summer-released bears combined) annual survival rate (0.66) of bears in BSFA is relatively high when compared to that of translocated nuisance black bears in southwestern Virginia, where cumulative survival was 0.37 for female bears (Comly 1993). First-year annual survival of winter-released bears (0.88) was similar to, or surpassed that of naturally occurring populations in Montana (0.86) (Jonkel and Cowan 1971), Tennessee (0.78) (Beeman 1975), Virginia (0.74) (Hellgren 1988), and Arkansas (0.98) (Clark and Smith 1994). This is not a common result among translocated bears and is another indication of the value of the winter-release technique. In Wisconsin, Massopust and Anderson (1984) found that survival was lower for translocated bears (0.56) than for non-translocated bears (0.72). Survival of translocated bears in Maine (Hugie 1982), Tennessee (Stiver 1991), and Virginia (Comly 1993) was lowest during the first several months after release. Furthermore, Comly (1993) found that survival of translocated nuisance bears became greater 150 days after release, presumably because of familiarity with the new area and home range establishment. I found similar results for summer-released bears but not winter-released bears because survival for the latter was high throughout the study. The denning period at BSFA likely acted as an acclimation period, effectively curbing the homing ability of some bears. Also, the presence of new-born cubs likely prevented extensive post-release movements that could have led to increased mortality. The 1 mortality of a winter-released bear occurred in the den just after translocation. As stated above, this mortality was caused by a uterine infection and was not associated with the translocation process. Survival of

adult bears typically is high during the denning season (Jonkel and Cowan 1971, Rogers 1987b, Comly 1993) and I regard this 1 mortality as an aberration.

The 3 mortalities of summer-released bears were caused by vehicle collisions during extensive post-release movements. Vehicle collisions were a major mortality source for translocated nuisance bears in Virginia (Comly 1993) and non-nuisance translocated bears in Pennsylvania (G. Alt, Penn. Game Comm., unpubl. rept.). Clearly, immediate post-release survival is an important component of any translocation effort to establish a population of black bears. Because of high post-release survival, releasing bears with the winter technique demonstrates a clear advantage over the summer release technique.

Bait-Station Survey

During the bait-station survey of 1996 there were 5 adult female bears with up to 11 cubs at BISO. During the bait-station survey of 1997, assuming censored bears were alive, there were up to 8 adult female bears, 8 yearling bears, and 5 cubs. During the 1998 bait-station survey there were up to 21 bears, excluding natural reproduction. With such a small number of bears, it is understandable that none of the bait sites were visited by bears. However, this does not diminish the importance of the bait-station survey. Bait-station surveys are a simple, economical method for monitoring trends in bear populations as well as relative density. I believe it is important to continue the bait-station survey at BISO to monitor future bear population growth and the distribution of bears.

Den Visits

The dramatic weight gain demonstrated by 2 translocated bears could be a testament to the quality of the habitat in BSFA. However, the absence of adult male bears could be a factor. Dominant adult male bears typically utilize areas with abundant fall food sources; consequently, adult females tend to avoid these areas to decrease the probability of agonistic encounters (Garshelis and Pelton 1981, van Manen 1994). If a viable population of bears comprised of a normal age and sex structure is established at BSFA, 2-fold increases in summer to winter weights may not occur.

Sightings and Human-Bear Interactions

The absence of nuisance activity by translocated bears is especially noteworthy considering the long-range movements and opportunities for encounters with humans by some bears, as well as the penned acclimation of summer-released bears. The on-site acclimation of wild-caught, summer-released bears in pens carried a risk of human habituation. Therefore, I implemented procedures to minimize this risk. I believe these procedures, as well as the use of wild-captured bears, helped prevent nuisance behavior by translocated bears. Griffith et al. (1989) found that wild-caught animals from a high density and increasing populations had the highest probability of translocation success. Clark and Smith (1990) attributed the use of wild-captured bears to the success of the repatriation effort in Arkansas.

Seven translocated bears were censored from the study because of dropped collars or collar failure. While the fates of these bears cannot be determined with scientific

certainty, I believe it is likely that many of these bears continued to reside in BSFA. It is unlikely that an uncollared bear left the area without notice. Because of the novelty of seeing a bear in BSFA, reports of sightings by the public were common. Thirty-three of the 53 bear sightings occurred during this study (July 1996-October 1998). I never encountered a situation when a bear sighting occurred outside BSFA that I could not verify the presence of these homing bears with telemetry. Most sightings were of summer-released bears attempting to return to GRSM. Furthermore, NPS employees and BISO visitors have reported sighting bears in areas that bears that had dropped collars were known to reside before being censored. Subsequent radio telemetry indicated that none of the radio-marked bears were in those areas. Therefore, I suspect that these reports are of translocated bears that had dropped their radio collars.

