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INTEGRATING ECOLOGY AND SOCIOECONOMICS FOR SPECIES
RESTORATION: FEASIBILITY OF A LOUISIANA BLACK BEAR
REINTRODUCTION IN AND AROUND BIG THICKET NATIONAL
PRESERVE, TEXAS

By

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ABSTRACT

INTEGRATING ECOLOGY AND SOCIOECONOMICS FOR SPECIES RESTORATION: FEASIBILITY OF A LOUISIANA BLACK BEAR REINTRODUCTION IN AND AROUND BIG THICKET NATIONAL PRESERVE, TEXAS

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Anita T. Morzillo

To mitigate effects of human activity on wildlife species, there are increasing efforts to recover locally extirpated species in human-dominated landscapes. Thus, the ability to integrate ecological and socioeconomic factors is critical to better understand needs of both humans and wildlife. The overall goal of this dissertation was to develop an interdisciplinary approach to quantify spatial and temporal dynamics of ecological and socioeconomic factors that may affect a Louisiana black bear (*Ursus americanus luteolus*) reintroduction in and around Big Thicket National Preserve (BTNP) in southeastern Texas. The local bear population was extirpated during the early 1900s, but a recent increase in the number of bear sightings in the area has prompted creation of a black bear management plan and a simultaneous interest in recovering bear populations. BTNP is a potential location to release bears, but BTNP's small size and disjunct distribution require the consideration of private timberlands and national forests in bear recovery planning. To determine the ecological feasibility, remote sensing data were used to identify potential bear habitat across the 2.6 million ha study area. Approximately 1.3 million ha of highly suitable habitat existed on both private and public lands. At a density of one bear/100 ha, and considering core habitat areas, there is enough habitat for approximately 2,200 bears. Stand management of vegetative species that are important for bear foraging will ensure adequate food resources for a bear

population. Because humans also inhabit the area, the study of social feasibility is also necessary. We surveyed 1,006 local residents to gain insight into attitudes toward black bears and a preferred recovery strategy. Males, younger residents, those with more knowledge about bears, and participants in passive-appreciative activities related to wildlife were more likely to have positive attitudes toward bears and to support increasing the bear population. Concern about the problems that bears may cause was a significant predictor of a respondent's preferred management strategy. Two significant clusters of survey respondents expressed support for a bear recovery: one in proximity to Angelina National Forest and the other in Orange County. A simple systems model was developed to integrate ecological (land cover) and socioeconomic (social survey) data. Model results suggested that national forests might be better potential release sites for bears than BTNP. An earlier trend of declining timberland area is likely to continue, and to be the main driver of degradation in bear habitat over time. Consequently, timberland loss will likely promote urban development. Furthermore, highest ecological feasibility did not overlap. Ecological feasibility for bear recovery was greatest in Sabine, Trinity, and San Augustine Counties. However, social feasibility was greatest in Jasper, Tyler, and Newton Counties. Public outreach aimed at increasing residents' knowledge about bears, as well as gaining insight into why local residents do or do not support bear recovery, are necessary before deciding whether and where bears should be released. The model framework provides a useful approach for assessing feasibility of a reintroduction and may be adapted for conservation programs in other locations.

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CHAPTER 1

BACKGROUND AND RESEARCH TOPICS

1.1. Introduction

There is an increasing recognition that large carnivores are valuable members of the ecological community (Sillero-Zubiri and Laurenson 2001). While the area of habitat for many species is decreasing, efforts are increasing to recover populations of locally extirpated carnivore species (Reading and Clark 1996). As human development rapidly expands into previously rural areas, protected areas (e.g., nature reserves) and other public lands are often identified as among the last available habitats for species recovery initiatives (Woodroffe 2001a). Unfortunately, recovery is often more difficult for large species that require contiguous areas of habitat larger in size than within a species geographical range (Pelton 1986; Meffe and Carroll 1997; Woodroffe 2001a).

