To the Graduate Council:

I am submitting herewith a thesis written by Brandon J. Wear entitled "Reintroducing Black Bears to the Arkansas Gulf Coastal Plain". I have examined the final paper copy of the 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:

Frank T. van Manen

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Sammy L. King

Acceptance for the Council:

Vice Provost and Dean of Graduate Studies

REINTRODUCING BLACK BEARS

TO THE ARKANSAS GULF COASTAL PLAIN

A Thesis Submitted for the

Master of Science Degree

The University of Tennessee, Knoxville

Brandon Jarrett Wear

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ABSTRACT

Black bear (*Ursus americanus*) populations in North America have been dramatically reduced as a result of habitat loss, fragmentation, and/or unregulated harvest. The Interior Highlands, the West Gulf Coastal Plain, and the Delta regions of Arkansas once supported large numbers of black bears but, by the early 1900s, bears in the state were limited to a remnant population in the present-day White River National Wildlife Refuge (hereafter "White River"). Bears have since been reestablished in the Interior Highlands of the state and the population in the Delta has grown, but the Gulf Coastal Plain remains uninhabited by a viable bear population. Restoration of bears to the Coastal Plain can provide ecological benefits such as linking isolated bear populations and reestablishing this component of the native ecosystem.

In an attempt to reestablish bears in this region, I used a winter-release technique to translocate 23 adult female black bears with 56 cubs. That technique has been shown to reduce homing of adult female bears. Bears were translocated approximately 160 km from their dens at White River to man-made den structures at Felsenthal National Wildlife Refuge (hereafter "Felsenthal") during spring 2000–2002.

I monitored the fates of all reintroduced bears and evaluated 1-month, 6-month, and 1-year movement parameters of surviving adult females. Total movement of adult female bears the first month post-emergence averaged 43 km. First-month mean daily movements averaged 923 m, and net movement for the first month averaged 27 km. Total movement of surviving adult females 6 months after emergence averaged 223 km; mean daily movement averaged 1,132 m, and net movement during this time averaged 34

km. Total movement of adult females that survived to 1-year post-emergence averaged 311 km. Mean daily movement averaged 782 m, and net movement during the first year averaged 33 km. Average circuity values decreased from 0.47 to 0.14 between 1-month and 6-month intervals, and after 1 year averaged 0.09.

I estimated survival for translocated bears using the Kaplan-Meier staggered entry procedure. Mean first-year post-release survival of adult female bears was 0.587. Cumulative annual survival for all female bears that survived >1-year post-release was 0.909. Mean annual cub survival of female bears surviving the first year was 0.637.

I conducted cub counts and visited winter dens to monitor the survival of translocated cubs. In all instances, the number of cubs present in winter dens corresponded with the number of cubs observed during fall cub counts. I documented natural reproduction in 2 translocated adult females. This, combined with sightings of unmarked adult male bears, suggests that male bears do not need be translocated to Felsenthal.

Project personnel documented interactions between humans and bears during the study. Over 40 bear sightings were reported from 2000–2002. There was little evidence of nuisance activity, and property damage by translocated bears was minimal.

I used a population model (RISKMAN, version 1.8.006; Ontario Ministry of Natural Resources, Toronto, Ontario, Canada) to estimate population growth and probability of extinction. The model was based on estimates of 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-, or 4-cub litters. I stochastically modeled population growth and extinction rates under various stocking scenarios. With no additional bears translocated to Felsenthal, extinction rates were 22% after 50 years. When I modeled up to 6 annual stockings of 6–12 adult females and 12–24 cubs, probability of extinction declined by 1–6%. Relatively high standard errors and yearly environmental variation incorporated into the model, coupled with low first-year survival rates, likely increased extinction probabilities.

I used compositional analysis (Aebischer et al.1993) to evaluate how translocated bears utilized available habitat. Available habitat was determined by the farthest distance traveled by any of the translocated bears. I delineated habitat types for the study area using Multi-Resolution Land Cover data (MRLC; Vogelmann et al. 1998) at a 30- x 30-m cell resolution. Woody wetlands ranked highest among available habitat types at both second- and third-order selection levels. All translocated bears were released in upland pine or mixed forest habitats at Felsenthal to avoid den-site flooding. Nevertheless, bears utilized wetland habitat types more than all other available habitats following den emergence. That trend was detected as bears made early exploratory movements, and became more evident as bears established home ranges within the landscape. Wooded wetlands were more exclusively used when searching for and establishing home ranges, but once established, all forested habitat types within the home range were utilized. The selection of wooded wetlands by translocated bears clearly demonstrates the importance of this habitat type to black bear restoration efforts in the Gulf Coastal Plain.

Lands containing wooded wetlands were influential in home range establishment, and should be managed as potential bear habitat to aid in the restoration process. Also, future land acquisitions should be focused in areas where this potentially limiting habitat type remains.

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CHAPTER I

INTRODUCTION

History of Black Bears in Arkansas

Black bear populations have been dramatically reduced in many areas as a result of habitat loss and fragmentation and unregulated harvest (Servheen 1990). Range contraction and fragmentation is particularly evident in the southeastern United States, where bears now only occupy 20% of their original range (Pelton and van Manen 1997; Fig. 1). In the Southeast, urban sprawl and clearing of bottomland hardwoods have negatively impacted black bear populations during the last century by decreasing suitable habitat, restricting access to important food sources, and reducing genetic exchange among local populations (Pelton 1991). Bottomland hardwood forests in the Mississippi River Alluvial Valley have decreased from 8.5 million ha prior to European settlement to approximately 2 million ha in 1991 (The Nature Conservancy 1992). In recent years, however, federal and state land acquisitions and subsequent management regulations, along with conservation-based programs for private landowners, have led to marked recovery of habitat and better protection of bears in many areas of their historic range.

Historically, the Interior Highlands, the West Gulf Coastal Plain, and the Delta regions of Arkansas supported large numbers of bears. Bears once were so abundant that Arkansas was unofficially known as "The Bear State" (Holder 1951). Black bears were prized by early settlers for their skins, meat, and oil, and early travelers provided many detailed accounts of bears in the area (Featherstonhaugh 1844, Gerstacker 1854, Nuttall 1821, Schoolcraft 1821). During the "logging boom" of the 1800s, the large number of

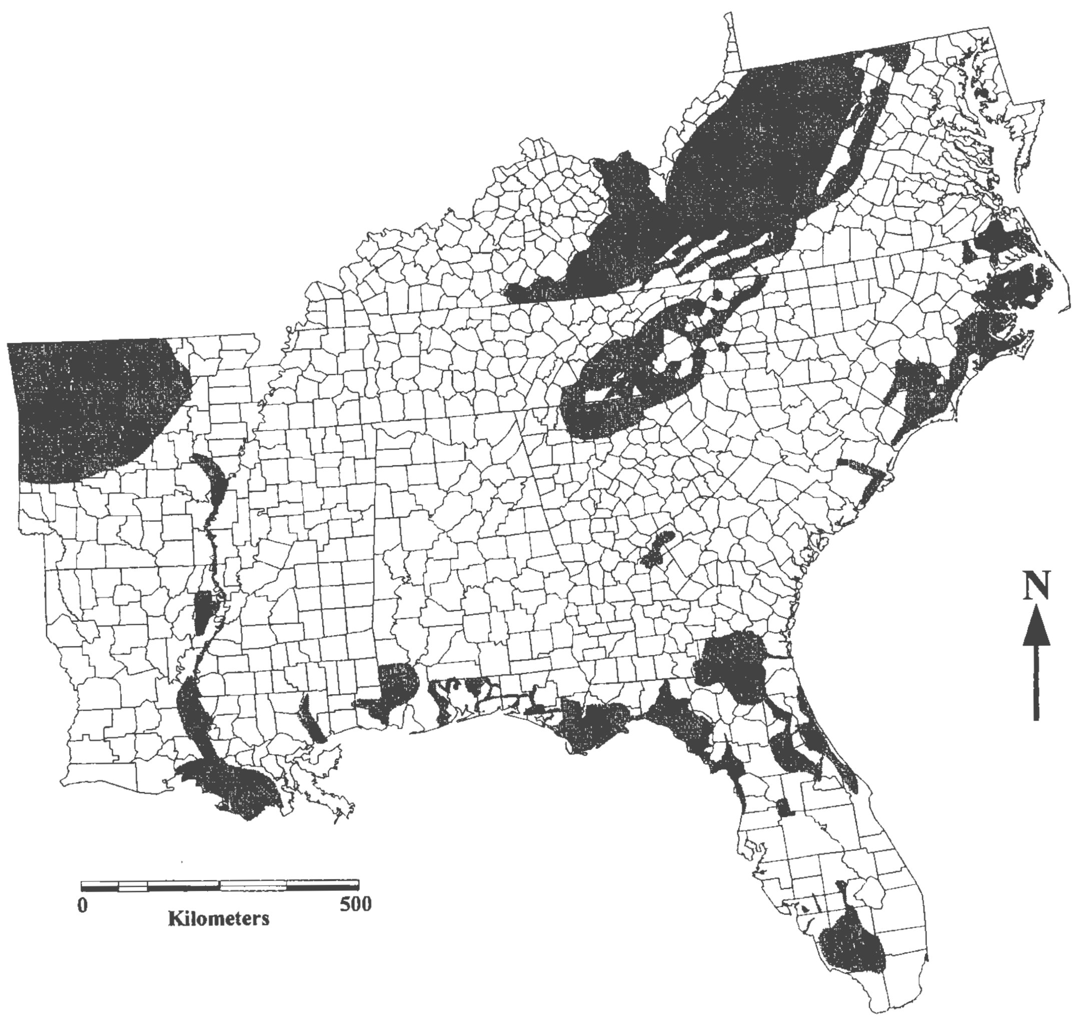

Fig. 1. Current distribution of the American black bear in the southeastern United States (Pelton and van Manen 1997).

people that had moved to the region had placed considerable stress on native bear populations. Severe habitat loss also occurred because of timber harvest in the Ouachita Mountains for saw timber (Smith 1986), clearcutting the forests of the Ozark Plateau for railroad ties during the westward expansion of the railways (Smith and Petit 1988), and other agricultural activities (Holder 1970). Unregulated market hunting, coupled with extensive habitat loss, led to the extirpation of black bears throughout most of the state by the early 1900s. In 1927, the Arkansas Game and Fish Commission (AGFC) closed the hunting season for bears due to severe population declines (Holder 1951). One remnant population of bears persisted in the eastern Delta region in what is now the White River National Wildlife Refuge. Although that population declined to an estimated 25 bears in the early 1940s (Holder 1951), habitat recovery and closure of the bear season has allowed the White River population to flourish.

Whereas viable bear populations existed in the Delta and Interior Highlands regions, the Gulf Coastal Plain was not inhabited by a reproducing population of bears. In 1999, the AGFC and the U. S. Fish and Wildlife Service (USFWS) proposed a plan to restore bears to the Gulf Coastal Plain by translocating bears from White River approximately 160 km southwest to Felsenthal National Wildlife Refuge. Bears at White River probably provide the closest available genetic match to those bears that originally inhabited the Gulf Coastal Plain (Warrillow et al. 2001). Also, bears from White River would be best adapted to the habitat and seasonal flooding that occurs at Felsenthal (Smith 1985, 1986, White 1996, Oli et al. 1997). Felsenthal is part of historic black bear range; although occasional bear sightings occur in the area, there have been no confirmed reports of females with cubs (J. Johnson, USFWS, personal communication).

Justification

In fragmented populations, long-term persistence depends on recolonization of vacant habitat patches following periodic local extinctions (Levins 1970, Hanski 1996). Because many bear populations in the Southeast occur in isolated habitat fragments (Pelton 1991), expanding their range to unoccupied habitats could reduce the risk of species loss caused by demographic or stochastic processes (Griffith et al. 1989). Bears, however, may not be well adapted to exploit such habitats through natural dispersal (van Manen 1997). Although the considerable dispersal capabilities of male black and brown bears (*U. arctos*) have been well documented (Kemp 1976, Blanchard and Knight 1995, Young and Ruff 1982, Schwartz and Franzmann 1992), that behavior is not typical of all age and sex classes. Female bears of some species typically do not disperse, residing instead within a portion of their mother's home range (Kemp 1976, Alt 1978, Schwartz and Franzmann 1992). In addition, bears have relatively low reproductive rates (Bunnell and Tait 1981), a characteristic that limits population growth and natural colonization ability (Hanski 1991, Hastings 1991). Thus, habitat fragmentation, coupled with the limited dispersal capabilities of female bears, may necessitate reintroduction to aid in the recolonization process (Clark et al. 2002).

Although recovered habitats are suitable for black bears, it is doubtful that bears would naturally colonize the Gulf Coastal Plain region in the foreseeable future. In 1986, the USFWS proposed reintroducing black bears to Felsenthal; however, personnel changes prevented implementation of the project. Occasional sightings were reported at that time, but biologists speculated that those sightings probably represented dispersing males and that natural colonization in the near future was possible but not probable. The lack of sightings of females and cubs prior to my study appears to confirm that assessment. Furthermore, a bait-station survey was conducted on Felsenthal in the 1980s (J. Clark, United States Geological Survey [USGS], personal communication) and again in 1999 (R. Eastridge, AGFC, personal communication). Both of these surveys resulted in no bear visits, indicating few, if any bears in the area.

A habitat assessment was performed at Felsenthal in 1986 to determine whether the refuge could support black bears. USFWS District Biologist Ray Aycock and University of Tennessee Professor Michael Pelton conducted an examination of refuge habitat. Those biologists determined that the habitat conditions on the refuge would meet the environmental needs of black bears (M. Pelton, University of Tennessee, personal communication). They also concluded that refuge management plans and practices would be conducive to maintaining suitable habitat for black bears as well as for a diverse array of other wildlife species.

Moreover, black bear habitat has improved since that assessment was made because of management activities of the USFWS and the further maturation of bottomland hardwood communities. The Arkansas Game and Fish Commission is charged with the responsibility of restoring native populations of wildlife to the state (Amendment 35, Arkansas State Constitution). Bear restoration to Felsenthal also is in agreement with USFWS policy of restoring native species and managing for a diversity of species, which historically occurred on refuge lands (USFWS 2000*a*). Restoration of bears to the area would provide ecological benefits such as a linkage to other isolated bear populations. Bears are considered an umbrella species because their area and habitat requirements encompass those of many other species (Noss et al. 1996). Finally, bear restoration to the Gulf Coastal Plain would provide benefits to humans such as wildlife viewing, photography, and hunting.

Past Translocation Efforts

Wildlife translocations have become an increasingly popular strategy in the conservation of threatened or endangered species and the management of game animals (Burke 1991, Dodd and Seigel 1991, Griffith et al. 1989), including black bears. One of the earliest black bear reintroduction attempts took place in Arkansas from 1958 through 1968, when 254 bears from Minnesota and Manitoba, Canada were released in the Ozark and Ouachita mountains (Rogers 1973). Animals were captured in culvert traps during summer and translocated to 3 locations in the Interior Highlands of northwest Arkansas. Many bears extensively moved following the release, with some animals traveling up to 435 km from release sites (Rogers 1973, Smith et al. 1990). The Arkansas reintroduction was considered a success, however, with the resulting population increasing to >2,500 animals over a 20-year period (Smith and Clark 1994). That effort is considered to be the most successful reintroduction of any large carnivore anywhere in the world (Clark et al. 2002). Factors that contributed to the success of the project include the use of wild-captured bears, 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 (Smith and Clark 1994).

In the mid-1960s, Louisiana officials attempted to augment dwindling populations of Louisiana black bears (*U. a. luteolus*) in the Tensas River area and the Atchafalaya River Basin by releasing 161 bears from Minnesota (Taylor 1971). As in Arkansas, post-release movements in the Tensas and Atchafalaya projects were extensive and mortality was high (Taylor 1971). Although bears now inhabit both locations in Louisiana, it is unclear whether increased numbers are the result of reintroduction attempts or population growth by native bears (Pelton 1991, Miller et al. 1998, Warrilow et al. 2001). Consequently, there has been concern that the genetic integrity of the native Louisiana bears, a federally threatened subspecies under the Endangered Species Act of 1973 (Federal Register 1992), was compromised by the augmentation (Pelton 1991).

Both the Arkansas and Louisiana projects used what is known as a "hard release". With this release technique, wild animals are captured, transported, and released with no acclimation period (Griffith et al. 1989). With "soft release" techniques, animals are captured, translocated, and held for a period of acclimation at the new site before release (Griffith et al. 1989).

Pennsylvania officials used a "soft-release" technique in an attempt to augment a sparse black bear population in their state. Between 1977 and 1984, officials translocated 22 adult female black bears approximately 440 km from northeastern Pennsylvania to the southwestern portion of the state (Alt 1995). At the source area, radio-collared female bears that had just given birth to cubs or were suspected to be pregnant at the time of relocation were tracked to their winter dens, immobilized, and translocated. At the release site, bears were then placed in natural den sites or in wooden crates lined with straw. The premise of this "winter-den" method was that the combination of hibernation, parturition, and cub rearing would act as an acclimation period, with the adult females remaining in the reintroduction area, thus increasing site fidelity. Prior to augmentation, harvests for the release area averaged 4 bears per year; the hunter-kill increased to an average of 111 per year following translocations. The success of that effort was influenced by (1) the use of native bears with no history of nuisance activity, (2) closure of the hunting season for >5 years, and (3) the use of hibernating, pregnant females or females with cubs.

Between 1995 and 1997, researchers in Tennessee compared 2 soft-release techniques for reintroducing black bears from Great Smoky Mountains National Park to the Big South Fork National River and Recreation Area in Tennessee and Kentucky, approximately 160 km to the northwest (Eastridge and Clark 2001). The winter-den technique was used to reintroduce 8 adult females with cubs. The second method involved reintroducing 6 adult and subadult female bears, not accompanied by cubs, to the release area during summer and holding them in pens for a 2-week acclimation period. Following the release, total distance moved from the release sites, net distance moved, mean daily distance moved, and circuity for winter-released bears were significantly less than for summer-released bears. Also, survival of winter-released bears was greater than summer-released bears (Eastridge and Clark 2001). Reproduction among reintroduced bears was documented; sires were thought to be transient adults or progeny of the reintroduced bears.

Also using the winter-den technique, a female black bear and 2 cubs were translocated from Madison Parish, Louisiana, and placed in a wooden den box on the southern portion of Tensas River National Wildlife Refuge, Louisiana in March 1998 (D. Anderson, USFWS, personal communication). In late February 1999, another female and her cub were taken to the Buckhorn Wildlife Management Area (WMA) in Tensas Parish and placed in a den. Both females stayed in the reintroduction area and at least 1 of the 3 cubs survived. In 2001, similar techniques were used to reintroduce 4 females with 9 cubs to the Three Rivers WMA in Concordia Parish. Although 1 female abandoned her cubs, all adults remained in the release areas.

Challenges and Considerations

Animal reintroductions are attractive management tools in wildlife science, but attempts are not always successful (Burke 1991, Dodd and Seigel 1991, Griffith et al. 1989). Griffith et al. (1989) and Wolf et al. (1996) conducted studies to assess factors associated with the success of past animal translocations and both studies had similar results. Translocations of native game animals were more successful than those of threatened or endangered species, releases were more successful if animals were released in prime habitats within the former range of the species, long-term programs were more successful than shorter ones, and the use of wild-captured animals was more successful in translocations than the use of captive-raised animals. Griffith et al. (1989) further suggested that reintroduction success is enhanced for species with a large number of founders, high genetic variability, a high rate of population increase with low variance, low intraspecific competition, low environmental variation, and access to refugia. Unfortunately, bears exhibit low population growth with high variance, are subject to high environmental variation (e.g., annual fluctuations in food production), and have low genetic variability relative to their population size (Manlove et al. 1980, Wathen et al. 1985).

A further obstacle to reintroduction is the powerful homing instinct of bears, evidenced by extensive movements to return to their original home ranges following translocation (Rogers 1973, 1987; Beeman and Pelton 1976). Because of their homing behavior, bears often suffer increased mortality following translocation (Rogers 1986, Fies et al. 1987, Stiver 1991, Comly 1993, Riley et al. 1994, Eastridge and Clark 2001). Factors influencing homing ability include age, sex, presence of cubs, food availability, translocation distance, and physiographic barriers. Several studies reported an inverse relationship between translocation distance and the probability of bears returning home (Beeman and Pelton 1976, Singer and Bratton 1980, McArthur 1981, Fies et al. 1987). Rogers (1986) recommended translocation distances of ≥64 km to reduce homing of translocated bears. Homing may be further reduced when translocation distance is combined with harsh topography or physiographic barriers (Beeman and Pelton 1976, McArthur 1981, Rogers 1986). Nevertheless, Eastridge and Clark (2001) found that despite translocation distances >160 km and numerous physiographic barriers including a mountain range, a major river, and 2 interstate highways, summer-released bears attempted to home, whereas winter-released bears did not. In addition, male bears typically display a stronger homing instinct than female bears (Fies et al. 1987, Comly 1993). Comly (1993) found that female nuisance bears with cubs did not leave the release area following translocation, eventually establishing new home ranges. Brannon (1987) also found that translocations of female grizzly bears with young were more successful than translocations of females without young. Furthermore, subadult black bears (Rogers 1988, Eastridge 2000) and subadult brown bears (Miller and Ballard 1982, Brannon 1987, Servheen et al. 1995) have shown weaker homing instincts than adults. Thus, the winter-den technique first developed in Pennsylvania for American black bears and later utilized by Eastridge and Clark (2001) seems promising in reducing post-release homing behavior.

Often overlooked, and perhaps more challenging than the biological considerations, are the social aspects of bear reintroduction. Reading and Kellert (1993) observed that many species reintroductions have failed because the socioeconomic and political aspects were not adequately addressed. Carlton (1986:266) stated, "Only when citizens perceive the protection of species as a public good, deserving of a cooperative effort...will a long range, effective preservation program be possible." Most people identify with bears and have a positive view of them because they are aesthetically appealing, are intelligent, are of large size, have the capacity to stand erect, and have an omnivorous diet (Kellert 1994). Despite positive overall attitudes toward bears, however, attitudes toward bear reintroduction tend to be more negative. These negative attitudes often are associated with potential danger to humans and the destruction of livestock and crops or the perception that reintroduction will result in land use restrictions. With bears, as with other carnivores, there seem to be differences between resident and non-resident attitudes toward reintroduction. For example, a 1995 Tennessee survey found that 81% of non-local residents were in favor of an American black bear reintroduction compared to 61% of local residents (Peine et al. 1995). This is noteworthy because attitudes of residents probably best reflect those of individuals most likely to be affected by the reintroduction program. Thus, the concerns of residents and non-residents should be adequately addressed prior to undertaking any reintroduction effort.

Public Support

In 1988, a survey was conducted to assess black bear damage complaints and landowner attitudes in Arkansas (Clark et al. 1991). Landowners owning >2 ha were surveyed; 58% of the 979 respondents were farmers. Only 17% of respondents had seen bears or bear sign on their property. Four percent had suffered some property loss due to bears, but 83% of those reporting damage claimed that losses were negligible. Thus, there was a relatively low occurrence of nuisance bear damage in an area where there was a large, reestablished bear population.

Prior to my study, 3 meetings were held with 6 corporate landowners near Felsenthal to inform them about the proposed reintroduction project. Corporate landowners indicated support for the project as long as the general public supported bear restoration. Consequently, in June 1999, AGFC sponsored a telephone survey conducted by the University of Arkansas at Little Rock. The survey sample consisted of 402 randomly chosen adults from the following counties in southern Arkansas: Ashley, Bradley, Calhoun, Clark, Cleveland, Dallas, Drew, Ouachita, and Union. A majority of the respondents (72%) indicated support for bear restoration in southern Arkansas (AGFC 2000). Additionally, 6 public meetings were held in the communities that surround Felsenthal. More than 80% of the written responses from these 6 meetings indicated support for bear restoration (R. Eastridge, AGFC, personal communication). Following those meetings, a black bear reintroduction plan was implemented. Reintroduced bears should be closely monitored to estimate survival, reproduction, site fidelity and population growth (Smith and Clark 1994, Eastridge and Clark 2001, Clark et al. 2002).

Objectives

The primary goal of my study was to evaluate the effectiveness of the winter-den technique in reintroducing black bears to the West Gulf Coastal Plain region of Arkansas. Specifically, objectives of my study were to:

1. estimate survival, reproduction, and site fidelity of translocated female black bears;
2. assess population viability to determine the need for additional releases of bears at Felsenthal;
3. evaluate habitat suitability for translocated bears; and
4. document bear sightings and human-bear interactions and conflicts.

CHAPTER II

STUDY AREA

White River

I conducted field research on portions of White River National Wildlife Refuge and Felsenthal National Wildlife Refuge. Both wildlife refuges are located in eastern Arkansas within historic black bear range (Fig. 2).

White River encompasses portions of Arkansas, Desha, Monroe, and Phillips counties in eastern Arkansas. Located within the Mississippi Flyway, White River was established in 1935 to preserve critical habitat for migratory waterfowl. The long, narrow refuge varies in width from 5 to 16 km and contains 145 km of the White River as well as some 350 lakes, largely connected by a network of streams, sloughs, and bayous.

White River is approximately 65,000 ha in size, with roughly 2,000 ha in permanent water, 62,300 ha in forests, 360 ha in crops, and 400 ha in grassland. The refuge represents the largest contiguous tract of bottomland hardwoods under a single ownership in the U. S. The bottoms are seasonally flooded, providing excellent wintering waterfowl habitat. More mallards (*Anas platyrhynchos*) winter at White River and the lands surrounding the refuge than any other area in the U. S. (USFWS 2000*b*). Lands surrounding the refuge are primarily used for agriculture, with rice being the major crop, followed by soybeans, corn, wheat, and sorghum.