In August 1998, NPS personnel received a report of an adult bear with 2 cubs near the intersection of TN 297 and Bandy Creek Rd in BISO; this is an area that a winter-released bear, that had dropped her collar, used prior to being censored. Also, a logging crew working in an area near the border of DBNF and BISO on Laurel Ridge Road reported seeing 1 adult bear with 3 cubs and another adult bear with 2 yearlings in August 1998. Both family groups were seen by the logging crew on multiple occasions over several months. If the sighting of the female bear with cubs is accurate, this would indicate that at least 1 transient male bear was present or that 1.5-year-old males stocked as cubs were capable of breeding. Breeding by subadult male bears is thought to be uncommon. The age of primiparity of female bears can be determined by radio collaring subadult female bears and tracking them to dens to determine when reproduction occurs.

Obviously, this technique will not work for subadult male bears. However, Rogers (1977) noted that female bears become sexually attractive to males before becoming receptive and this created competition between males prior to copulation. Rogers (1977) also noted that mating privileges were decided between males through aggression, with larger males often chasing smaller males away. The lack of older, dominant males could have allowed these bears to mate at such a young age. The possibility remains that transient males occupy the area and were able to breed this translocated female with 3 cubs. Also, the confirmation of natural reproduction found from den visits in 1999 lend further evidence that transient males may be in the area or that cubs stocked with their mothers in 1996, 2.5 years old at the time of estrus for these females, may have been capable of breeding. In any event, the confirmation of natural reproduction among these translocated females indicates there are sufficient males in the area to ensure reproduction.

Population Modeling

Because the actual population parameters at BSFA during those years following repatriation are unknown, I cannot accurately predict how many bears will reside in BSFA or when that number will be reached. However, the parameter values I chose to increase are realistic, if not conservative, for a colonizing bear population. I expect growth rates to increase as bears become more established and, indeed, survival rates of released bears increased after year 1. The purpose of modeling the future growth of the population under different stocking scenarios was to provide wildlife managers with

options for stocking bears in BSFA. Depending on objectives, managers can choose a stocking strategy that best meets the goals of population establishment. For example, if managers want to establish a population of bears in BSFA, they may want to avoid scenarios 1-3 because of the probability of extinction associated with those strategies. Depending on the objectives and constraints such as logistics, time, funding, and manpower, managers can choose the appropriate scenario. However, it appears that beyond scenarios 4-6, the effort required to translocate bears is not rewarded with the same population growth return as estimated with earlier scenarios. In other words, a point of diminishing returns begins somewhere around scenarios 4-6. Beyond scenario 6, it is projected that the resident BSFA bears will be better at adding new bears to their population than humans are. So, adding bears beyond scenario 6 will be inefficient and, perhaps unnecessary.

With this population model, I have attempted to mimic reality by using parameter values that reflect breeding and survival of a colonizing bear population. In the early years, the model likely underestimates potential population growth. Likewise, the model undoubtedly overestimates population size and growth in later years because growth rates will decline as the population nears carrying capacity. Therefore, conclusions regarding future population size should not be drawn from the graphs. My main intent here is to demonstrate the relative value of additional years of bear stockings, particularly in the early years, and also illustrate the relatively small contribution that bears released later in the program would have on the final population size. This is best demonstrated by comparing population size at any particular time among scenarios. Also, it is important

to note that variation has been built into the model based on stochasticity from the population parameter estimates; however, important environmental stochasticities remain unaccounted for in the model. For example, I cannot predict how tanslocated bears will respond when released in BSFA during a mast failure.