Sacredness of reserves is a result of the perception of them as exemplifying models for both biodiversity conservation and wilderness protection (Pimm and Lawton 1998; Soulé and Sanjayan 1998). However, the ability of reserves to protect resources is not guaranteed. For example, in the United States the National Park Service has identified categories of internal and external threats (e.g., pollution, visitor physical impacts such as trail overuse, physical removal of resources such as illegal hunting within park boundaries, land use such as construction of new visitor services within the reserve, and road construction that can result in increased vehicle collisions with wildlife) to reserves and their resources (NPCA 2001). However, there is a severe lack of quantitative and useful information about many important issues, such as 1) where the threats originate (e.g. result of a specific land use activity), 2) why the threats have occurred, 3) how these threats have changed over time and across space, 4) how much the impacts of these threats have affected the reserve (e.g. reduction in population size of

resident species, limitation of dispersal, and increase in dispersal mortality), 5) how to reduce the threats effectively, and 6) how to predict the future dynamics of these threats and their ecological impacts.

Recently, significant attention has focused on whether reserves effectively achieve management objectives such as wildlife conservation (Leader-Williams et al. 1990; Soulé 1991; Arcese and Sinclair 1997; Meffe and Carroll 1997; Liu et al. 1999; Cork et al. 2000; Cuarón 2000; Bruner et al. 2001; NCPA 2001). Areas that are remote (i.e., relatively safeguarded from human activity) with high biological productivity are of high value for particular species (Carroll et al. 2001). However, external ecological disturbance (e.g. fragmentation) can result in reserves becoming “habitat islands” (Brashares et al. 2001; Meffe and Carroll 1997; Soulé 1991). Habitat isolation, which mimics fragmented habitat patches (Brown 1971; Turner et al. 2001), are often more pronounced in smaller reserves (Harcourt et al. 2001) and for larger species (Newmark 1996). In addition, complexity of the surrounding land use and socioeconomic conditions may heavily influence the survival ability of wildlife that travels beyond reserve boundaries (e.g. Newmark 1996; Woodroffe and Ginsberg 1998; Rivard et al. 2000; Harcourt et al. 2001).

Mortality that occurs when wildlife travels beyond reserve boundaries is a particular concern for large home-ranging terrestrial species (Parks and Harcourt 2002). In fact, human activity and habitat alteration in proximity to reserves has greatly increased large mammal extinction rates worldwide (Newmark 1996), and is often more influential on extinction rates than processes within the reserve (Rivard et al. 2000). Woodroffe and Ginsberg (1998) indicated that [worldwide] 74% of adult large carnivore

mortality, for wide-ranging, generalist species with historical ranges that are both fragmented and in proximity to reserves, results from human conflict when animals travel beyond reserve boundaries. Along with wildlife management within a reserve, conservation efforts must also focus on private land use activities surrounding the reserve and local socioeconomics that make target species most vulnerable (Pressey and Tully 1994; Parks and Harcourt 2002; Pressey et al. 2002).

Lack of integrating ecology and socioeconomics has led to many conservation failures. For example, a great quantity of ecological data has been collected about the biology of giant panda (*Ailuropoda melanoleuca*) habitat. Until recently, socioeconomic studies were nonexistent. As a result, the Chinese government, even when providing free housing, largely failed to move residents out of Wolong Nature Reserve (established in 1975 for panda protection). This resulted from lack of understanding of two important social issues: 1) elderly residents were hesitant to relocate and adapt to new places, and 2) there was no available land in proximity to the free housing that this agriculture-based community could farm (Liu et al. 2001). Integrating ecology and socioeconomics will increase the effectiveness of policy makers' abilities to create feasible and flexible solutions to meet the needs of both wildlife and humans (Liu et al. 2001).