The climate of the region is characterized by long, hot, humid summers and short, mild winters with brief cold periods (National Oceanic and Atmospheric Administration [NOAA] 1978). Mean daily temperatures range from -2° C to 9° C in January and from

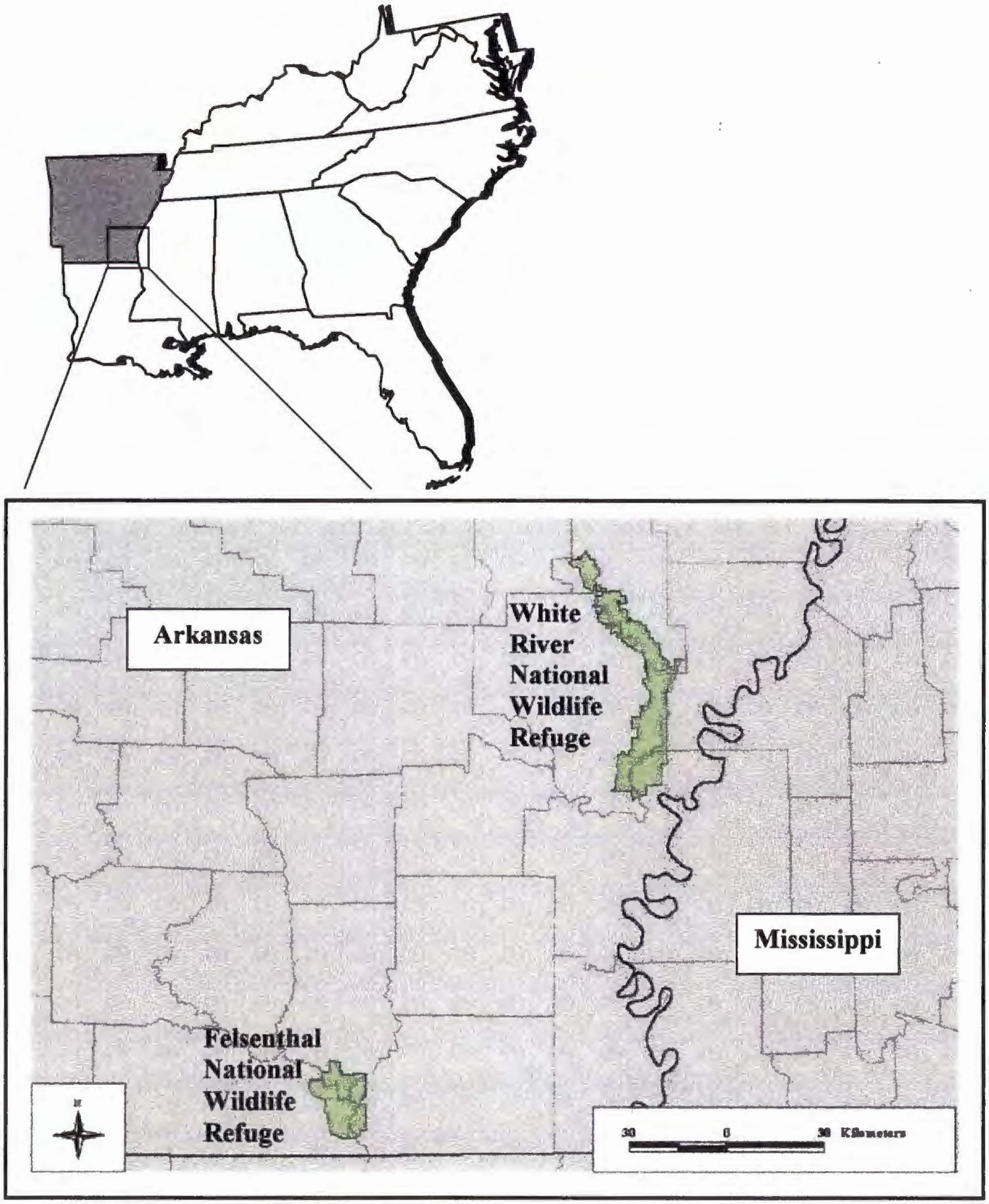

Fig. 2. Black bear study location, southeast Arkansas, 2000–2002.

22° C to 33° C in July (NOAA 2000). The average number of frost-free days is 209 (NOAA 2000).

Annual precipitation at White River averaged 131 cm (NOAA 2000). Most precipitation occurs in the form of rainfall, which is abundant throughout the year (NOAA 1978). Snowfall totals are usually <4 cm, with infrequent accumulations (NOAA 1978). Winter and spring are the wettest seasons, with March precipitation averaging 14.2 cm (NOAA 2000). Late summer to early fall is drier, however, and average rainfall in August is 6.6 cm (NOAA 2000), usually occurring in the form of afternoon thundershowers (Bailey 1995). Severe thunderstorms are common in the spring, with frequent tornado activity (NOAA 1978).

White River lies within the Lower Mississippi Riverine Forest Province (Bailey 1995), a broad, flat to gently sloping floodplain composed of alluvium and loess. Throughout most of the region, the slope is <13 cm/km (Bailey 1995), and elevations on the refuge range from 41 m to 49 m. The only noticeable slopes are natural levees and terraces that abruptly rise above adjacent bottomlands or stream channels (Bailey 1995). Flooding from the White River inundates approximately 75% of the refuge annually, most often during the winter and spring. The flooded hardwood forest and fields provide wintering waterfowl habitat, and excellent spring spawning habitat for many fishes. Soils range from Inceptisols in alluvial bottomland to Alfisols in loess areas, and Mollisols in areas where aquatic vegetation occurs (Bailey 1995).

The forested areas of the refuge are large, contiguous expanses of bottomland hardwoods, but subtle differences in species composition occur across the landscape. Vegetation occurs along a continuum of decreasing flood tolerance from the lowest to highest elevations (Fredrickson and Heitmeyer 1988). Overcup oak (*Quercus lyrata*) and baldcypress (*Taxodium distichum*) occur on low, poorly drained sites, especially backwater areas, oxbows, and depressions, with buttonbush (*Cephalanthus occidentalis*) occurring along the water's edge. Continuing along the elevation gradient toward drier sites, red maple (*Acer rubrum*), pin oak (*Q. palustris*), Nuttall oak (*Q. nuttallii*), sweetgum (*Liquidambar styraciflua*), cherrybark oak (*Q. pagoda*), and willow oak (*Q. phellos*) are more prevalent (Fredrickson and Heitmeyer 1988). The understory is somewhat less developed due to annual flooding, but dense seedbanks are present.

The productivity of this floodplain system supports a wide variety of terrestrial and aquatic animal species. Game species include white-tailed deer (*Odocoileus virginianus*), black bear, raccoon (*Procyon lotor*), gray squirrel (*Sciurus carolinensis*), fox squirrel (*S. niger*), eastern cottontail (*Sylvilagus floridanus*), swamp rabbit (*S. aquaticus*), and eastern wild turkey (*Meleagris gallopavo*). The area is well known for its waterfowl hunting, where hunters may take mallards, wood ducks (*Aix sponsa*), blue-winged or green-winged teal (*Anas discors* and *A. crecca*, respectively), American wigeon (*A. americana*), common pintail (*A. acuta*), and various other waterfowl. In addition to the game species, the land supports a myriad of shorebirds, wading birds, neotropical migrant songbirds, raptors, reptiles, amphibians, and fishes. Federally listed species include the threatened bald eagle (*Haliaeetus leucocephalus*). In addition, the White River and the nearby Arkansas and Mississippi rivers support some of the region's most productive commercial fisheries.

Felsenthal

Felsenthal encompasses portions of Ashley, Bradley, and Union counties in southeastern Arkansas. Felsenthal was established in 1975 as partial mitigation for the U. S. Army Corps of Engineers Ouachita-Black Rivers Navigational Project, and today provides valuable water resources to the region. The Ouachita and Saline rivers converge near the center of the refuge, where the Ouachita continues southward to the Black and eventually the Mississippi River in Louisiana. Felsenthal is managed with 3 other National Wildlife Refuges to form the south Arkansas complex. Overflow and Oakwood refuges are located to the east in the Mississippi River Delta, and Pond Creek refuge is situated along the Texas/Oklahoma border in the Red River Basin.

Located in Arkansas' West Gulf Coastal Plain, Felsenthal covers >26,000 ha of land, of which approximately 4,000 ha are in upland forest communities, and >16,000 ha are in bottomland hardwoods, along with an intricate network of rivers, creeks, sloughs, and buttonbush swamps. The Felsenthal Lock and Dam, approximately 5 km north of Louisiana, forms the 6,000-ha Felsenthal Pool, which increases to >14,500 ha during winter flooding. The large portion of bottomland hardwoods flooded during the winter and early spring forms the world's largest greentree reservoir, providing nutritional resources to migrating waterfowl and spawning grounds for numerous fishes. The upland sites within the refuge are dominated by loblolly pine (*Pinus taeda*), as are most areas surrounding the refuge. Timber production is the major land use in the region, with Georgia Pacific being the area's largest employer.

The climate is similar to that described for the White River area; however, temperature ranges slightly differ. Mean daily temperatures range from -2° C to 12° C in

January and from 20° C to 34° C in July (NOAA 2000). There is an average of 182 frost-free days on Felsenthal (NOAA 2000).

Weather patterns also are similar to White River, with abundant rainfall throughout the year (NOAA 1978). Annual mean precipitation for the study area is 143 cm (NOAA 2000). Like White River, winter and spring form the wet season, with March precipitation averaging 14.4 cm (NOAA 2000). Late summer to early fall is the drier period, with average August totals equaling 9.0 cm (NOAA 2000).

Felsenthal lies within Bailey's (1995) Southern Mixed Forest Province, the ecoregion that comprises the West Gulf Coastal Plain in the southern portion of Arkansas. The land in this region slopes gently toward the sea, with local relief of <30 m (Bailey 1995). The permanent pool level on Felsenthal refuge is 20 m, with elevations ranging to >30 m on some of the upland sites. Ultisols are the dominant soil type throughout the region, with some Vertisols in areas of soft limestone, and Inceptisols on floodplains of the major streams (Bailey 1995).

Oak-hickory forests cover large areas in the region, both on upland and bottomland sites. Bottomlands and areas with northern slopes contain white oak (*Q. alba*), cherrybark oak, water oak (*Q. nigra*), shagbark hickory (*Carya ovata*) and mockernut hickory (*C. tomentosa*). Willow oak forests occur on flat, poorly drained soils, and may contain willow oak, water oak, overcup oak, Nuttall oak, sweetgum, blackgum (*Nyssa sylvatica*), red maple, elms (*Ulmus* spp.), and sugarberry (*Celtis laevigata*). Loblolly pine may occur in combination with several of these species or form almost pure stands along ridges and higher elevations. Baldcypress and water tupelo (*N. aquatica*) are dominant in sloughs and other semi-permanently flooded areas. Prolonged, regulated seasonal flooding has caused a shift in species composition from Nuttall and willow oaks to the more water tolerant overcup oak in many of the refuge's low-lying areas (King et al. 1998). This has reduced available hard mast for waterfowl, however, because overcup acorns are much larger than willow oak and Nuttall oak acorns and are not preferred by waterfowl.

The unique mixture of uplands, wetlands, and bottomland hardwood forests supports a diversity of wildlife species. All of the wildlife species that occur at White River also inhabit Felsenthal, with the exception of black bears, which are occasionally reported but not considered common. Federally threatened or endangered species that occur on the refuge include the bald eagle and red-cockaded woodpecker (*Picoides borealis*). The red-cockaded woodpecker inhabits upland pine areas of the refuge; approximately 100 individuals comprise 15–17 active clusters (Robert Ellis, USFWS, personal communication). The wood stork (*Mycteria americana*) is an Arkansas species of special concern. Between 50 and 150 wood storks reside on the refuge during the summer.

Significant and abundant cultural resources also occur on Felsenthal. Several Native American mounds exist on the refuge and have been listed on the National Historical Register as significant archeological sites. The discovery of additional sites is expected as archaeological work continues (J. Johnson, USFWS, personal communication).

CHAPTER III

MATERIALS AND METHODS

Capture and Handling

Project personnel captured bears during summer from 1998 through 2001 at White River as part of an on-going study on population dynamics being conducted by AGFC, University of Tennessee (UT), USGS, and USFWS officials. We used Aldrich spring-activated foot snares (Aldrich Animal Trap Company, Clallam Bay, Washington, USA) to capture bears, as described by Johnson and Pelton (1980). We equipped snares with swivels and automobile hood springs to minimize injuries to captured animals (Johnson and Pelton 1980). We used trail sets and modified cubby sets to capture bears (Clark 1991). Traps were placed in shaded areas near stream drainages, bayous or sloughs, and baited with fish obtained from local commercial fishermen and AGFC hatcheries. Vegetation with stems >1 cm in diameter was removed to prevent entanglement of the snare cable. We checked all traps daily. When bears visited traps on >2 occasions without a capture, trap appearance and placement was changed, or additional snares were placed at trapsites.

We immobilized captured bears using a mixture of ketamine hydrochloride (Ketaset®, Fort Dodge Animal Health, Fort Dodge, Iowa, USA) at a concentration of 200 mg/ml, and xylazine hydrochloride (Rompun®, Bayer Corporation, Shawnee Mission, Kansas, USA) at 100 mg/ml. The immobilization drug was intramuscularly injected with a push pole or blowgun at a dosage of 1 ml/22.7 kg (50 lb) estimated body mass.

After immobilization, we applied an optical wetting solution (Akwa Tears, Akorn Incorporated, Abita Springs, Louisiana, USA) to prevent desiccation of the eyes, and placed a cloth over the eyes of the bear to reduce stress and prevent damage. All bears were examined for physical injuries following sedation. We monitored the bear's pulse, body temperature, and respiration throughout the workup. Bears with body temperatures >103° F were doused with water, a cold water enema was administered, and ice packs were placed on the chest and groin areas to prevent overheating. We treated any injuries of the bears with external and internal antibiotics (LA-200® liquamycin, oxytetracycline, Pfizer Animal Health, New York, New York, USA) at a dosage of 4.5 ml/45 kg body mass. We injected lactating females with 1 ml of oxytocin (Oxoject®, Burns Veterinary Supply, Rockville Centro, New York, USA) to counteract the inhibiting effect of the immobilization drug on lactation.

Project personnel affixed a pair of uniquely numbered plastic ear tags (National Band and Tag Company, Newport, Kentucky, USA) to each bear, and applied a lip tattoo using 0.8-cm numeric digits (Nasco, Fort Atkinson, Wisconsin, USA) and animal tattoo ink (Ketchum Manufacturing Inc., Ottowa, Ontario, Canada). We classified adult female bears that showed vaginal swelling or pinkish vaginal discharge as being in estrus (Wathen 1983). We considered bears that were in estrus or not lactating during summer trapping to be prospective candidates for winter translocation and fitted these bears with MOD-500 radiocollars (Telonics Incorporated, Mesa, Arizona, USA). Collars were equipped with an oiled leather spacer, which was expected to deteriorate within 2 years, thus allowing collars to be retrieved before the batteries expired.

We extracted an upper premolar from each bear for aging by cementum annuli analysis (Willey 1974). Matson's Laboratories (Milltown, Montana, USA) sectioned, stained, and aged the teeth. We weighed each bear and recorded the following body measurements: total body length, head length, head width, zygomatic circumference, shoulder height, forearm circumference, foot pad length and width, and chest circumference (Eason 1995). Descriptive information also was recorded, including sex, general condition, reproductive status, age class, ectoparasite load, prominent scars and wounds, and anomalies. Finally, we collected hair samples for microsatellite DNA analysis (Paetkau and Strobeck 1994).

After all measurements were collected and recorded (>45 min), we injected yohimbine hydrochloride (Spectrum Laboratory Products, New Brunswick, New Jersey, USA), an antagonist to xylazine hydrochloride, in the sublingual or femoral vein at a dosage of 5 mg/22.5 kg. Recovery time was approximately 15 min for most bears. All immobilization procedures were in accordance with University of Tennessee Animal Care Protocol #905.

Translocation

We used the winter-den technique described by Alt (1995) to translocate female black bears with cubs from their dens at White River to pre-selected den sites at Felsenthal. Researchers in Tennessee found that the translocation of 6 adult female bears each year was feasible based on logistics of translocation, access to denning bears, and the window of opportunity provided by the denning period (Eastridge and Clark 2001). Eastridge and Clark (2001) also found the use of post-parturient females resulted in less abandonment at the release site and allowed more accurate estimates of reproductive output. Therefore, females that had been previously trapped during the summer and fitted with radiocollars were tracked to their winter dens during February through March, 2000–2002, respectively. This allowed suspected pregnant females sufficient time to give birth so we could document the presence of cubs. We then determined whether the den site would be accessible to select candidates for translocation. Because >90% of black bears at White River used elevated tree cavities for winter dens (Oli et al. 1997), accessibility of denned females was determined in large part by the overall stability of the den tree, dimensions of den entrance and cavity, height of opening, and distance to den floor. When deemed stable, I climbed the den tree using rope, ascenders, and climbing harness (Petzl, Crolles, France) to determine den dimensions and verify the presence of cubs.

Once translocation candidates had been identified, I returned to the den site in March to early April, re-ascended the den tree, and immobilized the female using either push pole, blowgun, or dart rifle. I then secured a pulley above the den entrance and descended into the den. First, the cubs were placed in a cloth pack and removed from the den. They were followed by the adult female, which was secured in a cargo net or safety harness, and removed using the pulley system. Following removal from their den, project personnel transported females and cubs from the den sites with a stretcher, all-terrain vehicle (ATV), or boat. We then placed cubs with the female in a transport cage that was lined with pine straw or leaves, and transported the family group by vehicle to Felsenthal. I applied mentholated salve to the cubs' bodies and to the nose of the adult female to hide human scent and prevent cub abandonment (Eastridge 2000). I then intramuscularly injected oxytocin to promote lactation.

Bears were normally held overnight at Felsenthal and released the following day. On the day of release, we again immobilized adult females and transported the bears by ATV to pre-selected den sites. Beginning in 2001, we equipped all translocated cubs with passive internal transponder or "PIT" tags (Electronic I. D. Inc., Cleburne, Texas, USA) for identification purposes in the event of recapture. Wooden den boxes lined with pine straw or leaves were constructed and used as ground dens at release sites. Den boxes had a removable top and measured 1.22 m (4 ft) L x 0.91 m (3 ft) W x 0.91 m (3 ft) H, with a 56 cm (22 in) diameter circular opening at the front (Fig. 3). Similar den structures had been used in winter-den releases of black bears in the Tensas River area in Louisiana (D. Anderson, USFWS, personal communication). I chose den sites at Felsenthal that were above the 100-year flood stage in elevation and those that were isolated from camping areas, open ATV trails, or other areas of high public use. Once at the den site, females and cubs were placed in den boxes, mentholated salve was again applied, and an intramuscular injection of oxytocin was given to the adult female bear.

Radiotelemetry

Using ground telemetry, I monitored translocated female bears each day to determine the date of den emergence of each bear. For the first month following den emergence, translocated bears were radiolocated daily by ground or aerial telemetry. Aerial telemetry was used because extensive post-release movements prohibited me from obtaining daily locations from the ground. I gradually reduced the frequency of

Fig. 3. Wooden den box used in black bear reintroduction at Felsenthal National Wildlife Refuge, Arkansas, 2000–2002. Note the immobilized bear in the box.

radiolocations to 2 times/week then weekly for each bear as movements became more constrained.

I performed ground telemetry with a model TR-4 receiver (Telonics Incorporated, Mesa, Arizona, USA) and a 5-element Yagi antenna (Wildlife Materials Inc., Carbondale, Illinois, USA) using triangulation and the loudest signal method (Springer 1979). I obtained three azimuths for each location and plotted them on 1:24,000 U.S. Geological Survey quadrangle maps. I only used azimuths that formed angles between 30° and 150° and collected within a time interval between first and third azimuths of <50 minutes. Additionally, if triangles formed by the 3 azimuths were >2 ha in size, those azimuths were rejected. Those procedures helped identify spurious azimuths and significant animal movement between azimuths (Schmutz and White 1990). For each estimated animal location, I recorded bear identification number, date, time (Central Standard Time), and Universal Transverse Mercator (UTM) grid system coordinates. Most radiolocations were obtained between 0800 and 2000 hours.

Aerial locations were obtained from fixed-wing aircraft with an H-antenna (Telonics Incorporated, Mesa, Arizona, USA) attached to each wing strut and connected with coaxial cable to a switch box and telemetry receiver inside the cabin. Locations were obtained by flying the aircraft 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 UTM grid system.

Telemetry Error Analysis

The accuracy of estimated bear locations was tested by placing radiocollars throughout the study area in locations similar to actual bear locations. The location of each test collar was unknown to the observer being tested. Project personnel obtained test locations throughout the study in 2000 and 2001. Test collars were located with the same procedures described above for ground and aerial telemetry. I then calculated the distance from the actual location to the estimated location to obtain an error distribution (Schmutz and White 1990, Zimmerman and Powell 1995).

Movements

Post-release movements were intensively monitored following den emergence. I compared several movement parameters to evaluate post-release homing behavior. Mean daily movement was calculated by dividing the total movement by the number of days the bear required to move that distance. I determined net movement by calculating the straight-line distance between the starting point and the ending point. Circuity, a measure of the linearity of an animal's movements, was then determined by dividing the net movement by the total movement. A circuity value of 0 indicated the animal returned to its starting point, or never left it; a value of 1 indicated the animal moved away from its starting point in a linear movement (Eastridge and Clark 2001). Total movement and mean daily movement were calculated with the Animal Movement extension (Hooge and Eichenlaub 1997) in ArcView® GIS (Environmental Systems Research Institute, Incorportated, Redlands, California, USA). I calculated net movement and circuity in Microsoft Excel®.

Bait-Station Survey

A bait-station index program was developed to monitor bear activity in Felsenthal. Two bait-station routes had been established and sampled in 1999 prior to my study. Those routes were along portions of the Ouachita and Saline rivers within Felsenthal, north of U. S. Highway 82, which bisects the refuge. I used 2 additional routes during the study; these were south of U.S. Highway 82, along Pine Island Road and North Road, which lie east and west of the Felsenthal Pool, respectively. Together, these 4 routes included 58 bait sites along 46.7 km (29 mi) of roads and rivers in Felsenthal according to protocols established by Johnson (1992). I placed baits at 0.8-km (0.5-mi) intervals, determined by odometer on vehicles or GPS when traveling by boat. Individual baits consisted of portions of fish hung approximately 3 m (10 ft) above the ground with nylon twine. Baits were inconspicuously placed in the forest, away from roads or riverbanks. I marked bait sites with flagging at the road or riverbank and by GPS to aid in recovery.

I checked baits 7 days after they were set. Evidence of bear visits included feeding sign, presence of bear scat, or claw or bite marks on trees. I recorded whether the baits were visited by bears, other animals, or were untouched. While bait sites were set, I monitored the locations of radio-collared bears. Presence of bears other than those translocated to Felsenthal could thus be determined, in case a bait was taken by a bear in an area where radio-collared bears were not known to be present.

Survival

I estimated annual adult survival with the Kaplan-Meier staggered entry procedure (Pollock et al. 1989) because bears were added to the population at Felsenthal at different times. The procedure is based on the equation:

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

$$j/a_j < t,$$

where $\hat{S}$ is the estimated survival rate, 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 $a_j < t$. The variance (var) of the survival rate is estimated:

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

The Kaplan-Meier procedure is based on the assumptions that all bears monitored for survival were randomly sampled, survival times were independent among bears, capturing or radiocollaring did not influence survival, censoring (e.g., dropped collars, bears leaving the study area) mechanisms were random, and newly radiocollared bears had the same survival function as previously radiocollared bears (Pollock et al. 1989).

I estimated first year post-release survival for all translocated adult female bears. I then estimated annual survival for all female bears that survived >1 year after release. I also calculated cub survival and litter survival estimates for each year with den data collected from females surviving 1 year after release and subsequent cub sightings. In addition, I estimated annual survival for all translocated adult females for the duration of the study. Bears that lost radio collars, bears whose signals were lost before the completion of the study, and bears that permanently left the area were censored at that time (Pollock et al. 1989).

Cub Counts and Denning

I conducted cub counts at regular intervals to assess survival of translocated cubs. I first determined the adult female's location with ground or aerial telemetry, and then slowly approached her from downwind. Once within sight, I monitored the female and determined the number of cubs present. I also assessed the physical condition of the adult and cubs, and documented their behavior. The duration of individual monitoring events ranged from <1 minute to 1 hour. I performed cub counts at 2 and 4 months post-release, when cubs were approximately 4 and 6 months of age, respectively. I also considered reported sightings to be valid counts if they met the following criteria: an individual female bear and her litter were sighted on multiple occasions, the same number of cubs was reported each time, and locations were concurrent with telemetry data. I regarded all cub counts as minimum estimates.

In addition to periodic cub counts, I radiotracked translocated bears at Felsenthal to their winter dens during February and March 2001 and 2002. My objectives were to ascertain the physical condition of the translocated bears, determine yearling survival, verify if natural reproduction had occurred, count cubs, and document den site characteristics.

Population Modeling

I used a population model (RISKMAN, version 1.8.006; Ontario Ministry of Natural Resources, Toronto, Ontario, Canada) to estimate population growth and probability of extinction. RISKMAN uses the life table approach for birth-pulse species (Birch 1948, Cole 1957, Caughley 1977), expanded to include males, to model population dynamics. The model was based on estimates of 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-, or 4-cub litters. Litter survival was the probability that ≥1 cub in a litter survived. Litter production rate was the probability that females in reproductive condition (i.e., without the previous year's cubs) would produce a litter. I estimated post-release cub survival, litter survival, and adult female survival based on data from bears translocated to Felsenthal (Table 1). I calculated subadult female survival, litter production rates, and litter size probabilities from data collected at White River (R. Eastridge, AGFC, unpublished data). Because no male bears were radiocollared during this study, I incorporated adult male survival estimates with values less than those of a non-hunted black bear population in Great Smoky Mountains National Park (Coley 1995) but greater than those for a hunted population of reintroduced bears in western Arkansas (Clark 1991).