It is inappropriate to use the population model to predict future population size beyond a few years at BSFA. However, some idea of the potential for population growth can be determined from other bear populations in the Southeast. The limited dispersal capabilities of bears that limit colonization to new areas can create an advantage for localized population establishment and increase. Caughley (1977:58) explained that lack of dispersal increases rate of population increase, thereby promoting a rapid population build-up in low population density situations. After translocating 254 black bears into the Interior Highlands of Arkansas in the 1960s, that population grew to an estimate of >2,500 within 25-30 years (Smith et al. 1990), a 10-fold increase. Clearly, black bears have demonstrated the potential for relatively rapid population growth. Numerous studies have pointed to the importance of establishing an adequate number of founding individuals to ensure population establishment (Griffeth et al. 1989, Smith and Clark 1994, Wolf et al. 1996, van Manen and Pelton 1997). It will be important to translocate a sufficient number of bears to BSFA to ensure successful population establishment and growth. This is illustrated in the population model; the model required the translocation and establishment of 96 bears (including cubs), excluding environmental stochasticities, to eliminate the chance extinction could occur.

Habitat Analysis

Overall HSI values were 0.63, 0.49, 0.56, 0.71, and 0.55 for sections 1-5, respectively (van Manen 1990:123). van Manen (1990) indicated that sections 1, 3, and 4 appeared to have the best black bear habitat because of high availability and productivity of food sources and protective cover. However, my data indicate that translocated bears only used sections 1 and 4 more than section 3. More importantly, section 3 was used less than all other sections.

The lack of bear utilization of section 3 is most likely influenced by the site of their release. Section 3 is 20-30 km away from all release sites; all other sections are within <5 km from any release site. This distance could have influenced utilization by translocated bears, and favored the closest sections for subsequent home range placement.

TN highway 297 traverses east and west across BISO, effectively separating section 3 from the remaining sections to the north. This road could have deterred use of section 3 by translocated bears. Road avoidance by resident bears has been documented in North Carolina (Brody 1984, Brody and Pelton 1989, Seibert 1989, Beringer et al. 1990), GRSM in Tennessee (Quigley 1982), Cherokee National Forest in Tennessee (Villarubia 1982), West Virginia (Miller 1975), and Maine (Hugie 1982). However, Comly (1993) found that translocated bears in southwestern Virginia typically do not exhibit road avoidance.

van Manen (1990) reported that fall food productivity was adequate but suboptimal in BSFA and expected productivity to become optimal in approximately 10 years, as the forest matured. Because this project was conducted approximately 10 years

after the time that van Manen (1990) collected vegetation data for habitat analysis, the forest could have matured to the extent that bears would not use sections 1, 3, and 4 more than other sections. Therefore, it is understandable that translocated bears may not use the habitat as expected according to the 1990 habitat analysis.

CHAPTER 6

MANAGEMENT AND RESEARCH IMPLICATIONS

The relationships among post-release movements, site fidelity, homing, and post-release survival govern short- and long-term success of repatriation efforts. The winter translocation technique demonstrated clear advantages over the summer technique for all these measures. Therefore, the winter translocation technique should be used for future repatriation efforts. The effectiveness of the summer-release technique might be improved with longer acclimation periods or the use of subadult bears. However, longer acclimation periods would limit the number of animals that could be released per year, slowing population establishment.

Extensive movements by bears without cubs were common regardless of translocation technique. However, winter-released bears without cubs moved within BSFA and not homeward. Winter-released bears with cubs displayed the most restricted post-release movements. Extensive movements within the release area should be expected. However, these movements typically become more concentrated within 9 months of release.

If no more bears are translocated to BSFA, the data suggest a 56% chance that the population will become extinct. This is due to the atypical standing age distribution and skewed sex ratio currently at BSFA rather than habitat quality. Every indication is that habitat quality at BSFA is excellent. The population simulations suggest that 4 additional stocking of 6 adult female bears with 12 cubs will ensure population viability. It is

important to note that no males, other than cubs, were added to the population. I anticipate that it may be difficult to successfully relocate males to BSFA and, because den visits and sightings have confirmed that natural reproduction is occurring among translocated bears, the translocation of adult males may not be necessary. The addition of 6 adult females with 12 cubs each year for 4-6 more years will yield the most timely results. Stocking bears beyond 4-6 years yields greatly diminished returns. Likewise, based on the model, anything less than 4 stockings fails to eliminate the probability of extinction.

The bait-station survey should continue at BISO to monitor trends in the bear population size. This will become increasingly important if the population increases and expands. The current bait-station survey is established on BISO only. Translocated bears also used the southern portion of DBNF and Pickett State Park; managers may want to expand the bait-station survey to those areas.

If managers decide to establish a viable population of bears in BSFA, that effort should include proper monitoring through radio telemetry to refine survival estimates and monitor reproduction. This information will help develop better growth projections that will be important in determining the failure or success of the repatriation effort.

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