Wildlife management in US national parks historically focused on management of ungulates, and often at the expense of other species (Wright 1999). Over time, an ecosystem approach has been adopted for reserve management with a focus on the ecological needs of species. For example, even though Yellowstone National Park contains enough area to accommodate home ranges of many individual animals, successful habitat protection for populations of focal species including the grizzly (*Ursus*

arctos), wolf (*Canis lupus*), and wolverine (*Gulo gulo*) would require an expansion of the reserve area by 50% (Noss et al. 2002). As is the case on other continents (Newmark 1996; Harcourt et al. 2001), smaller US reserves are often located in areas of higher human density, as compared to large reserves (Parks and Harcourt 2002). Gurd et al. (2001) suggested that to adequately conserve mammals within eastern North American reserves, a combination of corridors, buffers, and reserves of at least 2,700 km² would be necessary. Because ecosystems are dynamic, management goals and potential courses of action must also be dynamic and continuously evaluated even in instances of incomplete knowledge about particular species and their behaviors (Wright 1999).

Large species with negatively perceived (by humans) consequences (e.g., danger to humans) have the potential to provoke negative feelings in humans (Kellert et al. 1985a, b, c). In the US, such attitudes and opinions are often associated with carnivores, such as black bear (*Ursus americanus*) and wolves (*Canus lupus*). As a result, biologically (i.e., suitable habitat) and socially suitable environments (i.e., human acceptance of a species) for species are intertwined, which is a challenge for wildlife managers. A relatively large number of carnivore studies have been completed in US reserves, but many have focused on wildlife nuisance activity, such as in Yellowstone and Great Smoky Mountains National Parks (e.g., Beeman and Pelton 1976; Pelton et al. 1976; Garshelis and Pelton 1980; Stiver 1991; Blanchard and Knight 1995). Very little information is available that quantitatively supports how human activity affects particular species in proximity to protected areas, particularly as related to species reintroductions.

In a general sense, my dissertation goal was to integrate ecological and socioeconomic data to determine how human activities affect the ability of reserves to

protect wildlife resources. I extensively researched particular protected areas within the US to identify a case study that would allow me to achieve this goal. My inquiries led me to contact Roy Zipp, former Resource Manager for Big Thicket National Preserve, and Nathan Garner, Regional Director of the Texas Parks and Wildlife Department. After discussions with them and additional resource managers in southeast Texas about recovering locally extirpated black bear populations within eastern Texas, my dissertation evolved into a study of how threats to a protected area will affect recovery of a locally extirpated species. The overall goal of this research was to use an interdisciplinary approach to quantify spatial and temporal dynamics of ecological and socioeconomic processes that may affect a Louisiana black bear (*Ursus americanus luteolus*) reintroduction in and around Big Thicket National Preserve (BTNP), Texas.

1.2. Impetus for a Louisiana black bear reintroduction in southeastern Texas

There are 16 documented subspecies of the American black bear (*Ursus americanus*; Hall 1981). The Louisiana black bear (*Ursus americanus luteolus*) has several morphological characteristics that make it distinct from other black bear subspecies. Skull morphology, as well as DNA and tissue analysis suggested enough morphological and genetic difference between *U. a. luteolus* and other black bear subspecies for federal protection of *U. a. luteolus* as a separate subspecies (Kennedy 1989; Neal 1990). In 1992, the USFWS listed the *luteolus* subspecies as federally “threatened” (Neal 1990). Based on similarity of appearance, all black bears within the *luteolus* historical range are protected (BBCC 1997).