I calculated standard errors of recruitment estimates at White River from data collected during 5 den seasons (>175 bear-years; Table 1). I established standard errors at 30% of the sample means of the remaining parameters to account for demographic and environmental variability and parameter uncertainty (Eastridge and Clark 2001). Demographic parameter estimates typically pool parameter (sample size) uncertainty and

Table 1. Black bear population parameter estimates used for population modeling, Felsenthal National Wildlife Refuge, Arkansas, 2003.

	Year 1		**After Year 1**	
Parameter	$\bar{x}$	SE	$\bar{x}$	SE
Cub-of-the-year (COY) survival	0.637	—	0.750	0.225
Litter COY survival	0.833	—	0.850	0.255
Subadult (1–3) survival (M)	0.750	—	0.750	0.225
Subadult (1–3) survival (F)	0.900	—	0.900	0.270
Adult (4+) survival (M)	0.850	—	0.850	0.255
Adult (4+) survival (F)	0.587	—	0.900	0.270
Litter production rate (age 3)	0.500	—	0.500	0.150
Litter production rate (age 4+)	0.598	—	0.598	0.180
Mean litter size (age 3)	2.025	—	2.025	0.333
Mean litter size (age 4+)	2.090	—	2.090	0.140
Probability of COY litter = 1 (age 3)	0.275	—	0.275	—
Probability of COY litter = 2 (age 3)	0.450	—	0.450	—
Probability of COY litter = 3 (age 3)	0.250	—	0.250	—
Probability of COY litter = 4 (age 3)	0.025	—	0.025	—
Probability of COY litter = 1 (age 4+)	0.295	—	0,295	—
Probability of COY litter = 2 (age 4+)	0.364	—	0.364	—
Probability of COY litter = 3 (age 4+)	0.295	—	0.295	—
Probability of COY litter = 4 (age 4+)	0.045	—	0.045	—

environmental (annual and individual differences) variability (White 2000). RISKMAN allows the user to partition the standard error into parameter and environmental components. Thompson et al. (1998) noted that parameter uncertainty has a greater effect on simulation results than environmental variation. Therefore, I proportionally allocated the standard error at 75% for parameter uncertainty and 25% for environmental variability. Additionally, I used the covariance option in RISKMAN to simulate non-independence of parameter variances because environmental variation likely would affect both survival and reproduction of all age classes, and the covariance option would allow for this in the stochastic trials. I did not include density-dependent effects in the simulations.

I performed 1,000 stochastic simulations for 7 different stocking scenarios. Scenario 0 began with the standing age distribution of known bears at Felsenthal in 2003, with no additional bears being released. Scenario 1 involved the stocking of 6 additional adult females and 12 additional cubs (Eastridge and Clark 2001). I first performed a deterministic run to predict the standing age distribution of stocked bears in 1 year, incorporating first-year survival estimates of bears released at Felsenthal (Table 1). Next, I deterministically calculated the standing age distribution of bears surviving 2003–2004, using survival estimates of adult females >1-year post-release and correspondingly greater cub and litter survival rates (Eastridge and Clark 2001). I then summed the 2 standing age distributions to obtain the starting age distribution for Scenario 1. I similarly calculated starting age distributions for Scenarios 2–6, adding 6 adult females and 12 cubs each successive year. Stocking scenarios were then evaluated for a 50-year period, beginning in 2003 and ending in 2053. I considered those stochastic simulations to result in extinction if the population declined to <5% of its initial size.

After completing simulations for Scenarios 0–6, I performed 6 additional stochastic simulations to explore how a greater number of bears released annually might influence results. Scenarios 1B–6B were conducted using identical parameter estimates and procedures outlined above, but involved the release of 12 adult females and 24 cubs each successive year for 6 years. Finally, I compared projected population sizes, annual growth rates, and extinction rates among all stocking scenarios to evaluate the effectiveness of reintroduction efforts and to determine the most efficient stocking alternatives.

Habitat Use Analysis

Various methods have been devised to evaluate wildlife-habitat relationships. Aebischer et al. (1993) outlined 4 major shortcomings that may affect the validity of habitat analyses: first, methods that consider radiolocations as the sample unit, and pool locations over several individuals (e.g., Smith et al. 1982, Byers et al. 1984), result in increased degrees of freedom and over-sensitive statistical tests. Second, techniques that measure habitat preference or avoidance (e.g., Neu et al. 1974) encounter the problem of non-independence of proportional use; here, the avoidance of 1 habitat type automatically leads to the apparent preference for the other habitats. A third problem is that of differential habitat use by groups of individuals (e.g., age or sex classes), which also is confounded when radiolocations are used as the sampling unit. Finally, available habitat often is arbitrarily defined, but habitat selection may occur at different levels within the defined area (Johnson 1980).

I used compositional analysis (Aebischer et al. 1993) to evaluate habitat use of translocated bears. Compositional analysis is based on log-ratios of use versus availability with a multivariate analysis of variance (MANOVA) to determine habitat preference by individual bears. Habitat types can then be ranked and compared according to their relative use. I delineated habitat types for the study area using Multi-Resolution Land Cover data (MRLC; Vogelmann et al. 1998) at a 30- x 30-m cell resolution. I identified locations in 8 major land-cover types: open water, developed, transitional, hardwood forest, pine forest, mixed forest, agriculture, and woody wetlands. Transitional land cover included barren ground and sparsely vegetated areas (<25% vegetation) in early successional stages, often the result of land-use practices (e.g., clearcuts). Although open water only accounted for 3% of available habitat, I included this category because a substantial portion of the home range of several bears. I did not further consolidate the land-cover types because I deemed it important to determine which of the remaining habitats translocated bears were exploiting, and to what extent.

Johnson (1980) described a hierarchical framework of habitat use. He defined first-order selection as the selection of physical or geographical range of a species. Second-order selection is the selection of a home range within this geographical range by an individual or social group, whereas third-order selection is the use of habitat components within the home range. Home range has been described as the area traversed by an individual during its normal activities such as feeding, reproduction, and rearing young (Burt 1943). I chose to analyze habitat use at the second-order and third-order selection levels.

Given that I was studying translocated bears, I wanted to examine habitat use during any post-release exploratory movements, but also as bears constrained their movements and began establishing home ranges. I created 100% Minimum Convex Polygon (MCP) home ranges, including early exploratory movements, to determine the land-cover types that were used by each bear at the third-order level. I had first considered using 95% fixed kernel home ranges (KHR) for consistency throughout the entire habitat analysis; however, upon inspection, many of the exploratory movements were treated as outliers and considered not part of the animal's home range. The resultant polygons were centered on locations at or near the release site and areas of subsequent settlement, but pathways in between were excluded. Because I wanted to consider all post-release movements, I calculated MCPs for the initial portion of the habitat analysis. I elected not to use MCPs for the remainder of the habitat analysis, however, because of the inability of the method to describe centers of activity and the high sensitivity of the method to outlying locations (Powell 2000). Instead, I estimated 95% KHRs to analyze habitat use exclusive of exploratory movements because of the method's ability to produce unbiased location density estimates through a nonparametric approach (Worton 1989). I then used 95% KHRs to analyze habitat use at second- and third-order levels for translocated bears that remained in the area and established home ranges. I excluded initial, post-release exploratory movements if a bear left her release site, but subsequent locations were more constrained, thus suggesting a definable home range as described previously.

Several techniques have been used to determine available habitat for black bears. For example, Quigley et al. (1979) focused on areas that included the greatest number of bear locations. Utilization distributions of all bears (Brody 1984, Hellgren 1988) and study area cores (Smith 1985, Hellgren 1988) also have been selected to determine available habitat for analyses. I delineated available habitat based on a circle with a radius represented by the longest distance from release site traveled by any bear. I then used the center of activity of all bears as the focus of the circle. I considered the entire area available to all bears, because any of the translocated bears conceivably could have traversed the same distance in any direction.

Sightings and Human-Bear Interactions

AGFC, USFWS, and UT personnel documented any interactions between humans and bears. Incidences of nuisance bear behavior, property damage reported by local landowners, and sightings of bears by project personnel, local citizens, and visitors were recorded.

CHAPTER IV

RESULTS

Translocation

We translocated 23 adult female black bears with a cumulative total of 56 cubs from White River to Felsenthal (approximately 160 km). Six adult females and 15 cubs were translocated from 25 to 29 March 2000. Four additional adult females and 10 cubs were translocated from 27 February to 13 March 2001. The third release was conducted from 12 March to 4 April 2002, during which time 13 adult females and 31 cubs were translocated to Felsenthal.

Telemetry Error Analysis

Two project personnel obtained 75 locations of test radiocollars from June 2000 through August 2001. Proportions of test locations obtained by aerial and ground telemetry approximated the proportion of bear locations collected by each of those methods during the study. The mean distance from the estimated location to the actual location was 109 m for aerial and ground telemetry combined. The distance between estimated locations and actual locations for both methods ranged from 4 to 427 m. Moreover, 95% of the estimated locations were within 324 m of the actual location; 90% were <250 m, and 75% of test locations were <135 m from actual radiocollar locations.

Movements

I monitored the fates of all reintroduced bears (Table 2) and evaluated 1-month, 6-month, and 1-year post-emergence movements of surviving adult females (Tables 3–5, respectively). Bear 162, released in February 2001, dropped her radiocollar upon den emergence approximately 600 m from her release site. Two other bears released in March 2002 died at their release site. The cause of death of 018 was undetermined, but poaching was suspected. Veterinarians from the Arkansas Livestock and Poultry Commission performed a necropsy on 006 and found cervisitis had contributed to the bear's death. No locations were collected for those 3 bears; consequently, post-release movements were not evaluated.

Total movement of translocated adult female bears during the first month after den emergence averaged 43 km and ranged from 2 to 251 km (Table 3; Figs. A.1–A.20). Mean daily movements for the first month averaged 923 m (range = 52–5,457 m). Net movement for the first month averaged 27 km (range = 1–130 km). Average circuity during this period was 0.47 (range = 0.11–0.96).

Total movement of surviving adult females 6 months after emergence averaged 223 km and ranged from 52 to 747 km (Table 4; Figs. A.2–A.8, A.11, A.14–A.18, A.20). Mean daily movement averaged 1,132 m the first 6 months (range = 288–3,775 m). Net movement during the 6-month period averaged 34 km (range = 1–85 km). Average circuity was 0.14 after 6 months (range = 0.01–0.34).

Total movement of adult females that survived to 1 year after emergence averaged 311 km and ranged from 110 to 750 km (Table 5; Figs. A.2–A.5, A.7). Mean daily movement after 1 year averaged 782 m (range = 278–1,894 m). Net movement during

Table 2. Fates of adult female black bears translocated to Felsenthal National Wildlife Refuge, Arkansas, 2000–2002.

Bear ID	**Release Date**	**Age at Release**	**No. Cubs**	**Fate as of January 2003**
003	25 March 2000	12	3	Mortality
048	26 March 2000	11	2	Mortality
126	26 March 2000	13	2	Felsenthal
053	27 March 2000	10	2	Overflow
112	28 March 2000	8	3	Dropped Collar
143	29 March 2000	10	3 (1 died at release)	Mortality
162	27 February 2001	13	2 (1 fostered)	Dropped Collar
045	06 March 2001	12	2	Dropped Collar
165	09 March 2001	7	3 (2 fostered)	Mortality
021	13 March 2001	15	3	Mortality
200	12 March 2002	4	4	White River
166	14 March 2002	8	4	Coastal Plain
167	14 March 2002	6	2	White River
139	15 March 2002	17	1	White River
018	19 March 2002	6	2	Mortality at den
072	19 March 2002	14	2	Felsenthal
180	21 March 2002	5	1	Mortality
199	21 March 2002	4	3	Mortality
146	22 March 2002	4	2	Coastal Plain
006	26 March 2002	14	3	Mortality at den
076	26 March 2002	11	4	Felsenthal
135	27 March 2002	6	1	White River
037	04 April 2002	13	2	Felsenthal

Table 3. One-month post-emergence movements of black bears translocated to Felsenthal National Wildlife Refuge, Arkansas, 2000–2002.

Bear ID	Total Movement (km)	Mean Daily Movement (m)	Net Movement (km)	Circuity
003	8	147	3	0.38
048	6	106	1	0.16
126	7	119	2	0.36
053	10	188	3	0.27
112	19	300	7	0.35
143	8	156	1	0.15
045	78	1,850	54	0.69
165	41	628	14	0.35
021*	130	2,836	96	0.73
200*	127	3,543	122	0.96
166	5	88	2	0.43
167*	49	828	6	0.11
139*	9	161	6	0.65
072	8	146	6	0.69
180	65	1,240	58	0.90
199	23	439	18	0.79
146	6	113	2	0.34
076	2	52	1	0.24
135*	251	5,457	130	0.52
037	33	71	1	0.40

*Indicates bear returned to original home range or exhibited homing behavior.

Table 4. Six-month post-emergence movements of black bears translocated to Felsenthal National Wildlife Refuge, Arkansas, 2000–2002.

Bear ID	Total Movement (km)	Mean Daily Movement (m)	Net Movement (km)	Circuity
048	62	289	4	0.07
126	95	444	5	0.05
053	233	1,098	53	0.23
112	158	750	4	0.03
143	340	1,568	55	0.16
045	747	3,775	63	0.08
165	240	1,041	61	0.25
166	103	537	35	0.34
072	120	640	5	0.04
180	365	1,971	53	0.15
199	248	1,486	50	0.20
146	304	1,661	85	0.28
076	52	288	7	0.13
037	52	305	1	0.01

Table 5. One-year post-emergence movements of black bears translocated to Felsenthal National Wildlife Refuge, Arkansas, 2000–2001.

Bear ID	Total Movement (km)	Mean Daily Movement (m)	Net Movement (km)	Circuity
048	111	278	2	0.01
126	138	347	2	0.01
053	282	711	52	0.18
112	269	680	48	0.18
045	756	1,894	63	0.08

the first year averaged 33 km (range = 2–63 km). One year after release, circuity averaged 0.09 (range = 0.01–0.18).

Bait-Station Survey

I conducted annual bait-station surveys in July from 2000 through 2002. One bear visit was recorded in July 2002 within the home range of a translocated female. From bait-station data, I was unable to confirm the presence of bears other than those translocated to Felsenthal during my study.

Survival

I monitored 23 adult female bears between March 2000 and January 2003. Of the 23 translocated bears, 3 dropped their radiocollars, 1 radiocollar failed, 4 bears left the area, and there were 8 confirmed mortalities (Table 2). Three of the 8 mortalities were the result of poaching, and poaching was the suspected cause of 1 additional death. One bear was killed because of a vehicle collision. Cervisitis contributed to the death of another, as mentioned previously. Causes of the remaining 2 mortalities were not determined.

First-year post-release survival of adult female bears translocated in 2000, 2001, and 2002 was 0.833 (95% CI = 0.5–1.0; Fig. 4), 0.333 (95% CI = 0–0.711; Fig. 5), and 0.595 (95% CI = 0.292–0.898; Fig. 6), respectively ($\bar{x}$ = 0.587). Annual survival for all female bears that survived >1-year post-release was 0.909 (95% CI = 0.719–1.0; Fig. 7). Cub survival in 2000, 2001, and 2002 was 0.625 (95% CI = 0.290–0.961), 0.500 (95% CI = 0.010–0.990), and 0.786 (95% CI = 0.571–1.0), respectively ($\bar{x}$ = 0.637). Litter

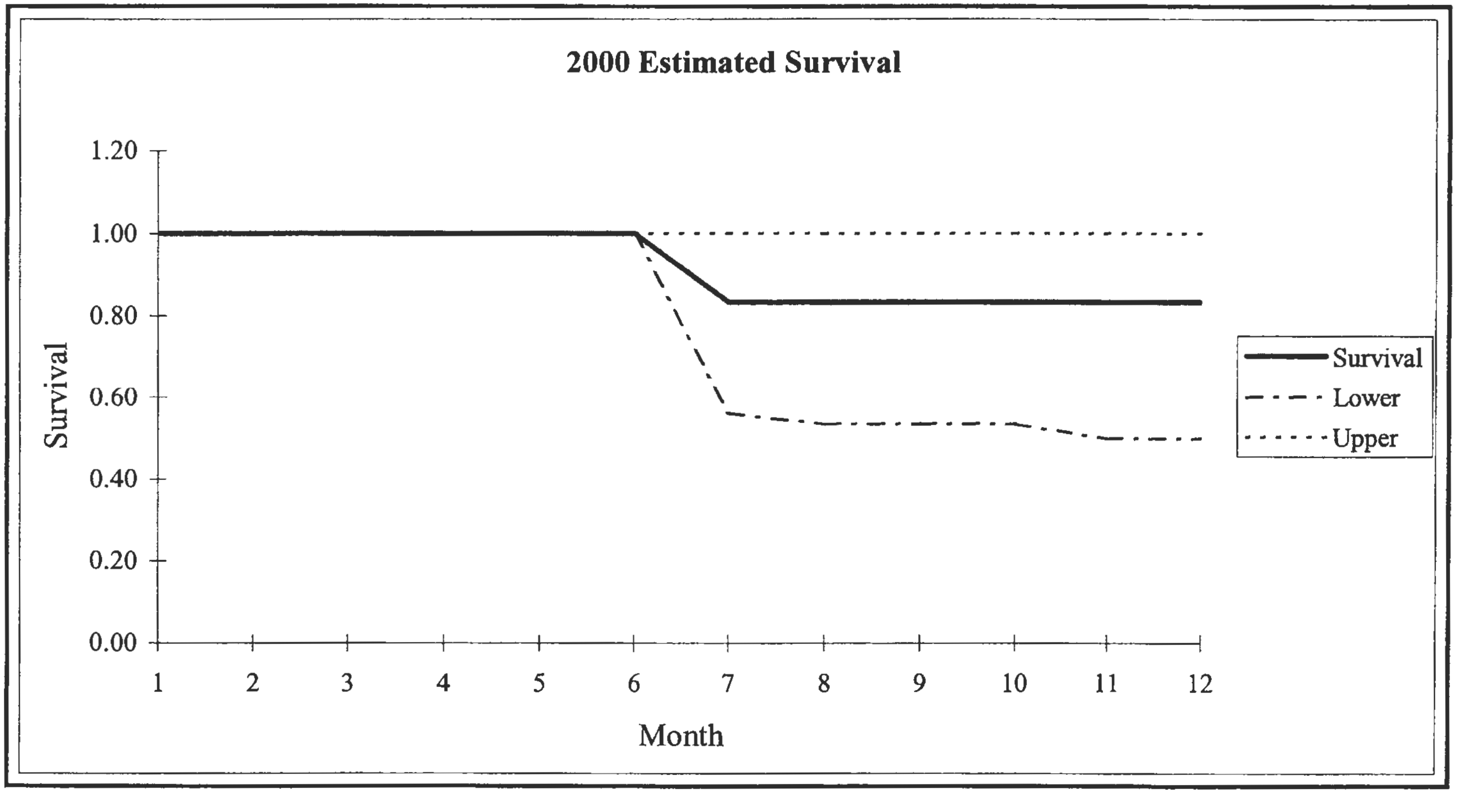

Fig. 4. Cumulative estimated first-year survival of translocated adult female bears, Felsenthal National Wildlife Refuge, Arkansas, 2000.

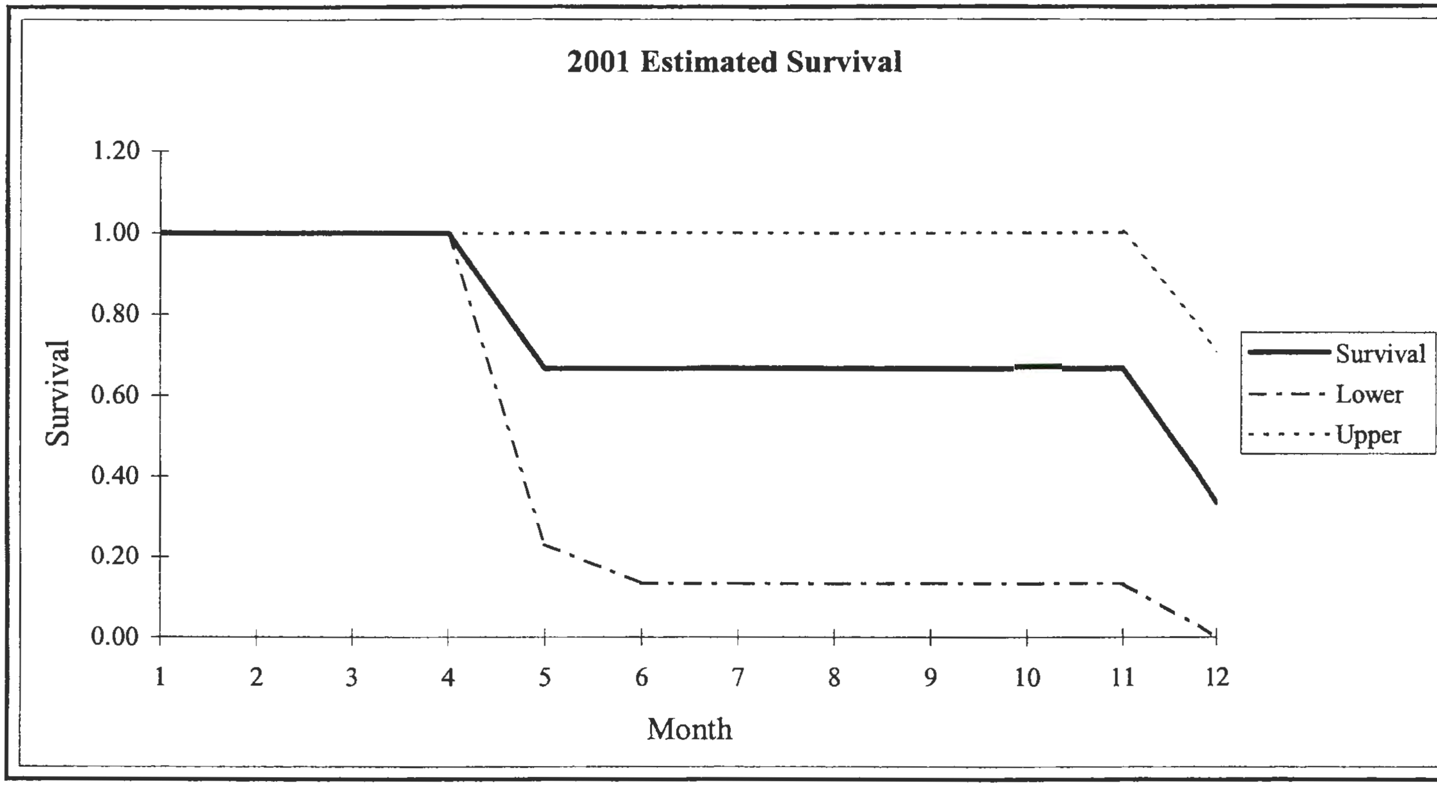

Fig. 5. Cumulative estimated first-year survival of translocated adult female bears, Felsenthal National Wildlife Refuge, Arkansas, 2001.

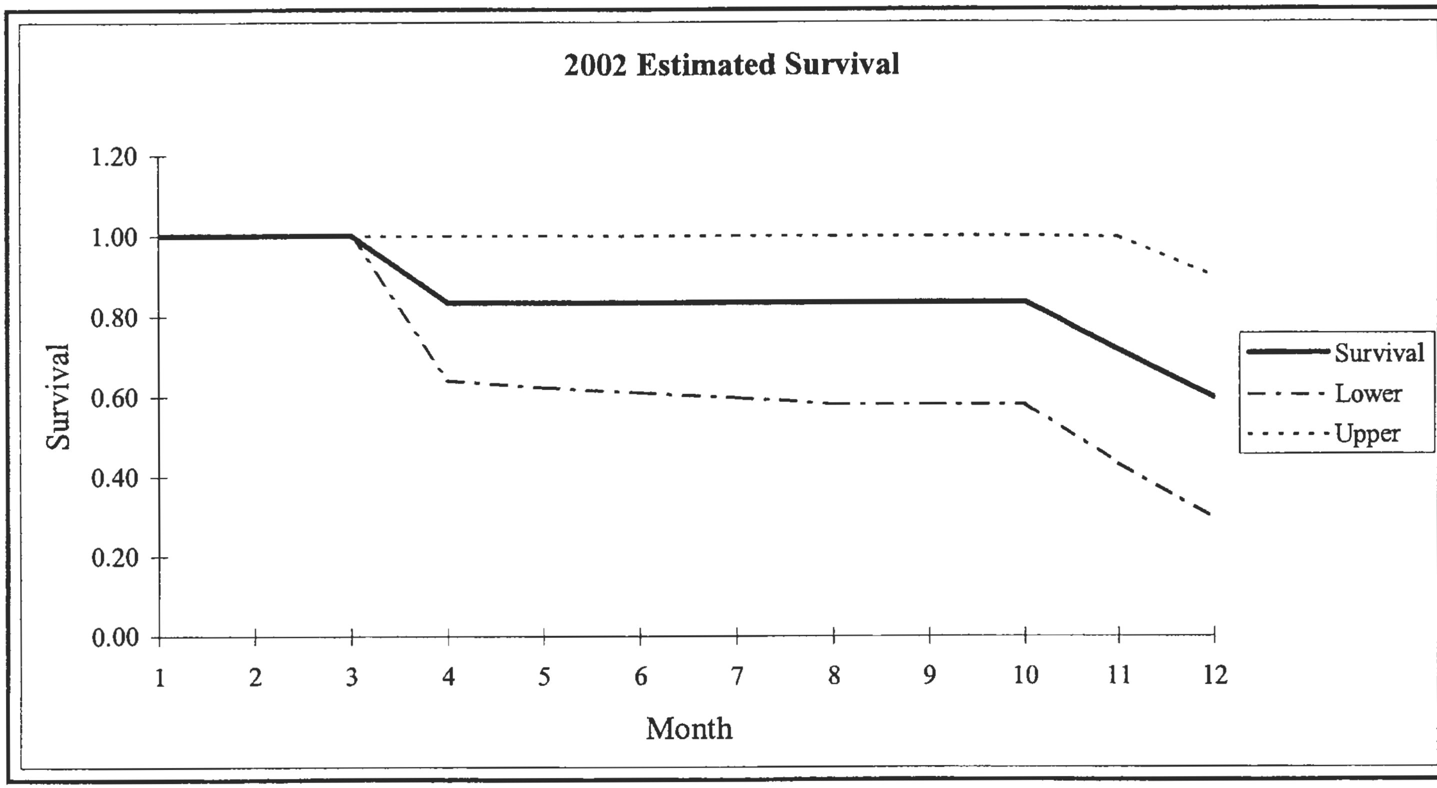

Fig. 6. Cumulative estimated first-year survival of translocated adult female bears, Felsenthal National Wildlife Refuge, Arkansas, 2002.