The historical range of the Louisiana subspecies included Louisiana, eastern Texas, and the southern half of Mississippi (Pelton 1982; Wooding et al. 1994a; Bowker and Jacobson 1995; BBCC 1997). Black bears were an important component of the economic history of southeast Texas. Bear meat and oil were widely used by local Native Americans and sought by riverboat captains. Settler accounts from the 1830s-1840s described years of successful bear hunting throughout the Big Thicket Region (Abernathy 1967). During the late 1800s, bear numbers quickly declined as a result of bear hunts organized by famous bear hunters including Ben Lilly (who collected specimens for the US Biological Museum) and Ben and Bud Hooks. Without game laws, some individual hunters killed more than 100 bears, some of which weighed more than 180 kg. Bears were almost eliminated from coastal southeastern Texas by 1900. Accounts of settlers suggested the presence of bears in the southeast Texas through at least 1906 (Truett and Lay 1984), although the last official reports of native bear were a female and two cubs, and a single large bear, killed in 1919 and 1928, respectively (Abernathy 1967). In Mississippi, the last recorded breeding occurred in 1976, although the exact date of extirpation of either subspecies found in Mississippi, *luteolus* or *americanus*, is unknown. Two remnant breeding populations survived within the bottomland hardwood forests of Louisiana: one within and surrounding the Tensas River National Wildlife Refuge and adjacent Big Lake Wildlife Management Area in northeastern Louisiana, and the other within the Atchafalaya Basin in southeastern Louisiana (Weaver et al. 1990; Marchinton 1995; Bowker and Jacobson 1995; Garner 1996; BBCC 1997; Eastridge 2000). Several sightings have occurred in Mississippi, but

no confirmed breeding population is present (Wooding et al. 1994a; Stinson and Pace 1995, Shropshire 1996; Stinson 1996).

During the mid 1990s, Louisiana landowners and members of bear-related conservation organizations launched a major public outreach and information campaign to recover statewide bear populations. The Black Bear Conservation Committee and US Fish and Wildlife Service created recovery plans, and one objective of each plan was to restore the Louisiana black bear throughout its historical range (Bowker and Jacobson 1995; BBCC 1997). To date, recovery in Louisiana has been successful (Van Why and Chamberlain 2003), and feasibility analyses were completed for Mississippi with positive results (Shropshire 1996; Bowman 1999).

Although there is no known breeding population of bears in eastern Texas, the number of black bear sightings has increased dramatically during the past decade. These are likely transient bears from bear populations in Louisiana, Arkansas, or Oklahoma. The number of increased sightings prompted the creation of a bear management plan for eastern Texas by the Texas Parks and Wildlife Department. The ultimate goal of the management plan is to restore habitat for the future reestablishment of black bear as a viable ecosystem component in eastern Texas (TPWD 2005). Short-term objectives (over the next 10 years) include public coordination, communication, outreach and information dissemination, habitat management, and research (TPWD 2005).

1.3. Big Thicket National Preserve – an area targeted for bear recovery

Big Thicket National Preserve (BTNP) is a potential target for bear recovery

(Figure 1.1; *images in this dissertation are presented in color*). Also known as the “Biological Crossroads of North America” and “America’s Ark,” eleven ecosystems within the region have been defined by the National Park Service based on dominant vegetative, geologic, and hydrologic characteristics (Peacock 1994). Native Americans originally called the region containing what is now BTNP “The Big Woods,” or “The Impenetrable Woods,” and few permanent settlements were established within it (Gunter 1971; Gunter 1993). While Texas was under Spanish rule during the 1820s, the Spanish government offered land holdings of 840 acres to settlers of European origin. However, many settlers deserted the area after becoming frustrated with the dense and swampy forest. Some of the swampiest land remained unclaimed until only recently (Abernathy 1967; Truett and Lay 1984).

After Texas became part of the US (1821), timber and oil were economic incentives for further settlement of southeast Texas. The first commercial timber operations began in the 1850s to meet Eastern demand for lumber after depletion of Great Lakes forests (Truett and Lay 1984). Large scale oil drilling began in 1901 and soon oil wells were so numerous that they often sank when the ground collapsed under their weight (Abernathy 1967; Truett and Lay 1984). Today, timber and oil are still important components of the local economy. Plans to establish BTNP were originally met by opposition of local residents who believed that the local economy would suffer, visitor services would force locals out, and children would be eaten by government-sponsored bears and panthers (Gunter 1993).