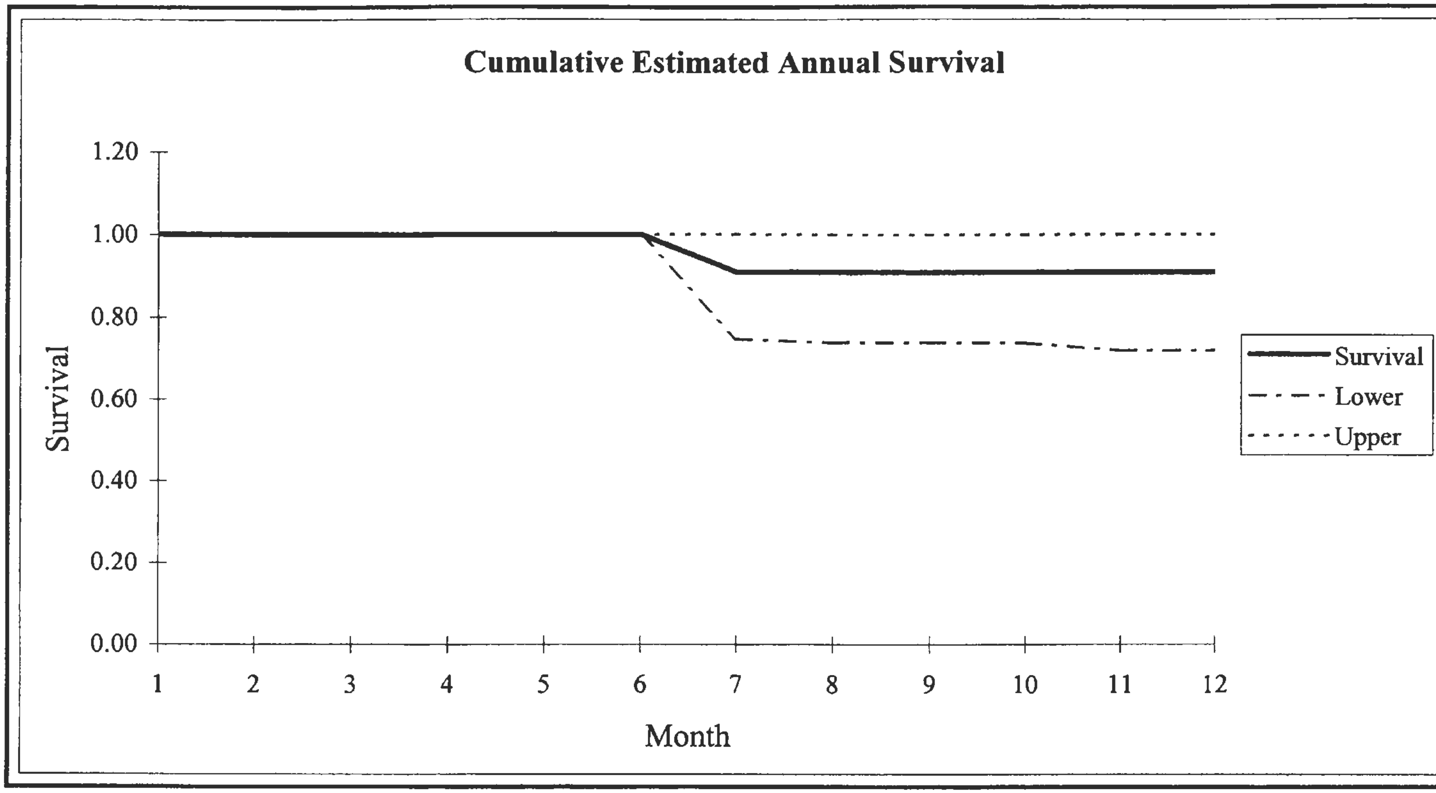

Fig. 7. Cumulative estimated annual survival of translocated adult female bears that survived >1-year post-release, Felsenthal National Wildlife Refuge, Arkansas, 2000–2002.

survival in 2000, 2001, and 2002 was 1.0, 0.5, and 1.0 (95% CI = 0–1.0). Cumulative annual survival for all translocated adult females over the duration of the study was 0.676 (95% CI = 0.487–0.864; Fig. 8).

Cub Counts and Denning

I conducted cub counts in June and August 2000 to determine the minimum number of cubs surviving to ages of 4 and 6 months. Bear 003 was translocated to Felsenthal with 3 cubs (Table 2). I sighted 003 with 2 cubs in June, but she was found dead along with the remains of 1 cub before the next count; I assumed the other 2 cubs also were dead. Bear 048 had 2 cubs when she was translocated. I observed her with 2 cubs in June and again with 2 cubs in August 2000. However, subsequent sightings in fall indicated only 1 remaining cub. Bear 126 also was translocated with 2 cubs, and was re-sighted with both cubs in June and August. Likewise, bear 053 had 2 cubs when translocated. I observed her with both cubs in June, but was only able to confirm 1 cub in August. Bear 112 was translocated with 3 cubs. All 3 cubs were still with her in June; by August I could verify only 2 remaining cubs. Bear 143 was brought to Felsenthal with 4 cubs, but 1 cub died in transport. I confirmed 3 surviving cubs in June and she was again seen with 3 cubs in late July.

In 2001, 1 adult female died in the den at White River following immobilization. I attempted to foster her 3 cubs to 2 females that had already been placed in dens at Felsenthal, following techniques described by Alt and Beecham (1984). I applied mentholated salve to the cubs and placed the cubs outside the den box entrance. Bear 162 had 1 cub at the time of translocation and 1 cub was fostered to her (Table 2). Upon

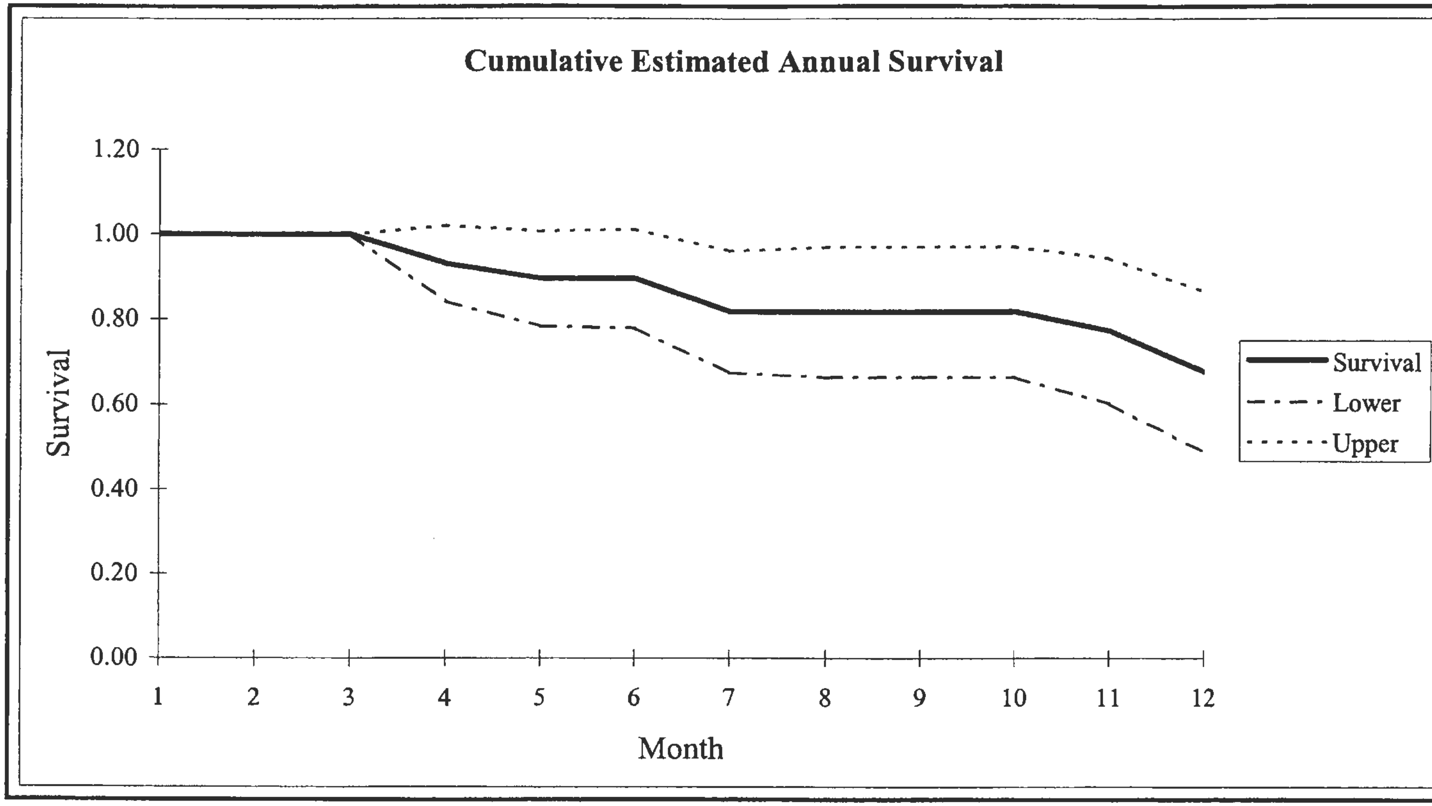

Fig. 8. Cumulative estimated annual post-release survival of all translocated adult female bears, Felsenthal National Wildlife Refuge, Arkansas, 2000–2002.

den emergence 162 dropped her radiocollar, thus prohibiting me from conducting scheduled cub counts. Nonetheless, sightings were reported in July and September 2001 of a collarless adult female with 2 cubs <3 km from 162's release site. Bear 045 had 2 cubs when translocated, but no cubs were present when I observed her in June. Bear 165 was translocated with 1 cub and 2 were fostered to her. She was sighted several times in May with 1 cub, and was seen in July and September with 1 cub as well. Bear 021 had 3 cubs at translocation. She left the study area following release and was struck and killed by an automobile on 20 May 2001. Earlier in May, project personnel had reported seeing 021 crossing a highway without cubs.

In 2002, bear 200 was translocated to Felsenthal with 4 cubs (Table 2). She appeared to be traveling back toward White River when AGFC personnel captured her on 15 April 2002. She was then transported to an area near her original home range at White River. No cubs were present at the time of capture. Bear 167 had 2 cubs when translocated. She was seen with both cubs in May, but returned to her original home range in July 2002. Bears 135 and 139 each were translocated with 1 cub, and both adult females returned to White River in May and June, respectively. The fate of their cubs was not determined. Bears 018 and 006 died at their release sites, as described above. Although the 2 cubs of 018 were presumed dead, project personnel were able to capture 006's 3 cubs at the den site. Precautions were taken to minimize human contact, and the 3 cubs were fostered to 2 adult females denned at White River, again using techniques described by Alt and Beecham (1984). Mentholated salve was applied to the cubs, and the cubs were placed in tree dens without chemically immobilizing the adult female. Bear 166 was translocated with 4 cubs to Felsenthal. She was last seen with all of her cubs on 24 October 2002. Bear 072 had 2 cubs when she was translocated. She and both her cubs were sighted in May 2002. Bear 180 was translocated with 1 cub. On 26 May 2002, AGFC personnel captured her and the cub in a residential area approximately 40 km east of the release site, and transported the bears back to Felsenthal. Bear 199 had 3 cubs when translocated. She and 1 cub were captured by AGFC personnel approximately 40 km east of Felsenthal on 4 July 2002, and transported back to the refuge. Bear 146 was translocated with 2 cubs to Felsenthal. She was last sighted with 1 yearling in January 2003. Bear 076 was translocated with 4 cubs. She also was sighted in January 2003, but with only 2 yearlings. Lastly, bear 037 was translocated with 2 cubs and was sighted with both of them in December 2002.

I visited the dens of 3 radiocollared Felsenthal females in February 2001. Bear 048 denned in a baldcypress tree located in a flooded area of Felsenthal. I documented 1 yearling present with the female, concurrent with sightings from fall 2000. Bear 126 also denned in a baldcypress in a flooded portion of Felsenthal. High water and den tree characteristics prevented me from documenting yearling survival on the date of inspection. However, we observed her with 2 yearlings in March 2001, again in agreement with counts obtained in August 2000. Bear 053 denned in a willow oak tree on Overflow National Wildlife Refuge, approximately 40 km east of Felsenthal. I documented 1 yearling present with that female; I had also previously confirmed the presence of 1 yearling in August 2000. Bear 112 was active when I conducted den work in 2001. Although she did not appear to den, she confined her movements to a small area within the southern portion of Felsenthal. Bear 112 was subsequently sighted with 2 yearlings in May and June 2001, reaffirming sightings from August 2000. All adult females and yearlings appeared to be in excellent physical condition.

I visited 2 dens of radiocollared female bears in March 2002. Bear 053 denned on the ground in a thicket on Overflow. She had given birth to 1 cub, the first natural reproduction documented in any of the adult females since their release. Bear 045 denned in a Nuttall oak tree south of Overflow, in northern Louisiana. I documented no yearlings with her in the den, supporting my assessment from June 2001. Bear 126 was active in 2002 when I attempted to locate her winter den. As a result, I was unable to determine her reproductive status.

Population Modeling

Scenario 0 began with the standing age distribution of bears present at Felsenthal in 2003 ($n = 28$) and the survival estimates for bears surviving >1 year (Table 1); the population size was projected to be 666 bears in 25 years (SE = 43.3). The mean annual growth rate (λ) was 1.135, with 13% of trials resulting in extinction (Table 6). Using the same parameter estimates, the mean annual growth rate after 50 years was 1.170, and 22% of the trials resulted in extinction. Without density effects incorporated into the model, the total population increased exponentially, with >70,000 bears projected after 50 years. Especially noteworthy, however, was the standard error of 13,000 individuals associated with the 50-year estimate. That large standard error was partially caused by the accumulation of yearly variation over time. Because the growth projections were less precise after 50 years, I compared average growth rates after 25 years.

Table 6. Stocking scenarios and population growth projections for black bears translocated to Felsenthal National Wildlife Refuge, Arkansas. Scenarios 1–6 involved releasing 6 adult females and 12 cubs each year for 6 consecutive years.

	25 years				50 years	
Scenario	**Total Population**	**SE**	**Mean Annual Growth Rate (λ)**	**Percent Extinctions**	**Mean Annual Growth Rate (λ)**	**Percent Extinctions**
Scenario 0	666	43.3	1.135	13	1.170	22
Scenario 1	754	52.1	1.141	12	1.170	19
Scenario 2	812	48.1	1.144	11	1.172	19
Scenario 3	745	35.3	1.140	10	1.163	19
Scenario 4	889	53.1	1.148	8	1.171	17
Scenario 5	961	47.2	1.152	8	1.171	15
Scenario 6	913	47.2	1.150	6	1.172	16

Subsequent stocking scenarios involved the release of 6 females and 12 cubs each year for the next 6 years, again using parameter estimates for bears surviving >1 year. The release of 18 (6 adult females, 12 cubs) additional bears in 2003 was simulated with Scenario 1 (Table 6). After 50 years, 19% of trials resulted in extinction. Scenario 2 involved the release of 36 bears during 2003–2004, and 19% of trials resulted in extinction. With 54 bears released 2003–2005 in Scenario 3, the cumulative extinction rate was 19%. Seventy-two bears were released 2003–2006 with Scenario 4; 17% of trials resulted in extinction. Scenario 5 involved the release of 90 bears during 2003–2007, with 15% of trials resulting in extinction. Finally, Scenario 6 involved releasing a total of 108 bears during 2003–2008. After 50 years, 16% of trials resulted in extinction.

The release of 12 adult females and 24 cubs in 2003 was simulated with Scenario 1B (Table 7). After 50 years, 25% of trials resulted in extinction. Scenario 2B involved the release of 72 bears during 2003–2004, and 18% of trials resulted in extinction. With 108 bears released 2003–2005 in Scenario 3B, 17% of trials resulted in extinction. In Scenario 4B, 144 bears were released 2003–2006, and 17% of trials resulted in extinction. Scenario 5B involved the release of 180 bears during 2003–2007; 17% of trials resulted in extinction. Finally, a total of 216 bears was released in Scenario 6B during 2003–2008. After 50 years, 16% of trials resulted in extinction.

Habitat Use Analysis

When all locations were examined at the third-order level, woody wetlands ranked highest among the 8 habitat types (Table 8; Fig. 9). The rankings did not reflect a

Table 7. Stocking scenarios and population growth projections of black bears translocated to Felsenthal National Wildlife Refuge, Arkansas. Scenarios 1B–6B involved releasing 12 adult females and 24 cubs each year for 6 consecutive years.

	25 years				50 years	
Scenario	**Total Population**	**SE**	**Mean Annual Growth Rate (λ)**	**Percent Extinctions**	**Mean Annual Growth Rate (λ)**	**Percent Extinctions**
Scenario 0	666	43.3	1.135	13	1.170	22
Scenario 1B	820	60.8	1.145	18	1.174	25
Scenario 2B	1016	59.3	1.155	11	1.174	18
Scenario 3B	1181	72.1	1.162	9	1.178	17
Scenario 4B	1213	62.9	1.163	8	1.176	17
Scenario 5B	1281	67.9	1.165	8	1.177	17
Scenario 6B	1302	67.0	1.166	7	1.179	16

Table 8. Ranking matrix for third-order habitat use (use of habitat components within home ranges) by black bears translocated to Felsenthal National Wildlife Refuge, including exploratory movements, 2000–2002. Each mean element in the matrix was replaced by its sign; a triple sign represents significant deviation from random at $P < 0.05$.

Habitat Type	**Habitat Types**								
	Wetland	Mixed	Pine	Hardwood	Agriculture	Open Water	Developed	Transitional	Rank
Wetland		+	+	+++	+++	+++	+++	+++	1
Mixed	-		+	+	+	+++	+++	+++	2
Pine	-	-		+	+	+++	+++	+++	3
Hardwood	---	-	-		+	+	+++	+++	4
Agriculture	---	-	-	-		+	+	+	5
Open Water	---	---	---	-	-		+	+	6
Developed	---	---	---	---	-	-		+	7
Transitional	---	---	---	---	-	-	-		8

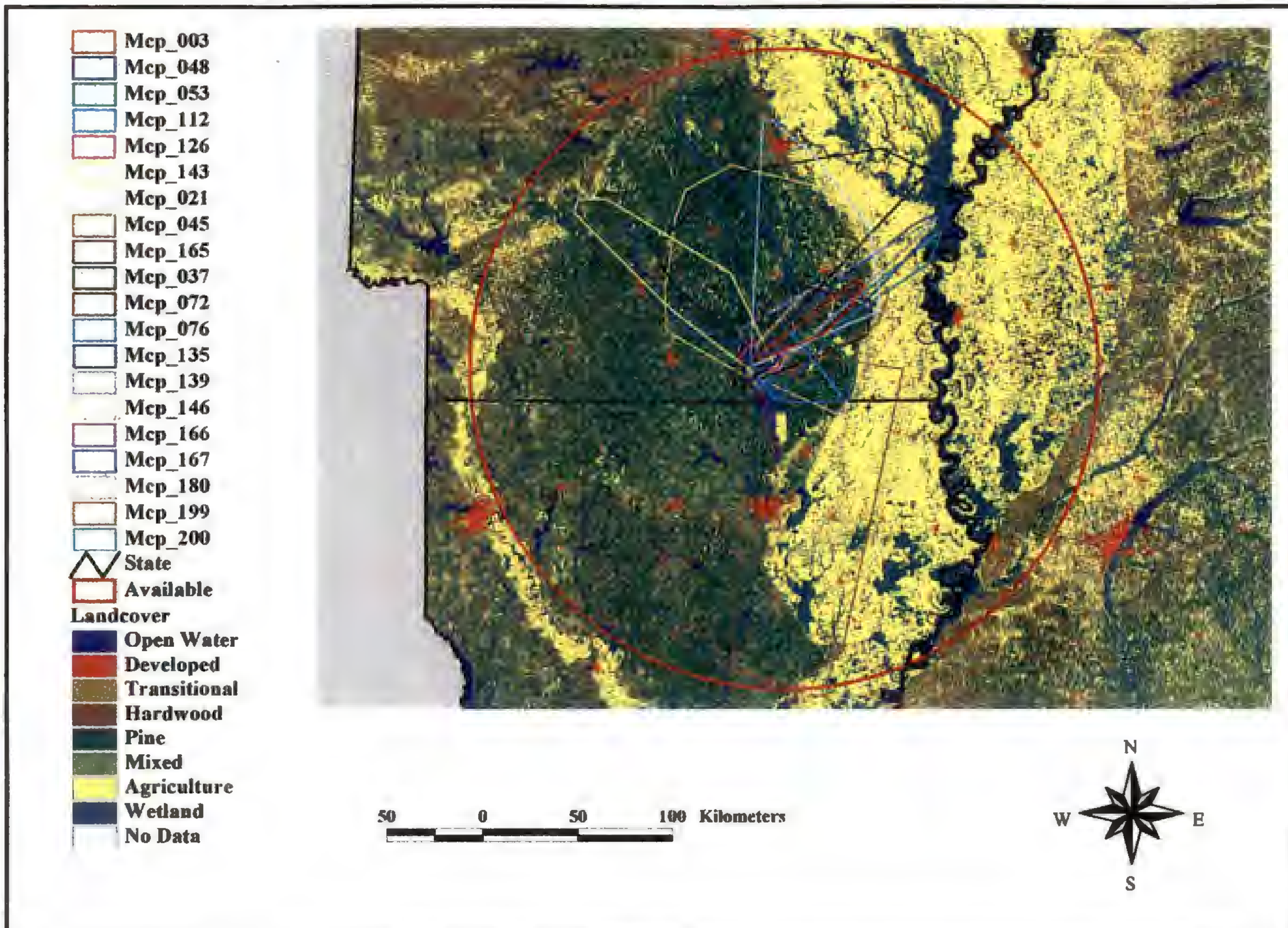

Fig. 9. Minimum convex polygon home ranges of translocated adult female black bears and available habitat, Arkansas and Louisiana, 2000–2002.

difference between woody wetlands and mixed ($P = 0.123$) or pine forests ($P = 0.101$). However, bears used woody wetlands more than all remaining habitat types ($P \leq 0.040$).

Analysis of second-order selection exclusive of exploratory movements indicated that female home ranges were primarily located in woody wetlands relative to the other 8 available habitat types (Table 9; Fig. 10). Woody wetlands influenced home range placement more than other habitat types ($P \leq 0.021$), with the exception of open water ($P = 0.177$). Although pine and mixed forests had less influence on the placement of home ranges compared with wetlands, they had more impact than remaining habitats ($P \leq 0.018$ and 0.036, respectively).

Wetlands also ranked highest among habitat types for third-order selection within 95% KHRs (Table 10). I failed to detect a difference in habitat use between woody wetlands and pine ($P = 0.507$), hardwood ($P = 0.656$), or mixed ($P = 0.395$) forests. Woody wetlands, pine, and hardwood forests were each used more than developed, agricultural, open water, and transitional habitats ($P \leq 0.007$, 0.018, and 0.049, respectively).

Sightings and Human-Bear Interactions

AGFC, USFWS, and UT personnel documented >40 bear sightings from April 2000 to January 2003. Those reports did not include bears sighted by project personnel during radiotelemetry activities. Furthermore, there were 4 reports of bears visiting deer feeders and 1 case in which a cloth ground-blind was pushed over by a bear. Hunting dogs treed translocated bears on 2 occasions near residential areas; in each case the bear left the area with no property damage reported. Two additional adult females were

Table 9. Ranking matrix for second-order habitat use (placement of home ranges within the landscape) by black bears translocated to Felsenthal National Wildlife Refuge, 2000–2002. Each mean element in the matrix was replaced by its sign; a triple sign represents significant deviation from random at $P < 0.05$.

	Habitat Types								
Habitat Type	Wetland	Open Water	Pine	Mixed	Hardwood	Transitional	Agriculture	Developed	Rank
Wetland		+	+++	+++	+++	+++	+++	+++	1
Open Water	-		+	+	+++	+++	+++	+++	2
Pine	---	-		+	+++	+++	+++	+++	3
Mixed	---	-	-		+++	+++	+++	+++	4
Hardwood	---	---	---	---		+	+++	+++	5
Transitional	---	---	---	---	-		+	+++	6
Agriculture	---	---	---	---	---	-		+	7
Developed	---	---	---	---	---	---	-		8

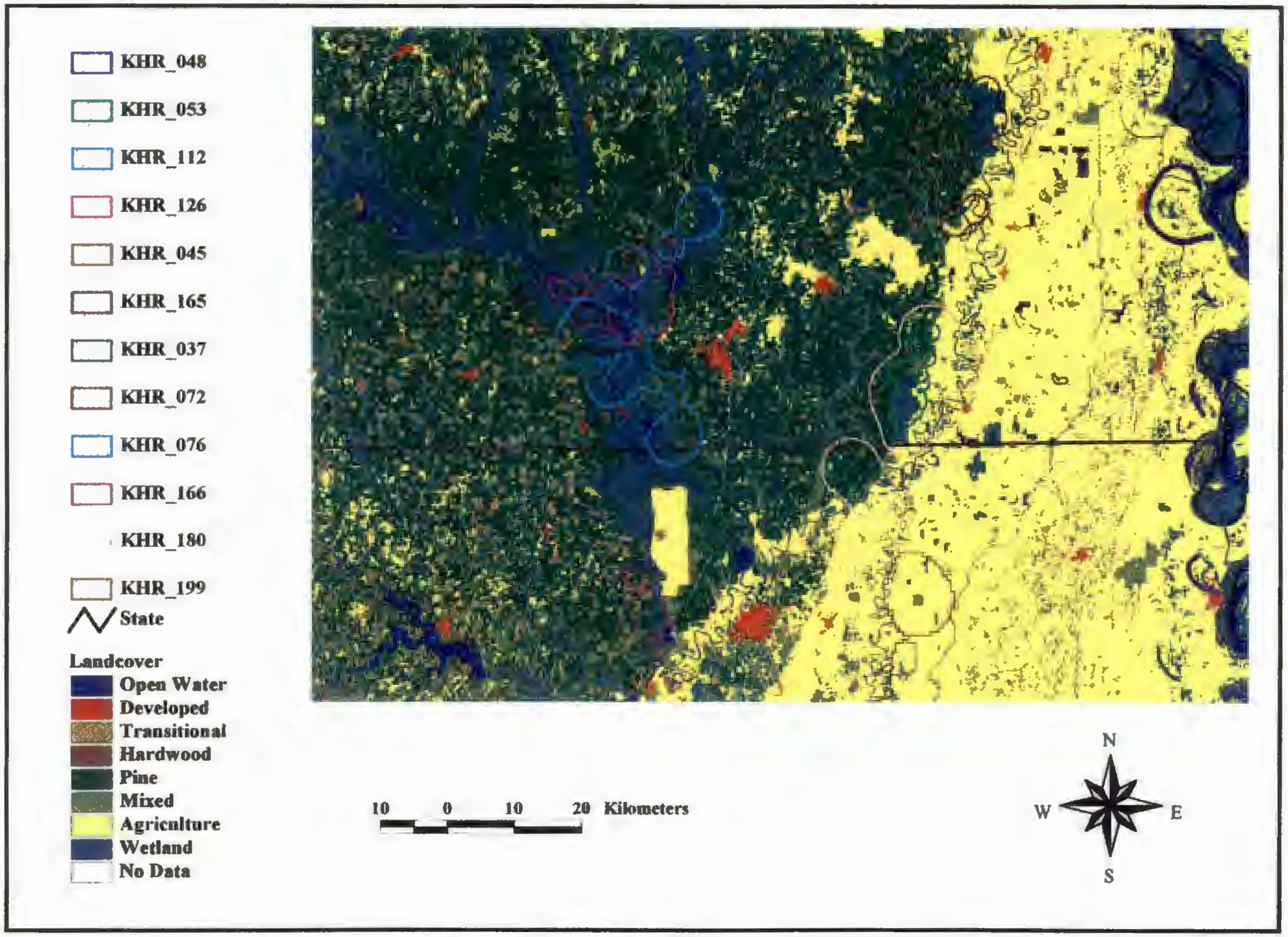

Fig. 10. Ninety-five percent fixed kernel home ranges of translocated adult female black bears, Arkansas and Louisiana, 2000–2002.

Table 10. Ranking matrix for third-order habitat use (use of habitat components within home ranges) by black bears translocated to Felsenthal National Wildlife Refuge, 2000–2002. Each mean element in the matrix was replaced by its sign; a triple sign represents significant deviation from random at $P < 0.05$.

Habitat Type	Habitat Types								
	Wetland	Pine	Hardwood	Mixed	Developed	Agriculture	Open Water	Transitional	Rank
Wetland		+	+	+	+++	+++	+++	+++	1
Pine	-		+	+	+++	+++	+++	+++	2
Hardwood	-	-		+	+++	+++	+++	+++	3
Mixed	-	-	-		+	+++	+	+++	4
Developed	---	---	---	-		+	+	+	5
Agriculture	---	---	----	----	-		+	+	6
Open Water	---	---	---	-	-	-		+	7
Transitional	---	---	---	---	-	-	-		8

captured in residential areas and transported back to Felsenthal, as mentioned above. Three adult male bears also were documented on or near Felsenthal. One was captured in a makeshift trap by a local landowner approximately 20 km west of the refuge. Project personnel snared another while attempting to capture an adult female on Felsenthal for collar replacement. A deer hunter videotaped a translocated female with cubs and what appeared to be a third male while hunting at Felsenthal. AGFC officials observed the footage and concluded that the unmarked bear most likely was an adult male, due to its larger size and behavior in the presence of the female with cubs (R. Eastridge, AGFC, personal communication). In addition to the above incidents, 1 translocated adult female (143) was struck by a train approximately 40 km north of Felsenthal. The collision knocked the bear from a trestle, into a dry creek bed, but the female walked away from the site. AGFC biologists observed her the next day, and I was able to assess her condition the following week. Motor functions of the female seemed normal and she had no apparent external injuries. I continued to monitor her movements for 1 month, at which time her radiocollar failed.

CHAPTER V

DISCUSSION

Movements

Short- and long-term success of reintroduction efforts is governed in part by the relationships between post-release movements, site fidelity, homing behavior, and post-release survival (Eastridge and Clark 2001). Eastridge and Clark (2001) found circuity to be a better measure of site fidelity than the test available in the Animal Movement extension to ArcView® GIS. I explored the site fidelity test in my study as well, and came to similar conclusions. Bears that exhibited homing behavior sometimes showed constrained movements, but they were constrained homeward and not a reflection of site fidelity. Also, bears that left their release site but established home ranges nearby were interpreted as exhibiting random movements. Conversely, circuity values decreased between 1-month, 6-month, and 1-year periods, reflecting a decrease in the ratio of net movement to total movement over time. Two factors could have affected the circuity values. First, bears that were censored or died between periods were not included in the next set of distance calculations. Most censored bears were those that left the study area, and the majority of deaths that occurred shortly after release was the result of extensive post-release movements. Second, bears translocated in 2002 could not be included in 1-year distance calculations because I did not include location data collected >6 months after emergence. Several of those bears also had exhibited extensive movements, which, if monitoring had continued, could have skewed the 1-year circuity values. Nevertheless, when only those bears surviving >1 year post-emergence were considered ($n = 5$), a marked decrease in circuity values over time remained apparent. Most notable was the decrease in mean circuity values between 1-month and 6-month periods ($\bar{x}$ = 0.47 and 0.14, respectively). Eastridge (2000) documented restricted movements among non-returning, translocated bears after 9 months, with most restricting their movements within 6 months after translocation. Bears in my study seemed to exhibit similar behavior.

Generally, bears that returned home or exhibited homing behavior did so within the first month following den emergence. Bear 021 was traveling toward White River when she was struck and killed by an automobile in late May 2001 (1-month circuity = 0.73). Bear 200 seemed to move in a homeward direction by mid-April 2002, at which time AGFC personnel captured and transported her to White River (1-month circuity = 0.96). The same year bears 135 and 139 returned to White River in May and June, respectively (1-month circuity = 0.52 and 0.65, respectively). Also in 2002, 180 and 199 were moving in a homeward direction when captured by AGFC personnel and returned to Felsenthal (1-month circuity = 0.90 and 0.79, respectively). Both females had 1 cub at the time of recapture, and both remained in the Gulf Coastal Plain following their second release.

Additionally, homing females traveled quickly and in a directed path, not appearing to be constrained by landscape attributes or habitat types. Researchers monitoring reintroduced female bears in Tennessee observed similar behavior in homing bears immediately following den emergence (R. Eastridge, AGFC, personal communication). In contrast, bears that extensively moved following release, but did not attempt to return home, tended to follow land attributes such as rivers, creeks, or bayous. Despite extensive movements, bears that eventually settled near Felsenthal did not traverse agricultural lands and tended to avoid developed areas. Non-homing bears also moved more slowly across the landscape during the first month, evidenced by their lower mean daily movements (Table 3). One exception should be noted: Bear 045 moved quickly and extensively following her release, but settled into a home range within 6 months.

Alt (1978) suggested that young bears demonstrate greater site affinity to the release area following translocation compared with older bears. Comly (1993) found that subadult male black bears were less likely to demonstrate homing behavior than adult male bears when translocated. Similar behavior also was documented among translocated female black bears in Tennessee and Kentucky (Eastridge and Clark 2001). I found no relationship between age and homing behavior among female bears translocated to Felsenthal. In all but 2 instances, however, females that attempted to return home during this study had no cubs when observed. Additionally, those 2 bears with surviving cubs were translocated back to Felsenthal and remained near the second release area, as noted previously. In previous studies of bears translocated in the Southeast, females with cubs also exhibited fewer post-release movements and demonstrated greater site affinity than unencumbered females (Comly 1993, Eastridge and Clark 2001). These observations provide further evidence of the effectiveness of reintroducing females with cubs using the winter-release technique.

Bait-Station Survey

Bait-station surveys enable managers to monitor trends in relative abundance and distribution (Johnson and Pelton 1980). When the bait-station survey was conducted in

2000, there were 2 adult female bears and 5 cubs residing on Felsenthal. In July 2001, there were up to 3 adults and 9 cubs remaining on Felsenthal. During the bait-station survey of 2002, up to 7 adult females with a maximum of 16 cubs remained on the refuge. The single visit, recorded in 2002, occurred in an area where a female was known to be present. Thus, I was unable to confirm the presence of non-translocated bears on Felsenthal. These bait-station data, however, can serve as a baseline for future monitoring.

Survival

Mean first-year survival of adult females translocated to Felsenthal (0.59) was lower than that of winter-released bears in Tennessee (0.88; Eastridge and Clark 2001). Nonetheless, survival of bears released at Felsenthal was greater than the survival of hard-released black bears in other areas (0.56; Massopust and Anderson 1984, 0.37; Comly 1993) or summer-released bears in Tennessee (0.20; Eastridge and Clark 2001).

First-year post-release survival of female bears translocated in 2001 (0.33) was noticeably lower than first-year survival estimates from 2000 (0.83) and 2002 (0.60). The lower 2001 survival rate reduced mean first-year survival by 12%. Data collected from denned females at White River suggest female bears often were in reproductive synchrony, with a greater proportion of females having cubs every other year (R. Eastridge, AGFC, unpublished data). This type of synchrony has been demonstrated by female black bears in other studies, and often coincides with mast crop fluctuations (e.g., Rogers 1976, Pelton 1989). Furthermore, post-natal cub development is highly dependent on the milk supply of the adult female, which, in turn, is dependent on nutrients acquired during the previous year (Rogers 1976). A poor hard mast crop in 2000 resulted in fewer cubs born to females on White River in 2001. In addition, extensive winter flooding led to higher instances of cub abandonment when rising water levels forced females from winter dens. Consequently, there were fewer translocation candidates in 2001, and bears were translocated earlier in the year as water levels continued to rise. All of these factors combined to yield fewer bears moved in 2001 with younger, less resilient cubs. Those cubs suffered greater mortality after translocation, which likely resulted in greater post-release movements and increased mortality among adult females.

One bear was killed in a vehicle collision after losing her cubs and making extensive movements homeward. Vehicle-related mortalities often are associated with homing and can be expected to be high for reintroduced bears the first year after release (Comly 1993, Eastridge 2000). Poaching appeared to be a significant mortality factor among translocated bears at Felsenthal, accounting for up to 50% of adult female mortalities. This demonstrates the importance of public support of reintroduction efforts. Although >70% of local residents surveyed prior to this study supported bear reintroduction, even a minimal number of opponents could have a dramatic impact on the success of the project if poaching continues.

Cub Counts and Denning

In all instances, the number of yearlings surviving with adult females in winter dens corresponded with the number of cubs observed during the fall cub counts. Several researchers have evaluated the use of radio telemetry to refine survival estimates for cubs (e.g., LeCount 1987). When feasible, however, visually assessing cub survival would provide a valuable, more economical alternative without increased mortality risks associated with affixing radio transmitters to young cubs. By conducting cub counts at regular intervals, I was able to define a window of time when cubs suffered higher mortality, although the cause of death could not be determined. All cubs I observed ≥4 months after release (6 months of age) survived to yearling age. This finding was similar to previously reported black bear cub survival (Erickson 1959, Rogers 1977, LeCount 1987). Additionally, 3 of 6 fostered cubs were known to have survived ≥4 months of age during my study. Alt and Beecham (1984) reported similar survival rates for fostered and non-fostered black bear cubs in Pennsylvania.

I documented natural reproduction with 1 cub being born to a translocated female in 2001. This was the first year the female (053) was not encumbered with offspring during the breeding season. Project personnel reported natural reproduction in a second female (126) in 2002, which also gave birth to 1 cub. Comly (1993) documented no reproduction among translocated females the first year following release. Eastridge (2000) documented reproduction in translocated females, but also noted a 1-year delay from the time females were unencumbered to when they actually reproduced. Sires were thought to be transient male bears or subadult males that were translocated as cubs and were able to breed in the absence of dominant adult males (Eastridge 2000). In my study, 053 was located on Overflow refuge for >1 year prior to giving birth. No translocated males were present in this area; however, reported bear sightings were more common on Overflow than other areas in the region (J. Johnson, USFWS, personal communication). Therefore, I speculate that a resident or transient male sired the cub born in 2001. Bear

126 gave birth just east of Felsenthal, and had remained on or near the refuge throughout 2002. These observations would indicate the presence of at least 1 transient male on Felsenthal or that a 2.5-year-old male, reintroduced as a cub, could have reproduced (Rogers 1977, Eastridge 2000). In either case, litter production among translocated females indicates there are sufficient male bears present in the release area to ensure natural reproduction.

Population Modeling

Without additional bear stockings on Felsenthal, my data indicate a 22% probability that the current population of bears will be extinct in 50 years. Therefore, I evaluated various stocking scenarios. With yearly releases of 6 adult females and 12 cubs, the probability of extinction declined to ≥15% after 6 years of stocking. Stockings of 12 adult females and 24 cubs each year only reduced the extinction probability to 16% after 6 years. Both sets of stocking scenarios reduced the probability of extinction to <20% after 2 additional yearly stockings. Eastridge and Clark (2001) found a point of diminishing returns where additional stockings became less efficient, and probability of extinction was <1%. However, whereas extinction probabilities steadily declined in my study, probability of extinction was ≥15% after 6 years of simulated bear stockings. Based on these projections, it would take several additional years to further reduce the probability of extinction. The possibility remains, however, that a point of diminishing returns already had been reached prior to the initial stocking scenario. To test this hypothesis, I decreased the initial starting population from 28 to 6 bears and ran the stochastic trials. I found that with no additional stockings, there was a 40% probability of extinction. After 3 simulated stockings of 6 adult females and 12 cubs, the extinction probability decreased to 20%. Thus, I believe that the starting population of 28 bears likely was near the point whereby diminishing returns begin to be incurred.

Numerous studies have emphasized the importance of releasing an adequate number of founding individuals to ensure population establishment (Griffith et al. 1989, Smith and Clark 1994, Saltz 1995, Wolf et al. 1996, Pelton and van Manen 1997). However, the low mean first-year survival rate (0.587) of adult female bears in this study, when incorporated in the model, likely diminished noticeable impacts of extended stocking scenarios. Additional factors likely influenced the simulation results. The relatively high standard errors (30%) incorporated in the stochastic trials increased the variability of simulation results. Environmental uncertainty was incorporated into the model at 25% as well, and likely added to the undulations among population growth and extinction rates. When each of the simulations was run deterministically, growth rates fluctuated between years but generally stabilized within 25 years. With survival and fecundity held constant in the deterministic mode, the population reached a stable age distribution, causing the growth rate to also stabilize (Lotka 1907*a,b*). However, survival and fecundity are rarely stable for long in nature (Caughley 1977), and the variability incorporated in stochastic trials helps account for natural and environmental variability. This variability is particularly relevant in a floodplain ecosystem such as Felsenthal, where seasonal and yearly environmental variation plays a vital role in natural processes (Junk et al. 1989).

Population growth projections and other results derived from the population model are meant to provide a general guideline only, and are highly sensitive to imprecise parameter estimates. However, the estimates I incorporated were realistic, if not conservative. Mean first-year survival of adult females likely was affected by poor cub survival in 2001. Excluding estimates from that year, mean first-year survival increased from 0.58 to 0.71. In addition, decreasing human-induced mortality (i.e., poaching) would noticeably enhance adult female survival, thus improving population viability. Moreover, the adult male survival estimates that I included in the model were not estimated from bears translocated to Felsenthal; however, this parameter has significantly less influence on population growth than female survival and fecundity and likely had less impact on model results. Finally, the documented presence of transient male bears in the area and confirmation of natural reproduction suggests the stocking of adult male bears should not be required to ensure reproduction.

Habitat Use Analysis

Woody wetlands ranked highest among the 8 available habitat types at both second- and third-order selection levels. Translocated female bears used mixed and pine forests only slightly less proportionally than wetlands at the third-order level when all post-release locations were included. However, the majority of locations within mixed and pine forest types occurred along the fringes of wooded wetland areas as female bears explored their new surroundings. In those instances when female bears exhibited homing behavior, they appeared less apt to confine their movements to riparian or other wetland areas, as noted above. For example, bears 021, 135, and 167 were located in pine forests 36%, 67%, and 36% of the time, respectively, and 48% of 139's locations were in hardwood forests. All of these bears attempted to return home, and each adult female had

≤23% locations in woody wetlands. In contrast, bears that did not exhibit homing behavior were located in wetland habitats an average of 60% of the time (range = 12–89%).

When exploratory movements were excluded, I found that woody wetlands influenced where translocated female bears established home ranges more than any other available habitat type. Open water also seemed to be influential in home range placement, but this likely was a secondary effect of home range establishment in wetland habitats. Wetlands accounted for only 15% of total habitat available to bears, whereas pine forests comprised 22% and agriculture made up an additional 35%. Mixed and hardwood forests each accounted for 11% of available habitat. Despite encompassing the largest proportion of available habitat, agriculture had nearly the least influence on second-order habitat selection, ranking only above developed areas. However, major agricultural crops included cotton, rice and soybeans, which are not preferred by black bears. Although wooded wetlands comprised a small proportion of the total available habitat, they clearly played an important role in home range establishment.

Third-order analysis of habitat selection among females that established home ranges also indicated that woody wetlands was the most used habitat type. This ranking did not, however, reflect a significant difference in proportional use among wetlands, pine, hardwood, or mixed forests. This suggests that wooded wetlands were more exclusively used when searching for and establishing home ranges, but once established, forested habitat types within the home range were used in proportion to availability.

All translocated bears were released in upland pine or mixed forest habitats at Felsenthal to avoid den-site flooding. Nevertheless, bears used wetland habitat types more than all other available habitats following den emergence. This was observed as bears made early exploratory movements, and became more evident as bears established home ranges within the landscape. Anderson (1997) and Beausoleil (1999) documented bears using forest corridors to move between otherwise isolated tracts of bottomland hardwoods in the Tensas River Basin in northeast Louisiana. Data from my study suggest that riparian areas (i.e., wooded wetlands adjacent to waterways) facilitated movement as translocated bears explored their new surroundings. Subsequent home range establishment also was influenced by the presence of woody wetlands. Many females established home ranges on other state or federally owned lands near Felsenthal. Forested lands surrounding the refuge were largely privately owned, and were predominantly pine uplands. Public lands in the area contained the only remaining sizeable tracts of woody wetlands or bottomland hardwoods. The selection of wooded wetlands by translocated bears clearly demonstrates the importance of this habitat type to black bear restoration efforts in the Gulf Coastal Plain.

Sightings and Human-Bear Interactions

Prior to my study, reported sightings of black bears were rare on Felsenthal and surrounding lands, with the majority of reported bear sightings occurring on or near Overflow (J. Johnson, USFWS, personal communication). Overflow is situated along the physiographic boundary separating the Gulf Coastal Plain and Delta regions. Consequently, Overflow contains areas of rolling pine forests and wooded wetlands, as well as fallow and cultivated agricultural fields. Bayou Bartholemew, which flows southward between the Delta and Coastal Plain, likely acts as a travel corridor for subadult male bears dispersing from the White River area. Despite scant previous reports on Felsenthal, sightings increased dramatically following the first release of bears in 2000. Sightings increased although relatively few bears were released, which suggests that a remnant population likely was not present prior to my study. As the study progressed, however, bear sightings were reported less frequently while the number of bears continued to increase. A similar trend was reported in the number of bear sightings following bear reintroduction efforts in northwest Arkansas (J. Clark, USGS, personal communication). The inverse correlation between bear sightings and bear numbers may be attributed to a novelty effect that diminished as the event of seeing a bear in the wild became more commonplace.

There were few instances of nuisance bear behavior during my study. Ttranslocated females used deer feeders in the area, but this was an infrequent occurrence given the number of feeders located on lands surrounding Felsenthal. Corn was found in bear scat near feeder sites, and on 2 occasions tripod-style feeders were overturned. As suggested by AGFC and USFWS officials, hunters periodically stopped feeding corn at these sites, and offending bears left within days. The ground blind that was pushed over appeared to be an isolated incident, with no additional reports of bear activity in the area. Property damage by bears was negligible in all instances, and public attitudes toward the reintroduction effort remained positive due largely to the responsiveness of project personnel. On the 2 occasions when translocated bears were treed by hunting dogs, the bears left the area shortly after the dogs were restrained.

I determined that ≥2 of the 3 unmarked males documented during my study were not reintroduced bears. The landowner that captured the first male originally had set the trap because of the bear's nuisance behavior. Upon inspection at capture, extensive tooth wear and fighting scars indicated that this male was an older bear. Alternatively, the male bear that was snared by project personnel had only light tooth wear, indicative of a subadult animal. The bear's young age and absence of a PIT tag caused me initially to suspect this was a 2.5 year-old male, reintroduced in 2000. However, microsatellite DNA analysis indicated the young male was not translocated to Felsenthal (T. King, USGS, personal communication). Interestingly, the unmarked male was more closely related to several of the translocated cubs compared with the relatedness among the translocated cubs themselves. This suggests that the young male bear was an immigrant from White River and shows further evidence that adult males need not be translocated to ensure reproduction.

CHAPTER VI

MANAGEMENT AND RESEARCH IMPLICATIONS

Bears that returned home typically did so within the first month following den emergence. Although I documented extensive movements for both homing and non-homing adult females, those movements were largely constrained within 6 months for those bears that remained at Felsenthal. Movement patterns also were indicative of homing versus non-homing bears, with homing bears traveling a more rapid, direct route toward the source area. Additionally, data suggested that the presence of cubs increased site fidelity. Two females with cubs were moving in a homeward direction when relocated back to Felsenthal, where they subsequently remained. When cub presence is known, this proactive approach may allow managers to ensure greater numbers of translocated females remain in the target area.

Translocated bears extensively used wooded wetlands as they explored their new environment and established home ranges. In particular, riparian areas were used as travel corridors as translocated females dispersed from release sites. Riparian areas have been the focus of regional land acquisitions in recent years, based on the premise that these linear formations and cover would act as natural travel corridors (Anderson 1997, Beausoleil 1999). However, no guidelines currently exist for delineating optimal corridor sizes for black bears. My observation of corridor use by bears in this study suggested that bears needed only enough cover to conceal movements between woody wetlands, in some instances <10 m of vegetation along either bank. Bears that established home ranges outside Felsenthal did so in areas where contiguous tracts of wooded wetland areas were present. The use of wooded wetlands in exploratory movements and home range placement emphasizes the importance of this habitat type to regional black bear restoration efforts. Although other forest habitats are important following home range establishment, sufficient wooded wetland areas may be required to contain exploratory movements and facilitate home range establishment. Public lands containing wooded wetlands were influential in home range establishment, and should be managed as potential bear habitat to aid in the restoration process. Also, future land acquisitions may be focused in areas where this potentially limiting habitat type remains.

Without additional stockings, my data suggest a 22% probability that the current population will become extinct within 50 years. Population analyses indicated that 2 additional stockings of 6–12 adult female bears and 12–24 cubs will lower the probability of extinction to <20%, with a 15% extinction probability at best after 6 additional stockings. My data indicated that the number of bears now present at Felsenthal likely is near a level where additional stockings will not greatly diminish extinction rates. I attribute the small reductions in extinction rates to low first-year female survival and high environmental and parameter variability incorporated into the model. Accordingly, whereas the model likely provides realistic estimates of population viability, extinction rates could be reduced if female and cub survival were increased. Half the adult female mortalities during this study were the result of poaching. The reduction of this mortality cause would greatly increase adult female survival and encourage population growth, thereby decreasing the probability of extinction. Den site locations should not be revealed to persons other than project personnel. Additionally, violation penalties should be enforced to the greatest possible extent. Furthermore, translocations should not be conducted prior to mid-March to allow sufficient cub development, as increased cub survival may encourage site affinity. Managers can choose the appropriate stocking regime according to project objectives, costs, and logistical, personnel, or time constraints.

Bait-station surveys should continue on Felsenthal to monitor future population trends. Additionally, managers may wish to expand existing routes to include areas outside refuge boundaries. This may be especially warranted due to the number of unmarked bears documented during my study. Monitoring Overflow Refuge may become increasingly important in the future, as 2 females established home ranges in that area and 1 cub was documented, in addition to previously reported sightings.

Bears now present in the Gulf Coastal Plain and newly reintroduced bears should continue to be monitored through radiotelemetry. This will provide better first-year and cumulative survival estimates and continued evaluation of habitat use. In addition, radiocollared females should be monitored to document reproduction and cub survival. Data collected will provide more precise parameter estimates and improve population viability assessments.

Finally, public education programs should continue to inform residents and non-residents of the reintroduction efforts. Increased awareness of the program likely would diminish misconceptions toward bear reintroduction.