In 1974, BTNP was established as the nation’s first National Preserve to protect the 11 unique ecosystems in the area. Since establishment, BTNP has also been

designated as a UNESCO International Biosphere Reserve, an American Bird Conservancy Globally Important Bird Area (IBA), and member of the United States Man and Biosphere Program. The preserve's 12 land and river corridor management units together total >39,256 ha. Three remaining units (4,290 ha total) have been authorized, but actual land has not yet been fully acquired.

Because timber management companies still own a large portion of land surrounding the preserve, forested areas have been maintained across the landscape and may provide refuge for bears. Two small ecological feasibility studies for the area have been completed for individual BTNP units, and some private lands surrounding the preserve (Garner 1996; Epps 1997). However, neither landscape-level ecological nor socioeconomic analyses have been completed to determine whether a black bear reintroduction is feasible. Therefore, I developed six focal areas of analysis: (1) use of remotely sensed imagery to quantify available bear habitat and assess the distribution of habitat within the study area to determine the ecological feasibility of a black bear reintroduction, (2) assessment of the dynamics of timberlands to determine if changes in timberland ownership affect the quantity of bear habitat, (3) implementation of a mail survey to determine socioeconomic factors that influence local residents' attitudes toward black bears and their reintroduction, (4) use of survey data to determine socioeconomic factors that influenced residents' selections of preferred management strategy for black bears, (5) development of a method to assess the spatial distribution of residents' selections of preferred management strategy, and (6) development of a method to integrate ecological and socioeconomic data to determine feasibility of a black bear

recovery across the study area based on resident attitudes and land use. A brief review for these focal areas, with a more detailed review within each chapter, is as follows.

1.4. Research topics

For bears to be reintroduced, habitat must be available. Therefore, the first goal of this study was to use remotely sensed imagery to quantify available bear habitat and assess the distribution of habitat within the study area to determine the ecological feasibility of a black bear reintroduction. To date, habitat suitability indices (HSI's) have been the most commonly used method for evaluating bear habitat (e.g. Landers et al. 1979, Pelton 1982; Rogers and Allen 1987; van Manen 1991). Although HSI's are useful tools for quantitatively comparing habitat quality between areas of interest, a major shortcoming of HSI's is that they provide a relative site-specific quantitative assessment based on predetermined variables that only allows for basic comparisons between different locations (USFWS 1981; Schamberger et al. 1982). In addition, generalizing HSI's to spatial and temporal dynamics of landscapes is extremely field intensive and difficult (Shamberger et al. 1982). Technological advances including geographic information systems (GIS) and modeling procedures (e.g. Buckland and Elston 1993) have allowed for more detailed spatial study of bear habitat (Clark et al. 1993; van Manen and Pelton 1997; Jones 1998; Larkin et al. 2004), but few studies have assessed how habitat suitability for black bears changes over time and across space (Schooley et al. 1994).

High quality habitat and large tracts of land with minimal human disturbance are considered highly influential factors of past successful bear reintroductions (Feis et al.

1986; Rogers 1986; Stiver 1991; Comly 1993; Riley et al. 1994; Blanchard and Knight 1995). A viable population, adequate area for home ranges, and large trees or dense understory for denning are important ecological characteristics for maintaining an established black bear population (Rogers 1987; Rudis and Tansey 1995; Oli et al. 1997). More specifically, forested lowlands with waterway corridors and a bottomland species complex containing oaks (*Quercus* spp.), hickory (*Carya* spp.), gum (*Liquidambar styraciflua*), and cypress (*Taxodium* spp.) have historically provided the best bear habitat in the southeastern US (Shropshire 1996; BBCC 1997) by providing understory cover as well as fruits and mast for forage (Sauer et al. 1969; Landers et al. 1979; Eagle and Pelton 1980; Maehr and Brady 1984; Smith 1985; Schullery 1986; Weaver 1992; Stubblefield 1993; Larivière 2001). Remote forest tracts (i.e., isolated from human activity), defined by forest areas >0.8 km from development (Rudis 1986), or contiguous tracts of >1,000 hectares are also desirable (Hellgren and Vaughan 1989a; Brody and Pelton 1989; Rudis and Tansey 1995; Larkin et al. 2004). Literature has suggested minimum areas of 7,580 ha for a population of 50 individual bears, 30,300 ha for 200 bears, and 152,000 ha for 1,000 bears (Hellgren and Vaughan 1989a; Rudis and Tansey 1995).