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APPENDIX

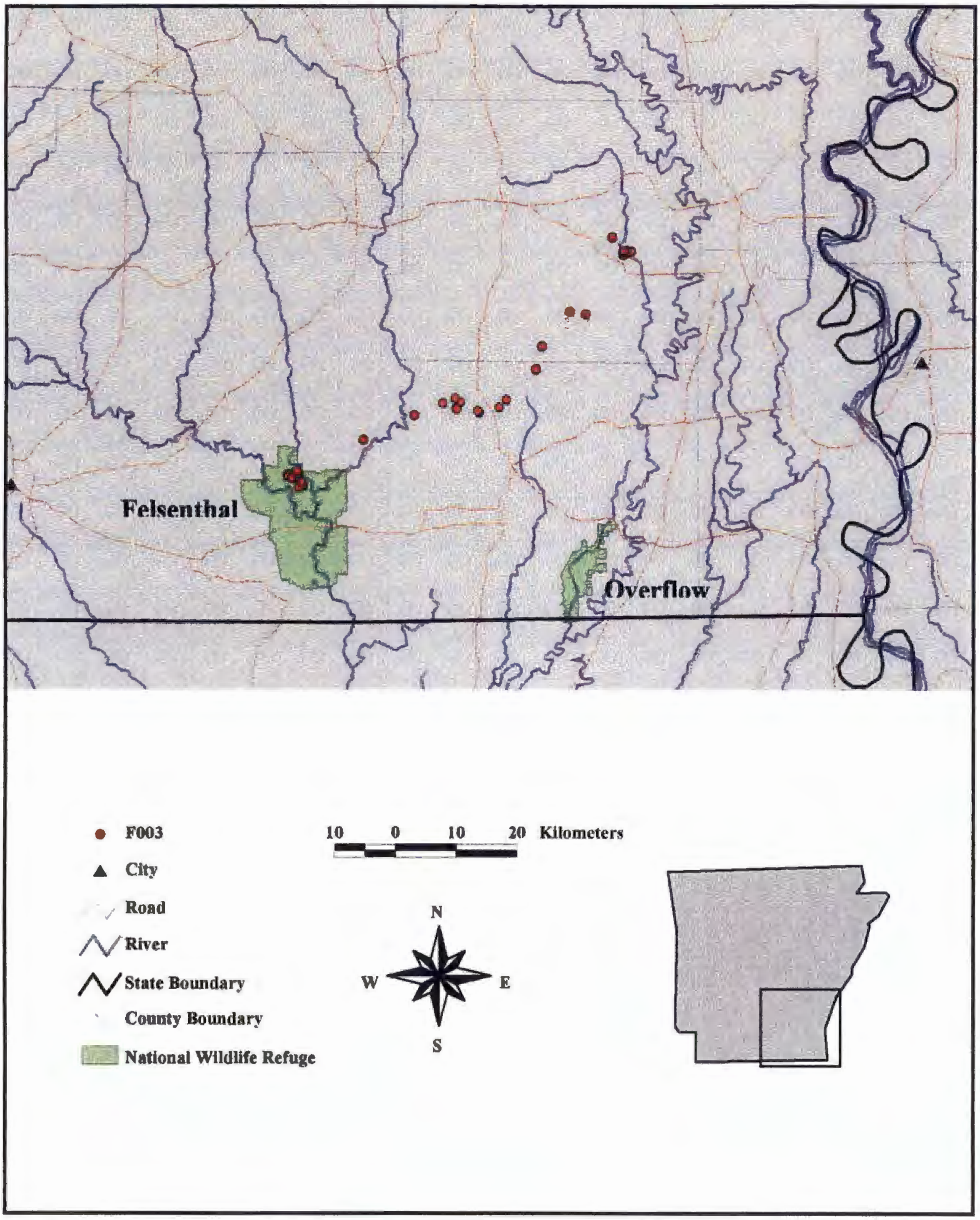

Fig. A.1. Post-release movements of bear 003, Felsenthal National Wildlife Refuge, Arkansas, 2000.

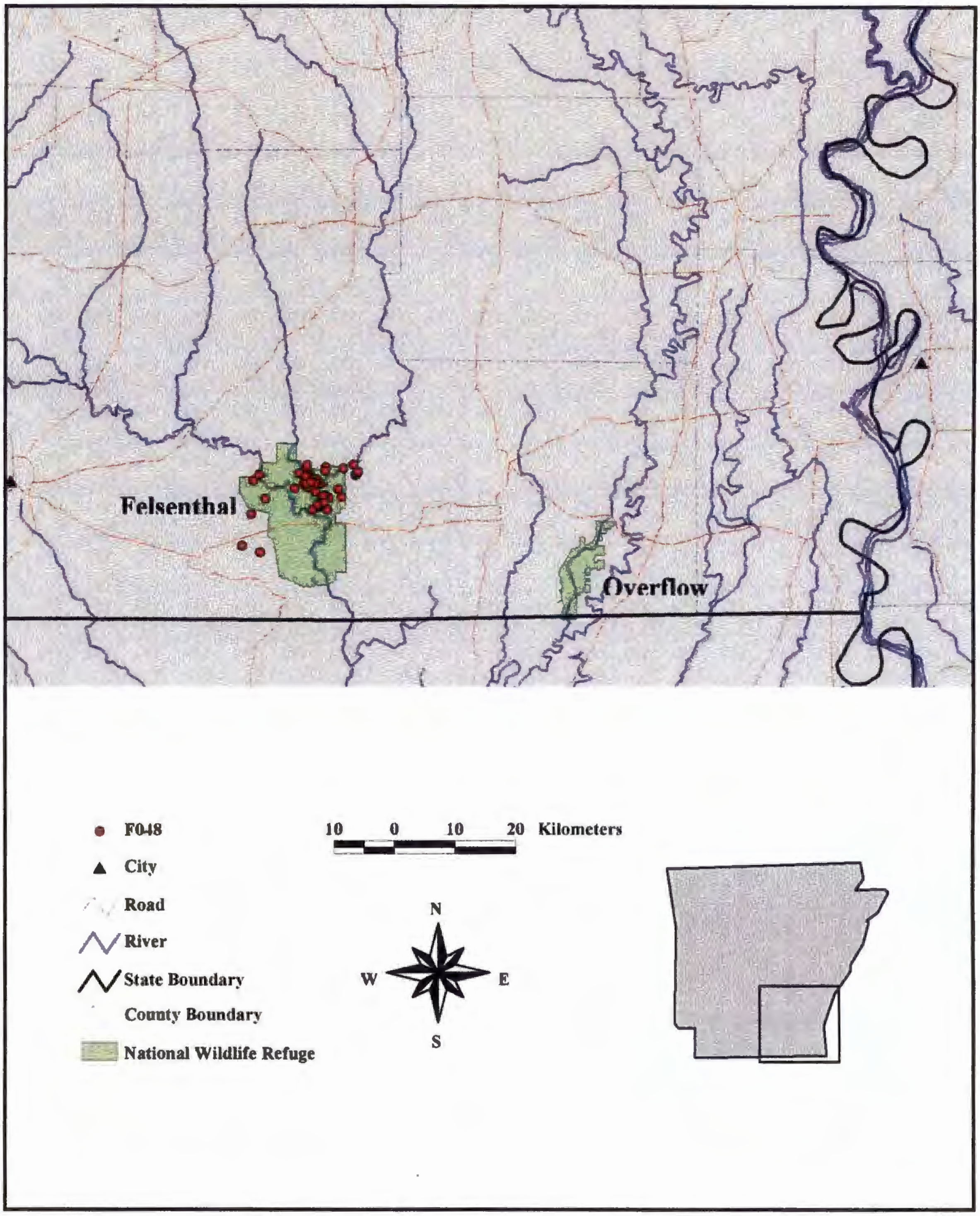

Fig. A.2. Post-release movements of bear 048, Felsenthal National Wildlife Refuge, Arkansas, 2000.

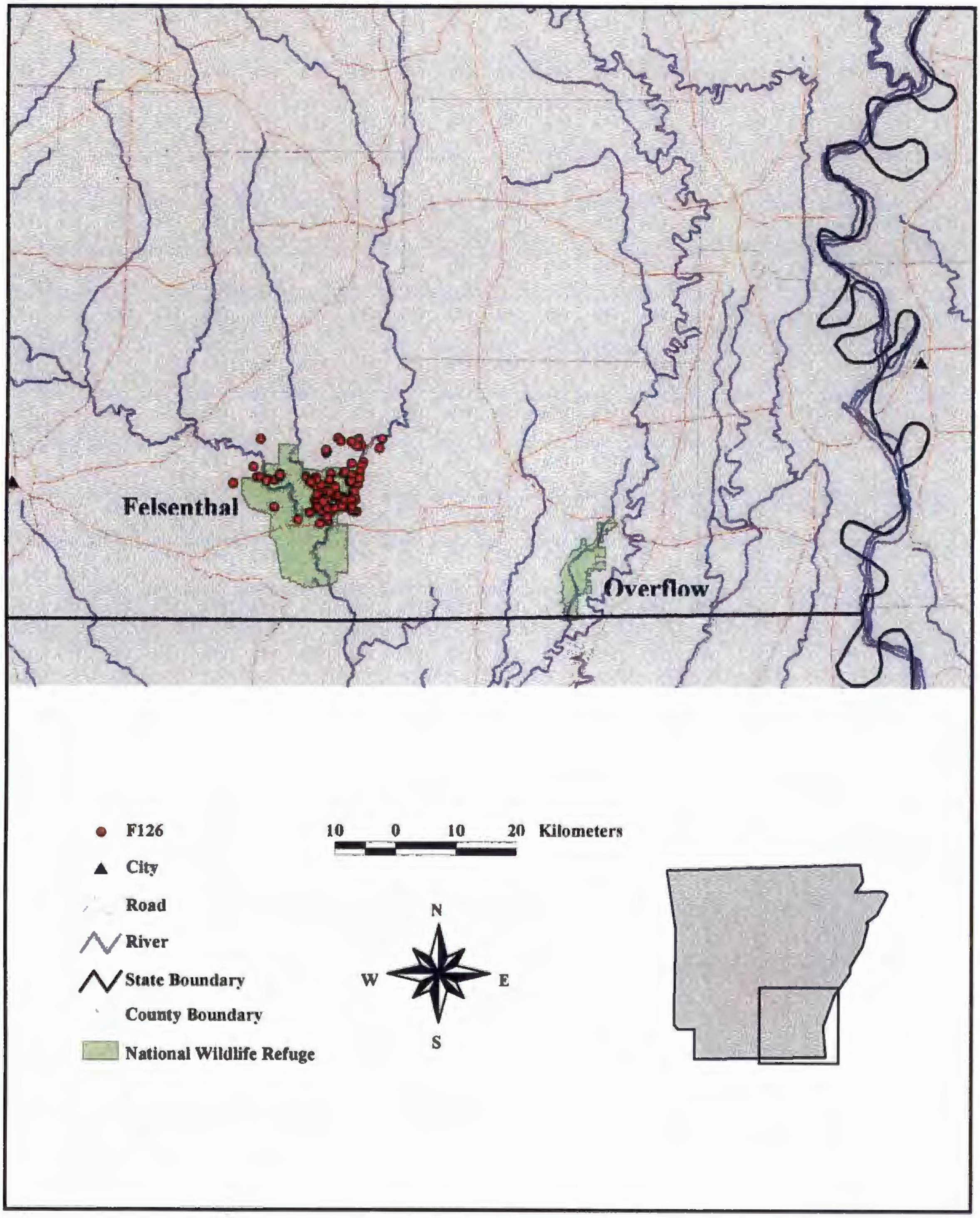

Fig. A.3. Post-release movements of bear 126, Felsenthal National Wildlife Refuge, Arkansas, 2000.

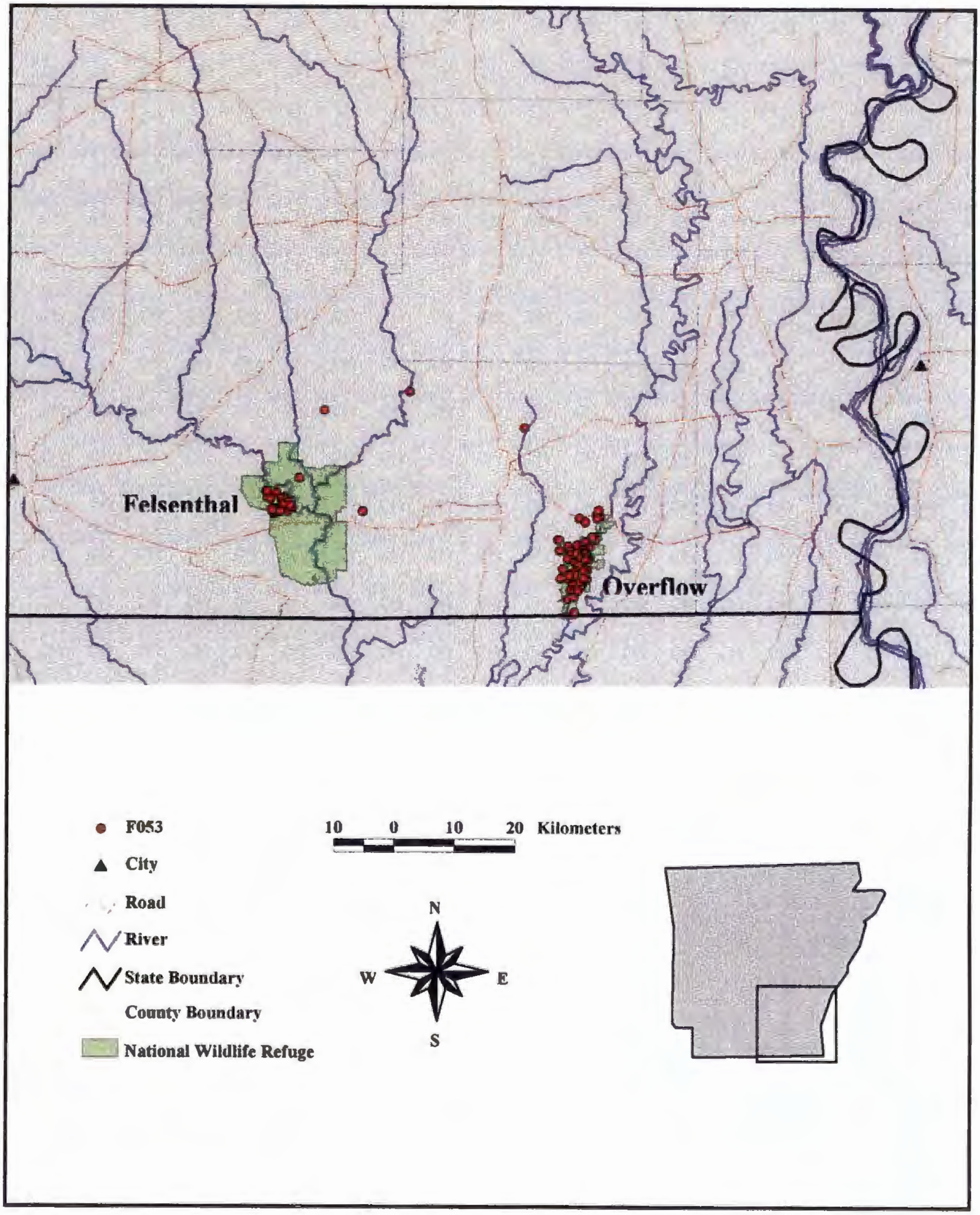

Fig. A.4. Post-release movements of bear 053, Felsenthal National Wildlife Refuge, Arkansas, 2000.

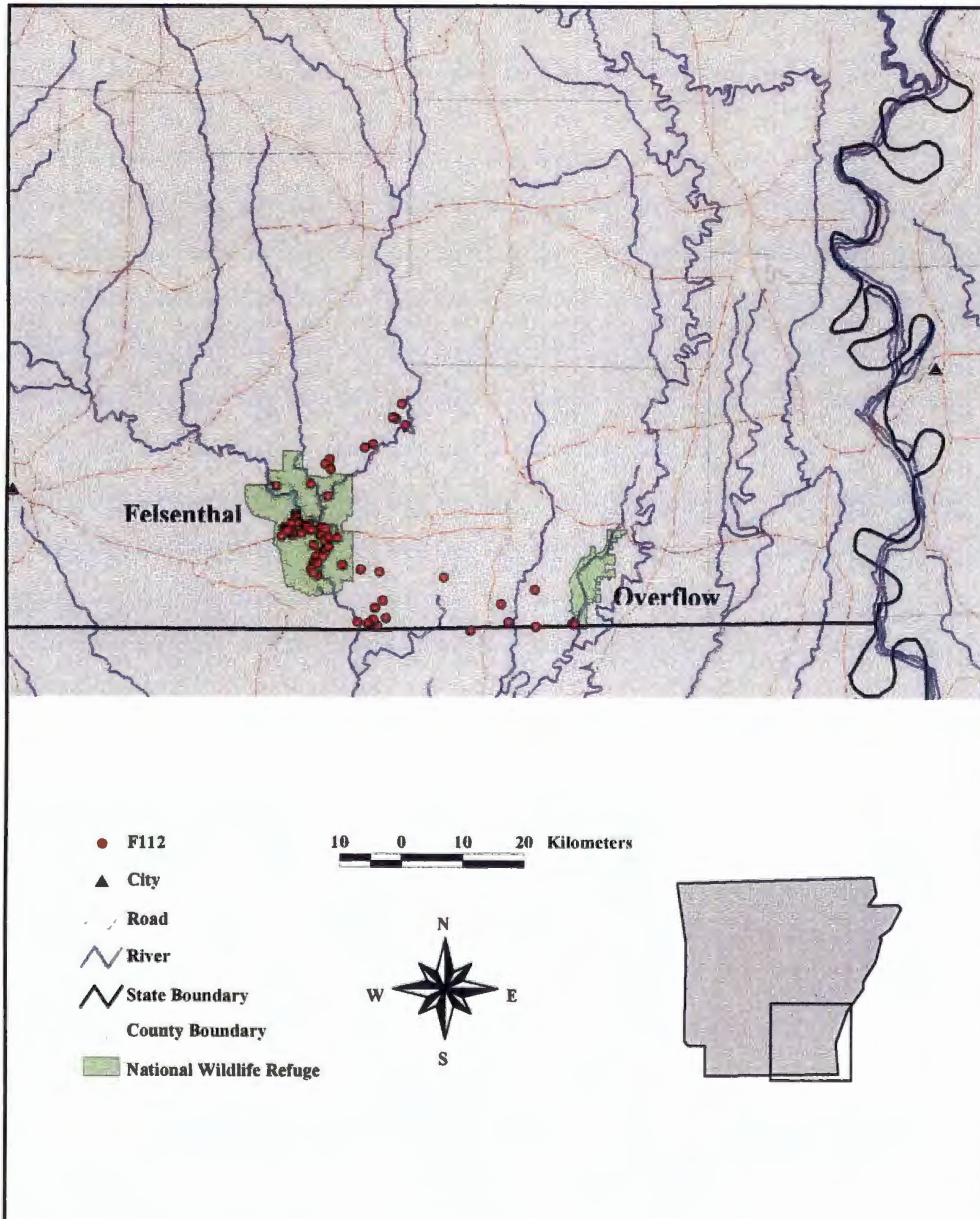

Fig. A.5. Post-release movements of bear 112, Felsenthal National Wildlife Refuge, Arkansas, 2000.

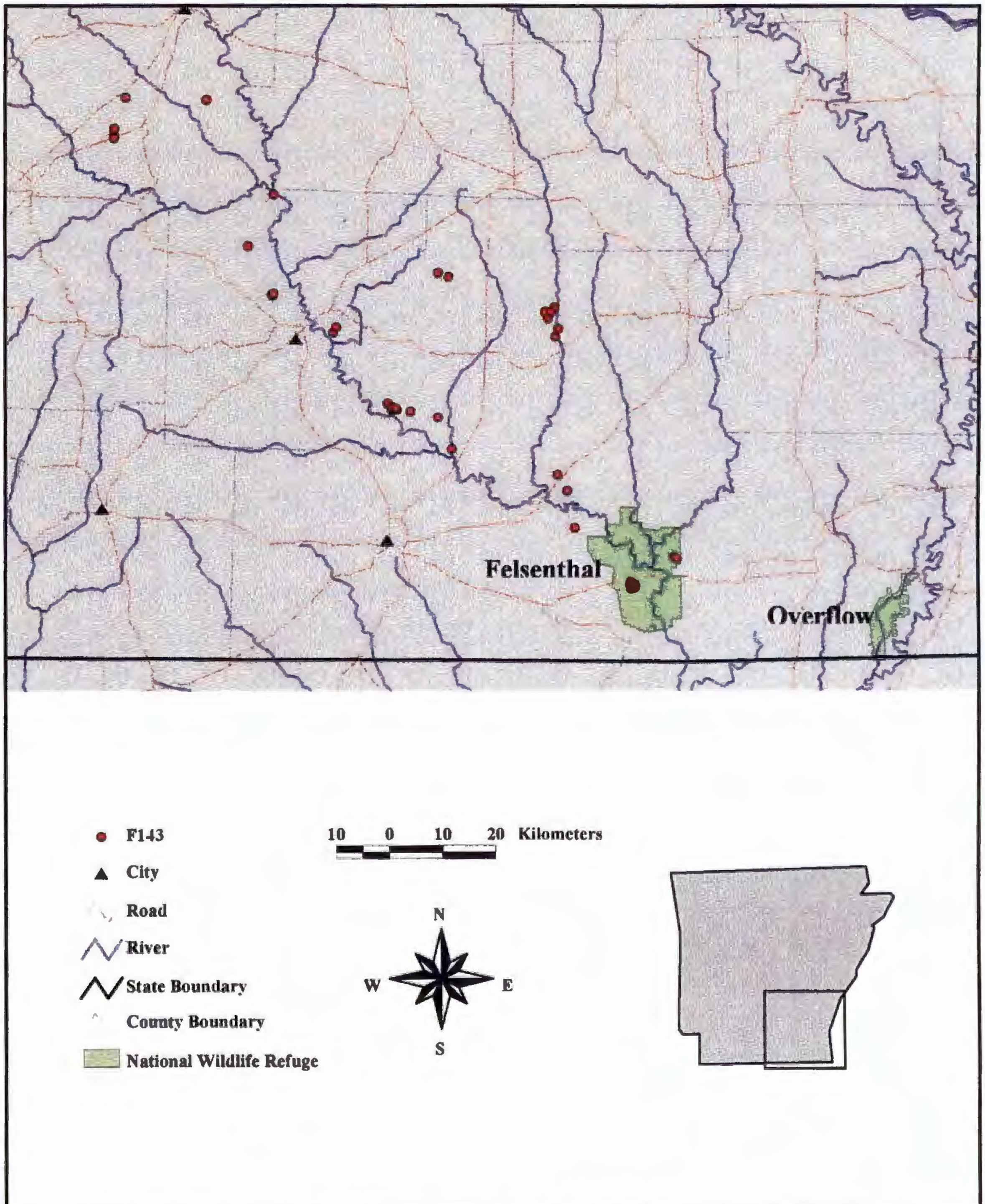

Fig. A.6. Post-release movements of bear 143, Felsenthal National Wildlife Refuge, Arkansas, 2000.

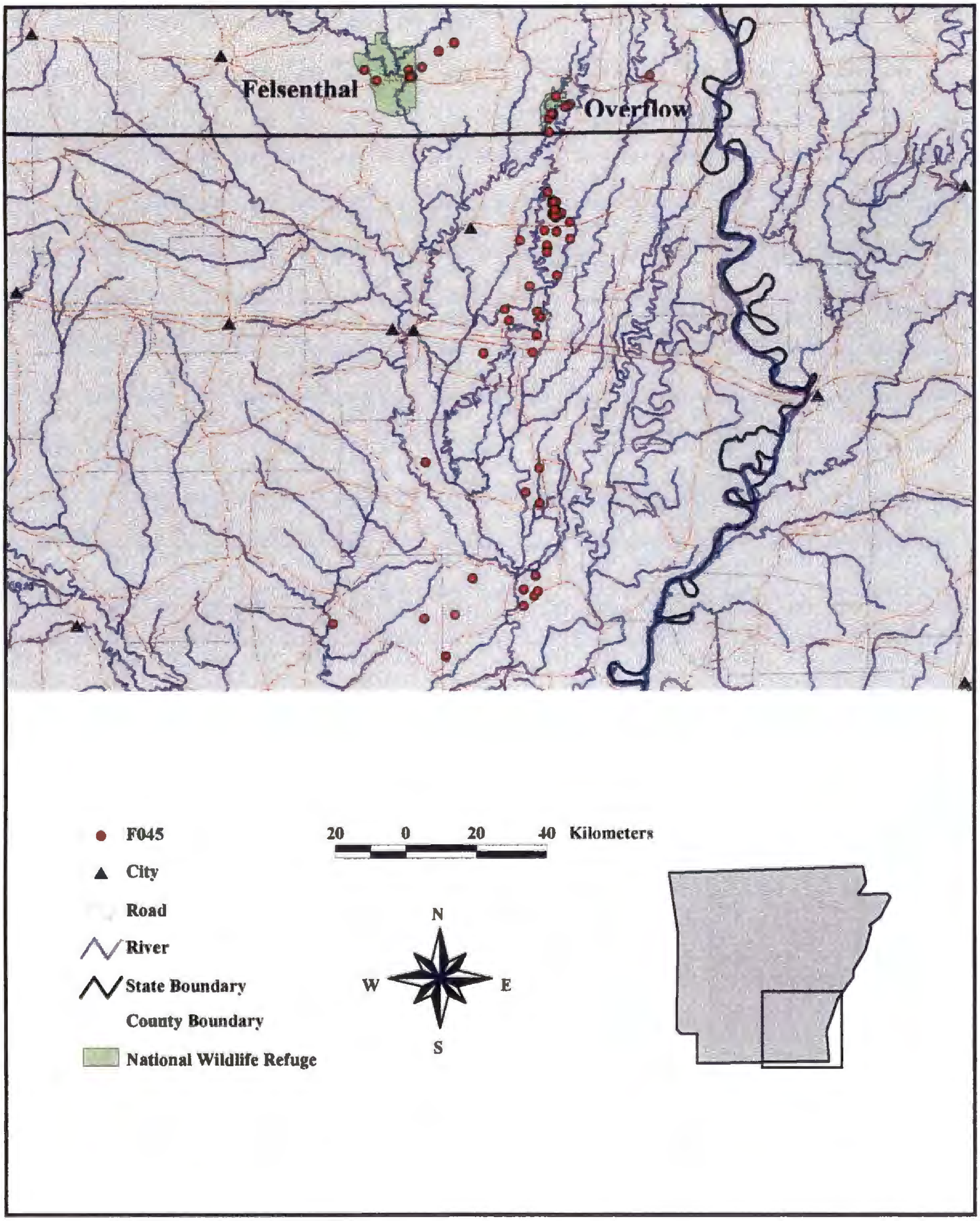

Fig. A.7. Post-release movements of bear 045, Felsenthal National Wildlife Refuge, Arkansas, 2001.

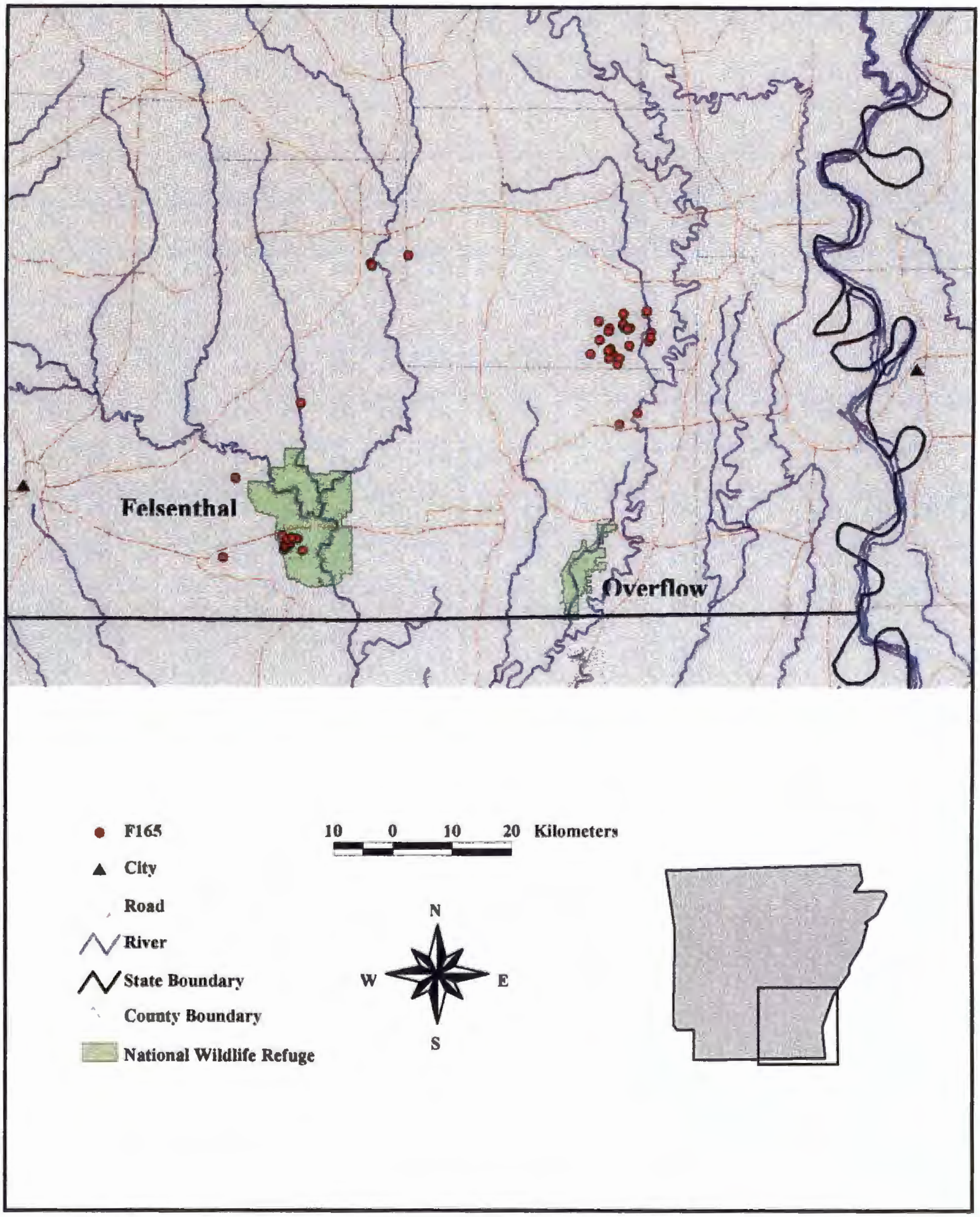

Fig. A.8. Post-release movements of bear 165, Felsenthal National Wildlife Refuge, Arkansas, 2001.

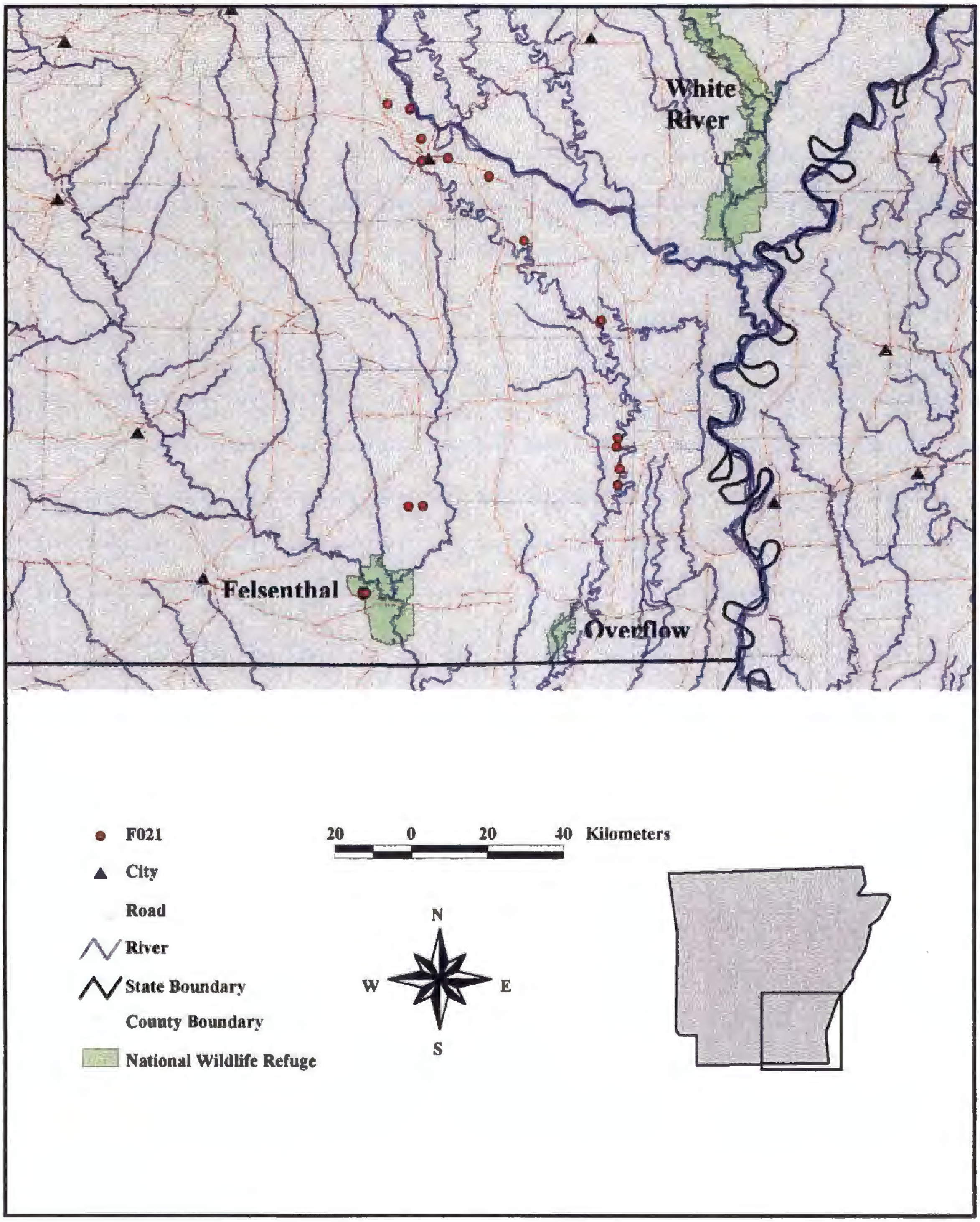

Fig. A.9. Post-release movements of bear 021, Felsenthal National Wildlife Refuge, Arkansas, 2001.

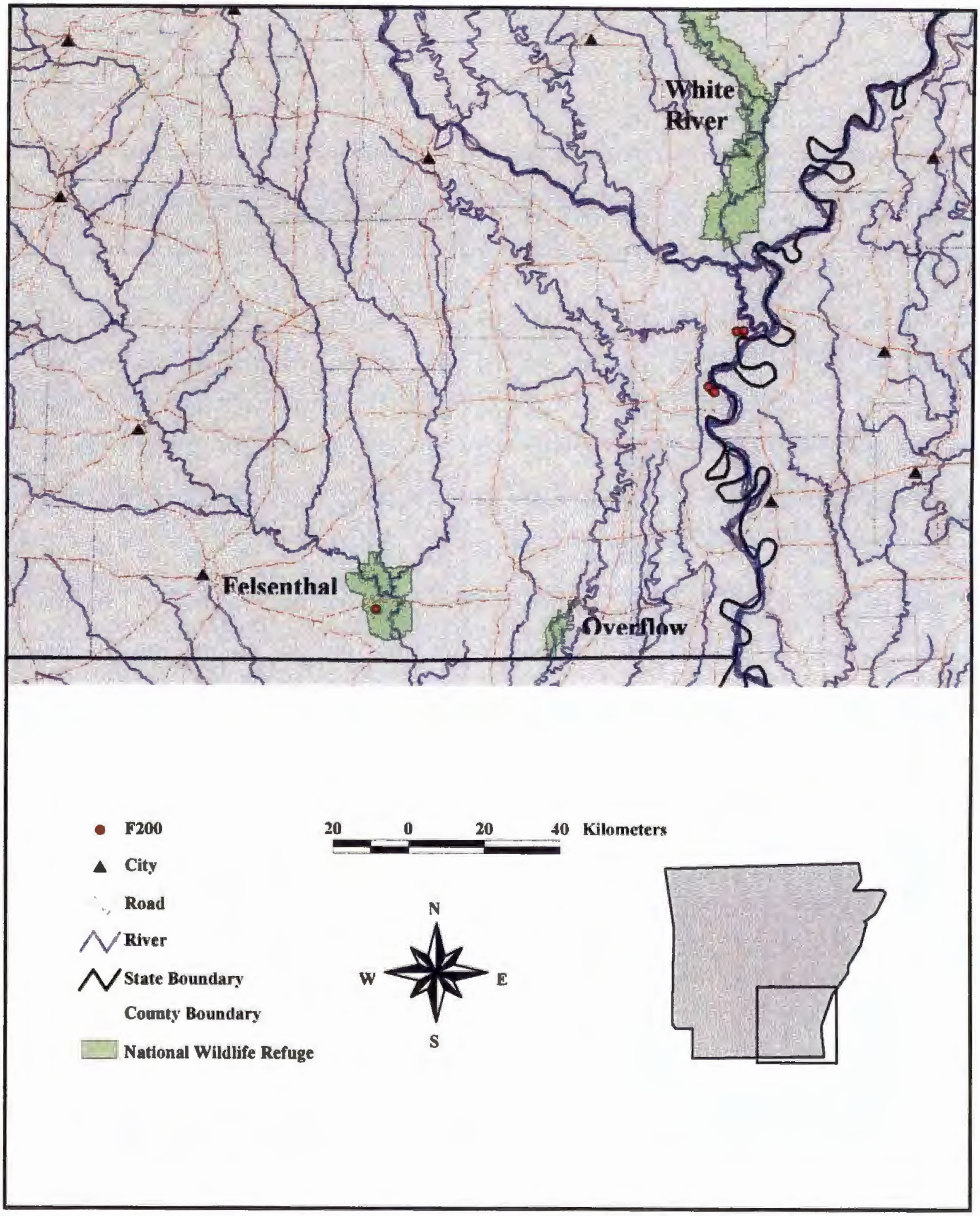

Fig. A.10. Post-release movements of bear 200, Felsenthal National Wildlife Refuge, Arkansas, 2002.

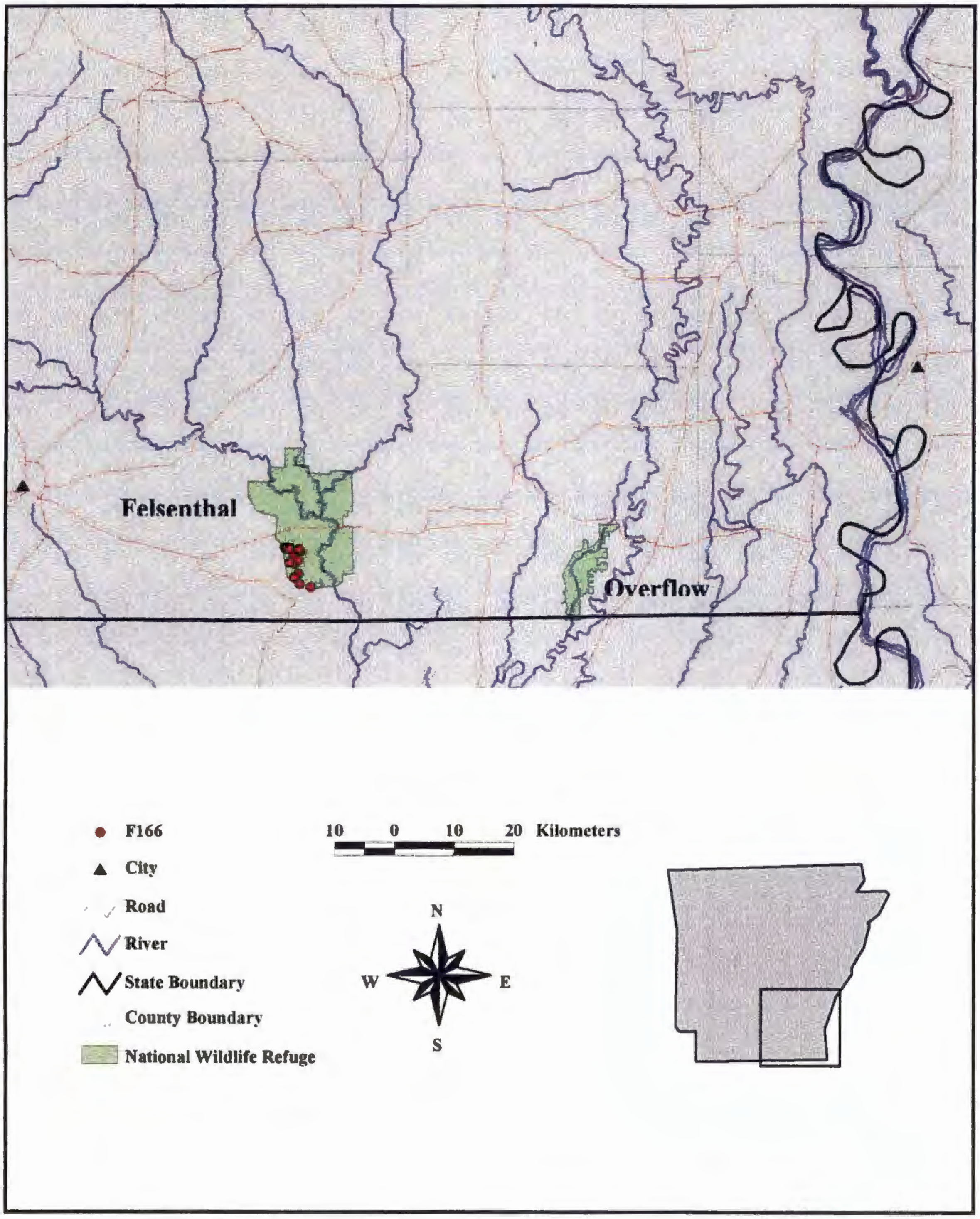

Fig. A.11. Post-release movements of bear 166, Felsenthal National Wildlife Refuge, Arkansas, 2002.

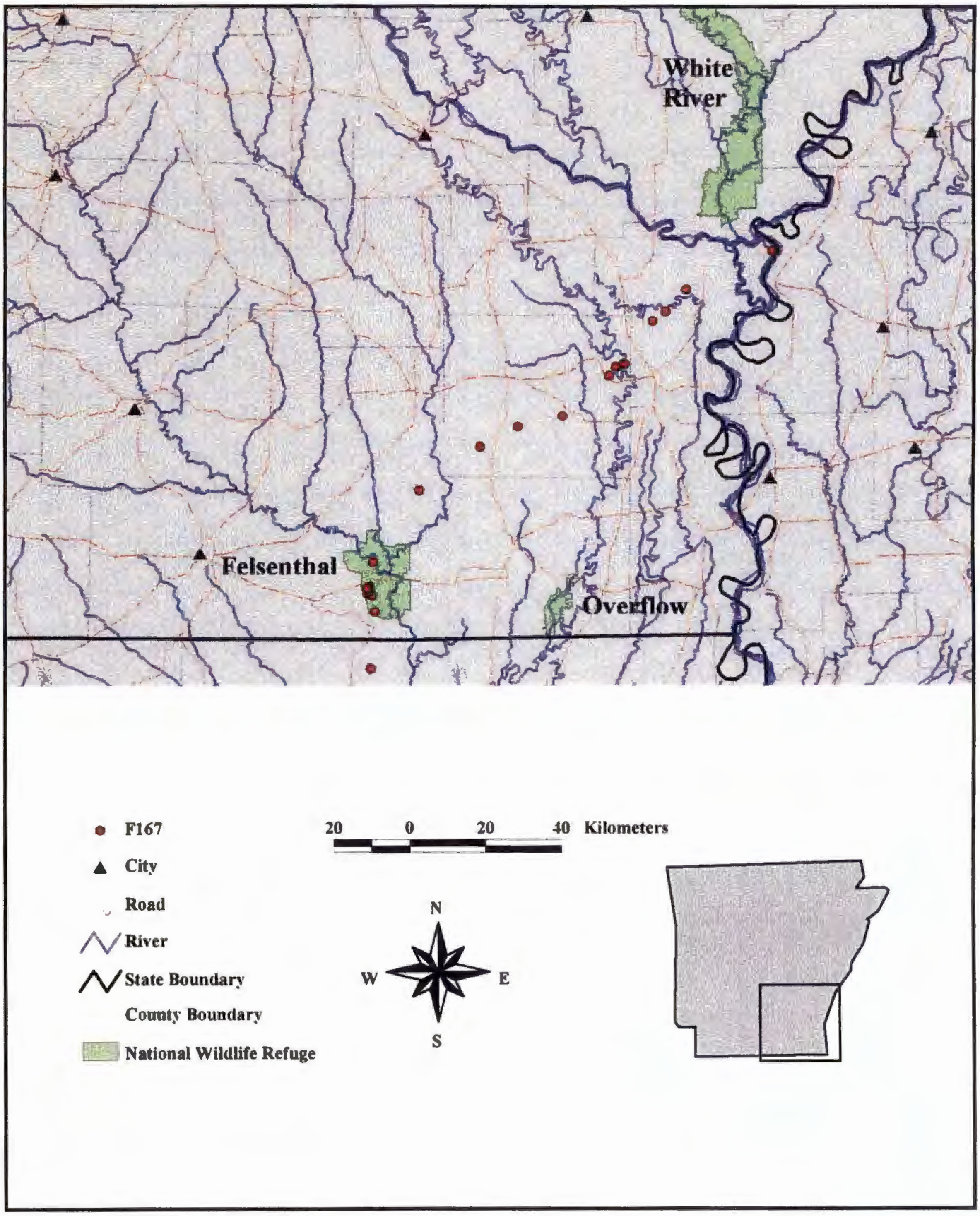

Fig. A.12. Post-release movements of bear 167, Felsenthal National Wildlife Refuge, Arkansas, 2002.

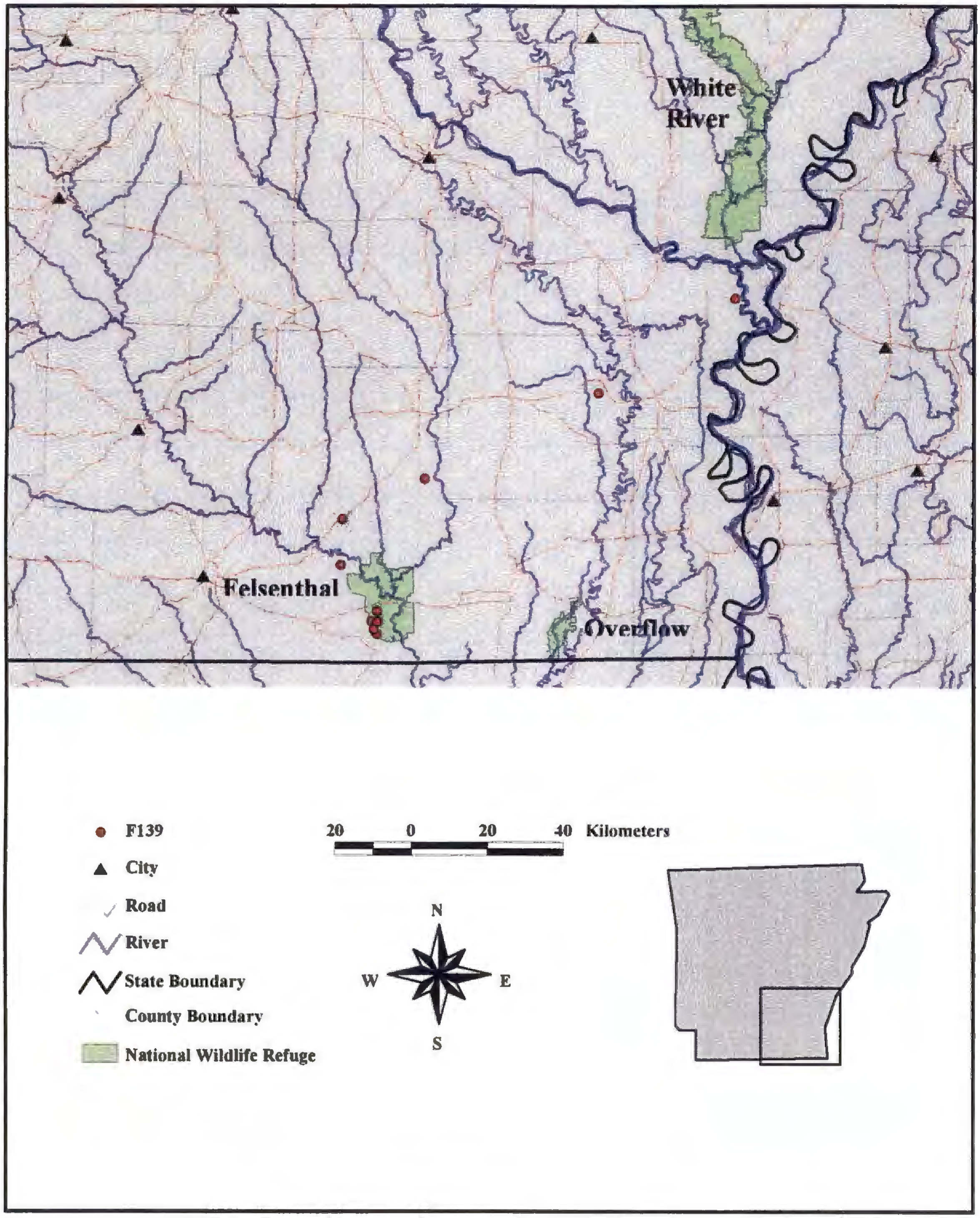

Fig. A.13. Post-release movements of bear 139, Felsenthal National Wildlife Refuge, Arkansas, 2002.

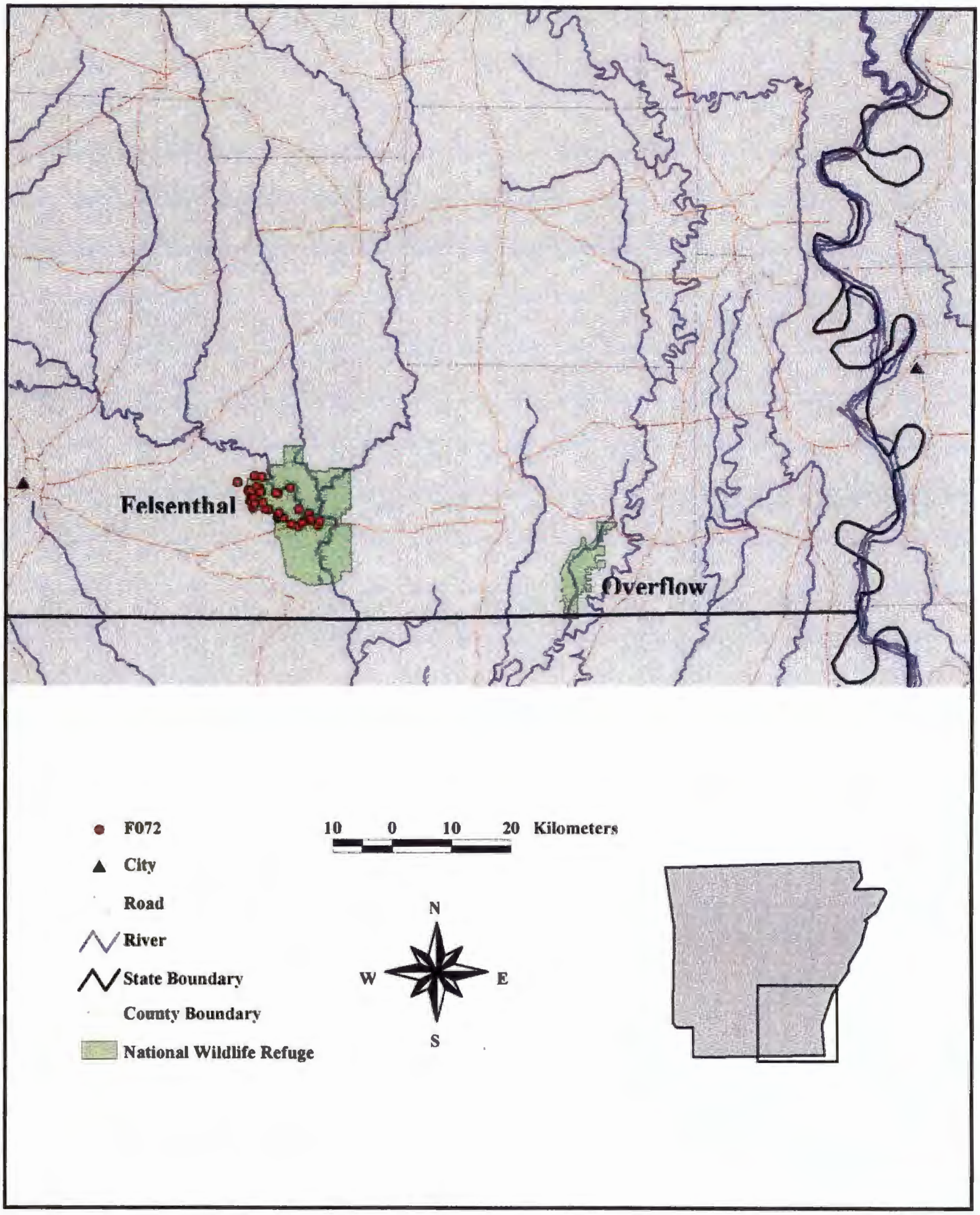

Fig. A.14. Post-release movements of bear 072, Felsenthal National Wildlife Refuge, Arkansas, 2002.

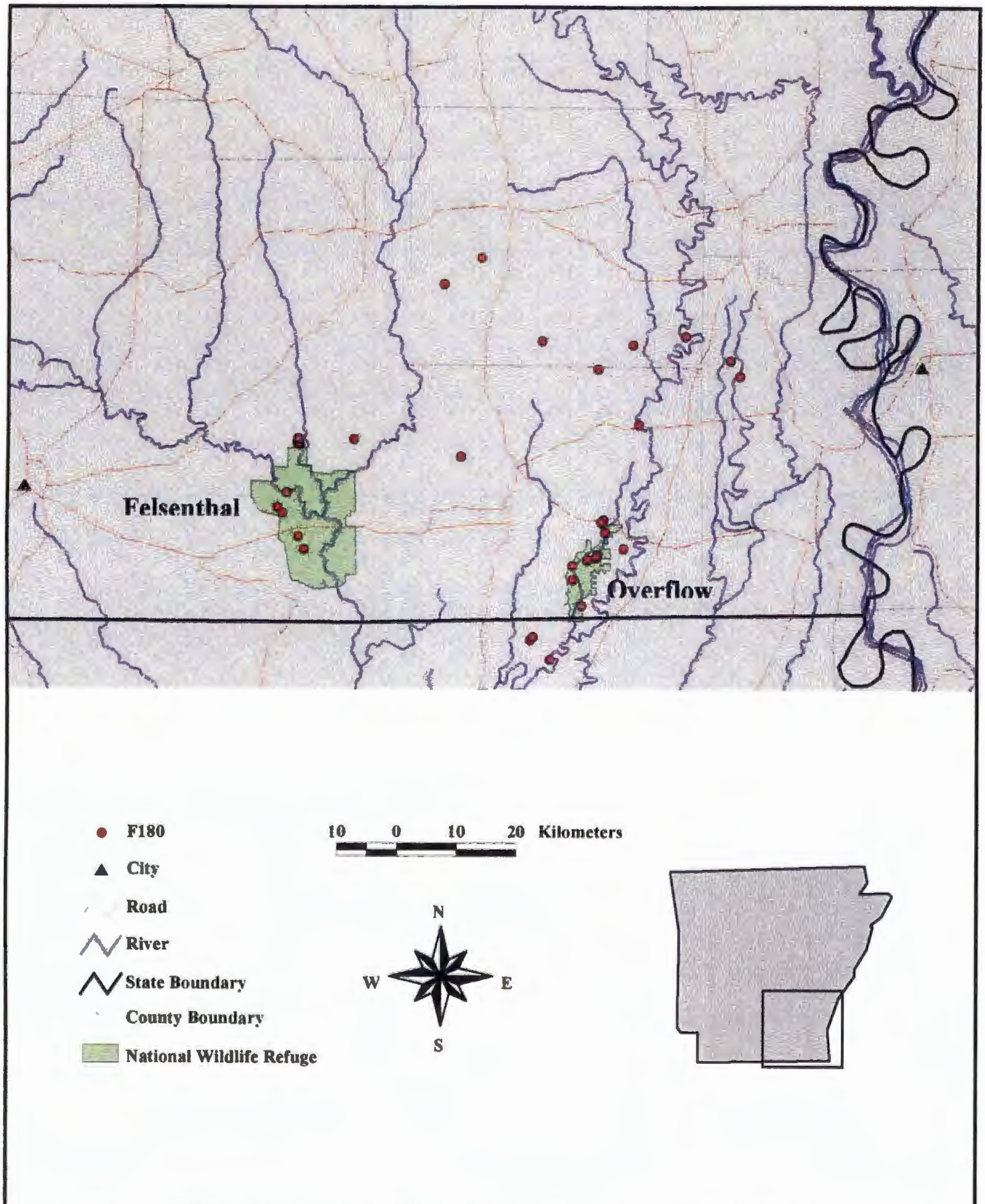

Fig. A.15. Post-release movements of bear 180, Felsenthal National Wildlife Refuge, Arkansas, 2002.

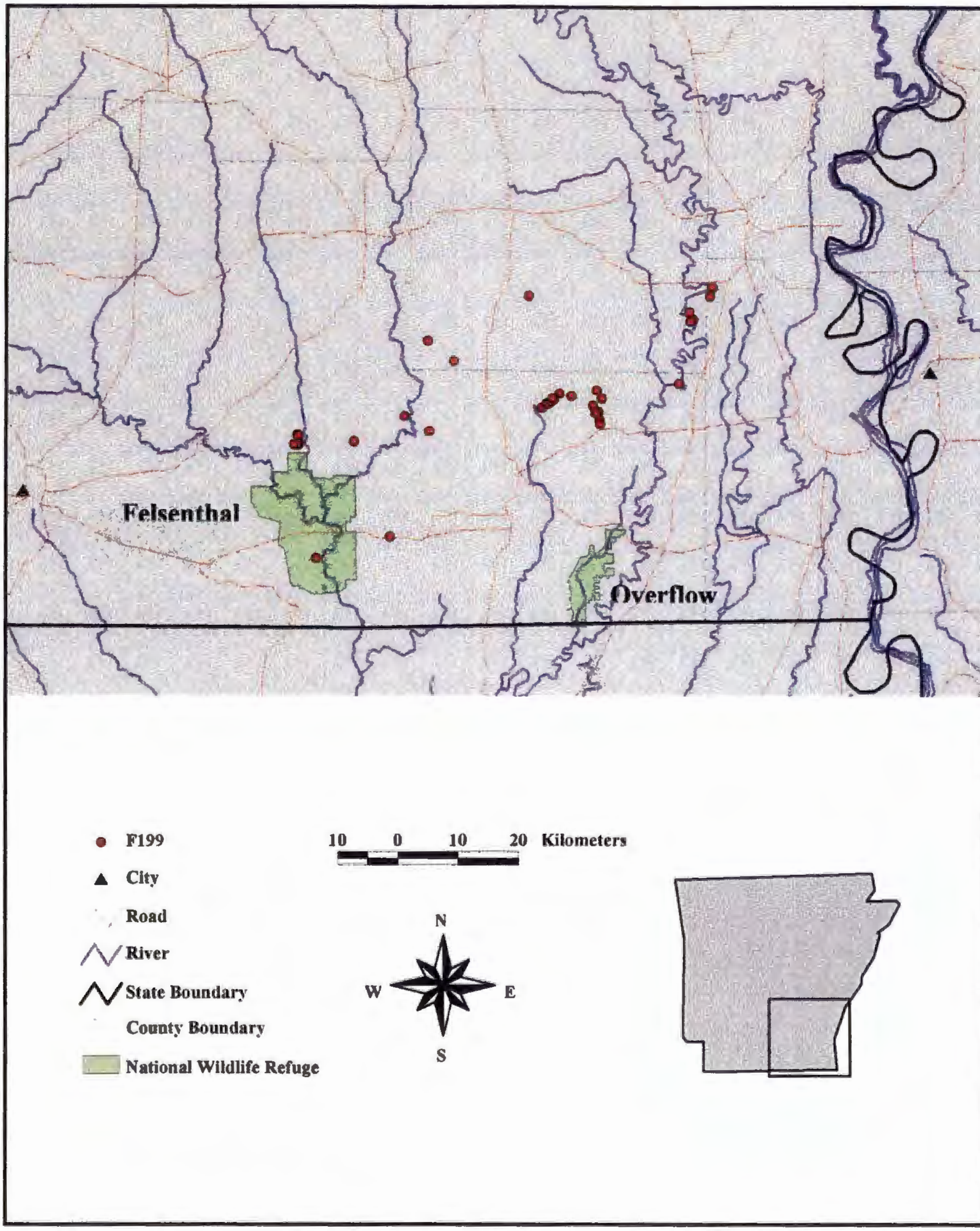

Fig. A.16. Post-release movements of bear 199, Felsenthal National Wildlife Refuge, Arkansas, 2002.

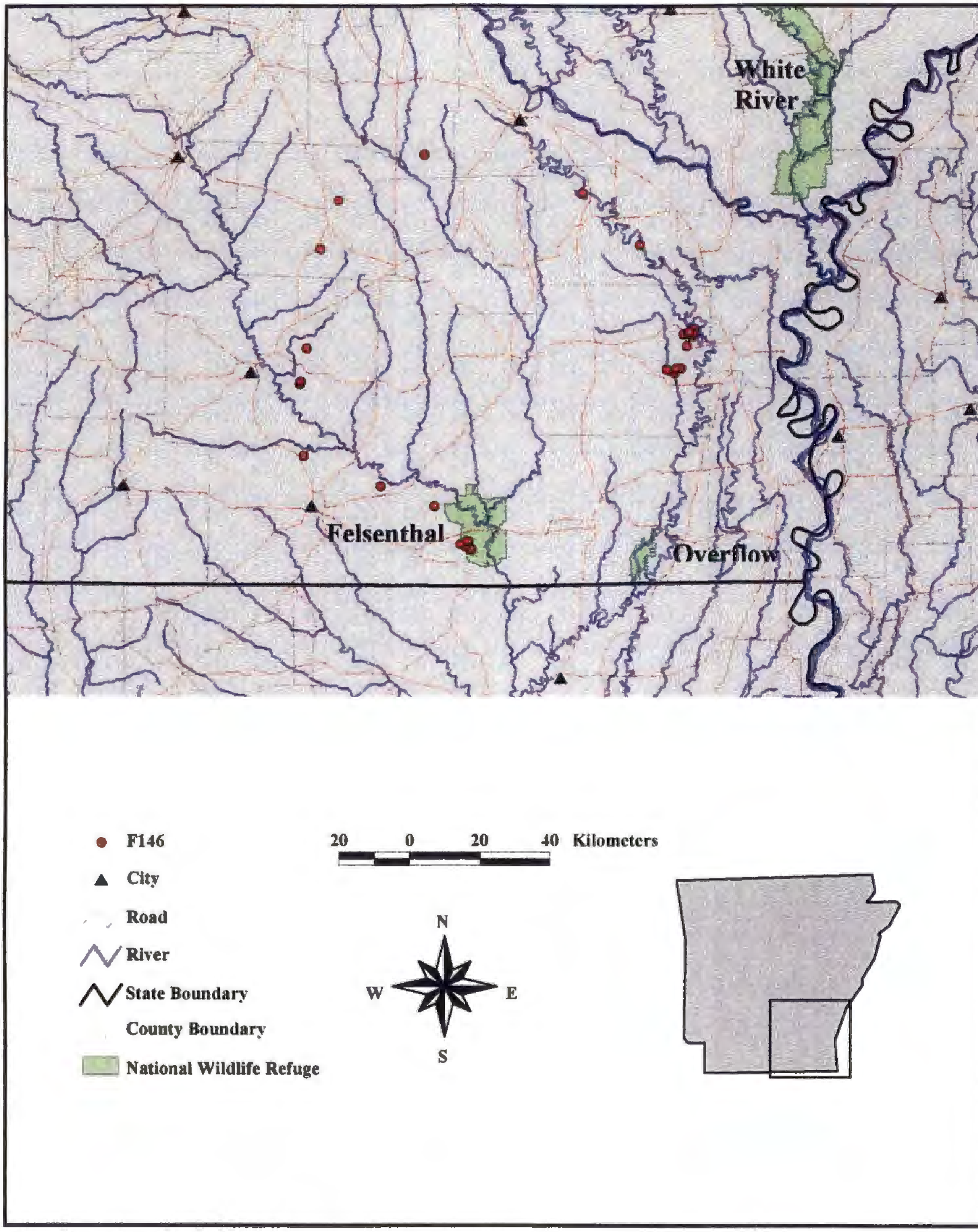

Fig. A.17. Post-release movements of bear 146, Felsenthal National Wildlife Refuge, Arkansas, 2002.

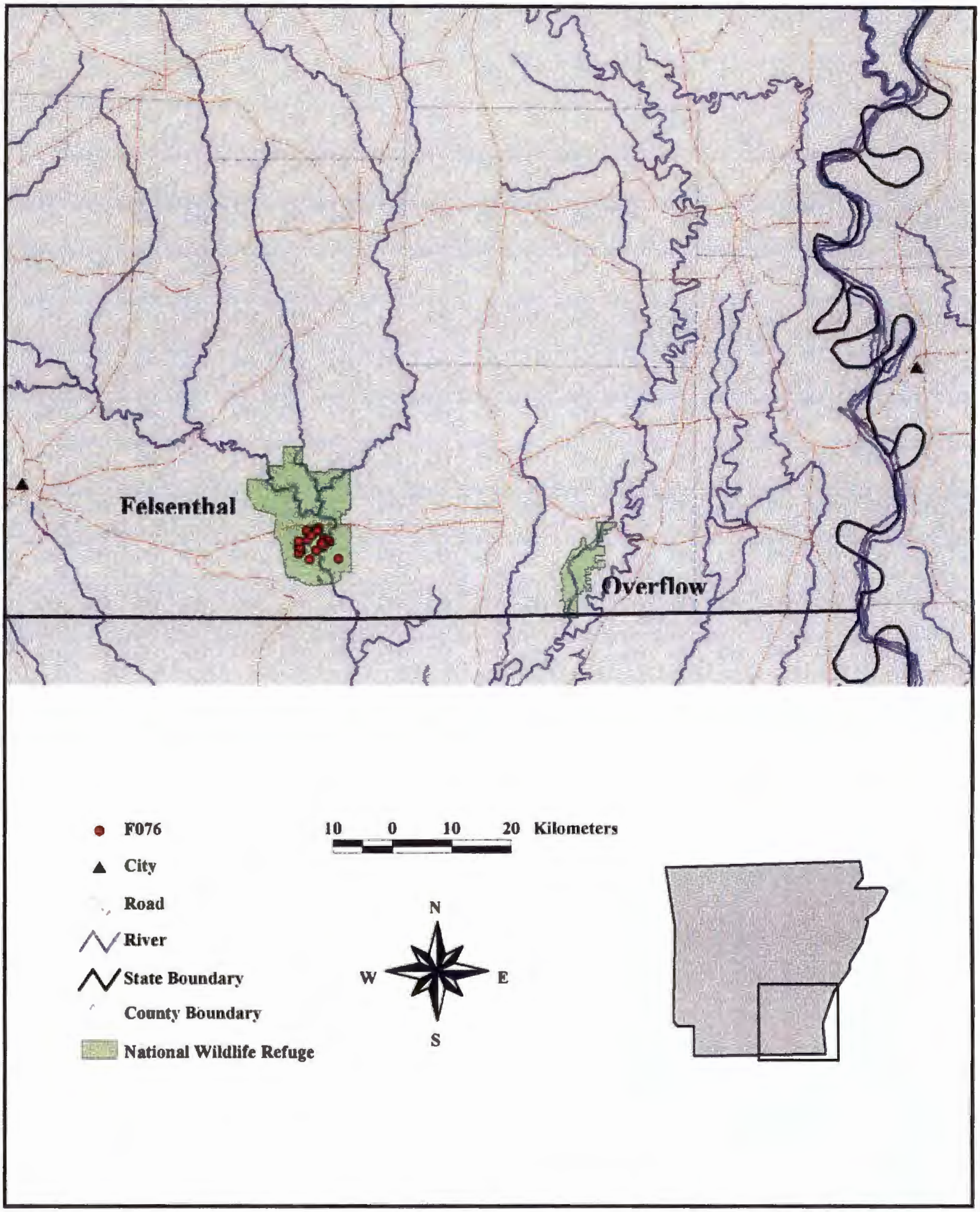

Fig. A.18. Post-release movements of bear 076, Felsenthal National Wildlife Refuge, Arkansas, 2002.

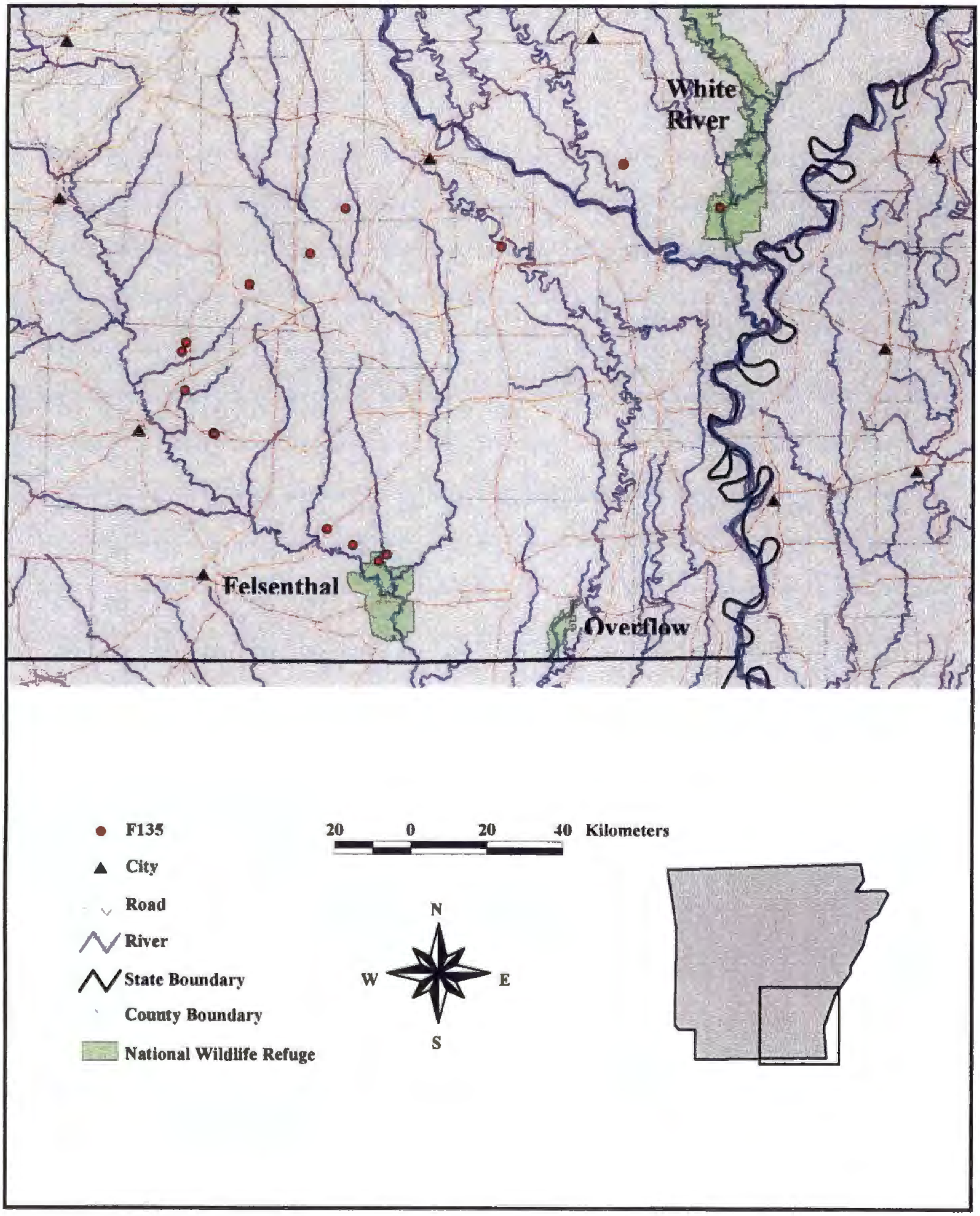

Fig. A.19. Post-release movements of bear 135, Felsenthal National Wildlife Refuge, Arkansas, 2002.

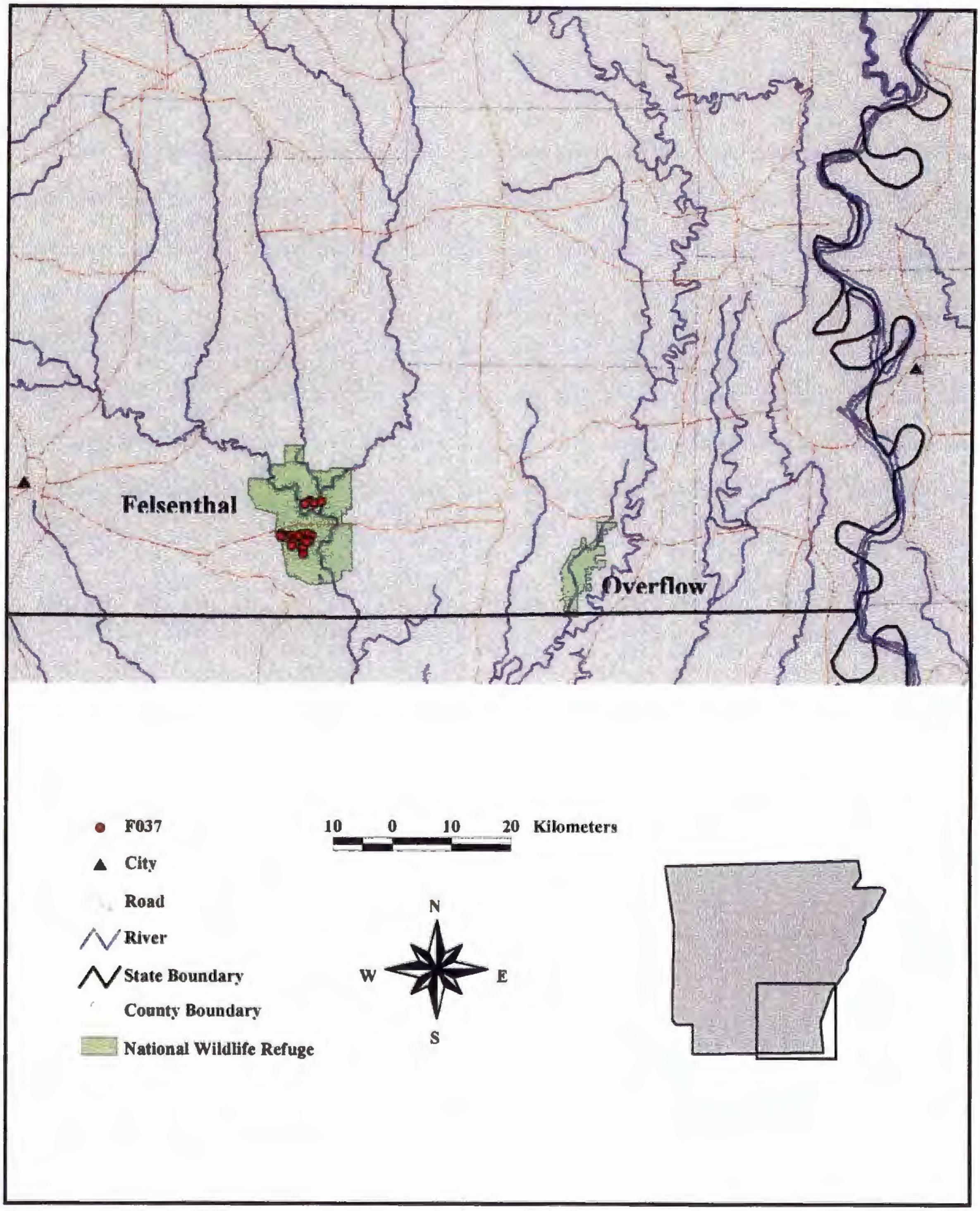

Fig. A.20. Post-release movements of bear 037, Felsenthal National Wildlife Refuge, Arkansas, 2002.

VITA

Brandon Jarrett Wear was born in Athens, Tennessee on September 5, 1976. The son of Jimmy and Vicki Wear, he was raised in Tellico Plains, Tennessee. He graduated from Tellico Plains High School in May 1994. He received his Bachelor of Science degree in Wildlife and Fisheries Science from the University of Tennessee, Knoxville in December 1999. Brandon then began his graduate research in Wildlife and Fisheries Science at the University of Tennessee, Knoxville in January 2000. He was awarded the Master of Science degree in Wildlife and Fisheries Science in August 2003. His professional interests include predator ecology, wetland ecology, and wildlife/habitat restoration.