In southeastern Texas, results from Garner (1996) suggested that habitat suitability for food, availability of cover, and that human impacts would likely not be a limiting factor for bears. Lack of large denning trees was not considered critical because bears in the southeastern US often den on the ground within thick undergrowth or slash piles (Weaver et al. 1990; Marchinton 1995).

Epps (1997) completed a more detailed study of two contiguous BTNP units (Neches Bottom and Jack Gore Baygall), an area of approximately 5,000 ha surrounded by large tracts of timberland. Based on fall food availability (Smith 1985) and tree den sites (Rogers and Allen 1987; van Manen 1991), results suggested a density of 4-54 potential den trees/km², a sufficient number for a bear population, and an estimated carrying capacity of 48-86 bears (Pritchard and Robbins 1990). This estimate (0.58-1.40 bears/km²) includes the range of other carrying capacity estimates for the southeastern US (0.18-0.77 bears/km²; Hamilton 1978; Beecham 1980; Smith 1985; Hellgren and Vaughan 1989b; van Manen 1991).

Nearby forested areas may help support a core population within the preserve (Johnson and Pelton 1981; Pelton 1986; Epps 1997). Both Garner (1996) and Epps (1997) concluded that adequate habitat exists in southeastern Texas for a bear population. However, bears are potentially far-wandering (Beeman and Pelton 1976) and the area of BTNP (>37,000 ha) is likely too small for a large black bear population. As a result, individual bears will likely wander between BTNP's 12 disjunct units (Figure 1.1). Consequently, the connectivity of habitat, or how close areas of habitat are to each other, may be a factor in bear movement between preserve units (Beausoleil 1999; Maehr et al. 2003; Larkin et al. 2004). By using remotely sensed imagery, our objectives within the first research goal (ecological feasibility) were to: (1) quantify how much habitat is available within the preserve, and how this estimates of habitat change when the preserve is considered within the context of the surrounding landscape, (2) estimate changes in habitat area as a result of changing the scale of analysis, (3) assess how changing the scale of analysis affects connectivity of habitat, (4) identify and quantify core areas (see

Methods) of habitat, and whether their distribution change as scale of analysis changes, and (5) based on habitat area, estimate black bear population size that may exist within the study area.

To reiterate, as a result of BTNP's disjunct distribution bears will likely travel beyond the preserve's boundaries in search of food, cover, and mates. Therefore, private land between the preserve's units will likely be important as black bear habitat as well. A majority (~70%) of land in southeast Texas is owned by timber companies and managed for timber production, which has likely been a major influence in the continuous presence of forestland over time. The subtropical climate allows overall primary productivity to be high, and fast growth rates of trees within forested areas provides bear cover and forage. Results from Rudis (1986) suggested that approximately five million ha of timberland existed in southeast Texas during the 1980s, with a large amount of timberland >1 km away from the nearest road than in Louisiana. The adaptability of bears to diverse habitats has allowed for easy integration of timber management to meet bear habitat needs, particularly through maintenance of land access and habitat that may serve as corridors (Brody and Stone 1985; Hillman and Yow 1986). In fact, bears often denned within slash piles created from timber harvest or road construction, and thick understory vegetation (Hamilton and Marchinton 1977; Hillman and Yow 1986; Weaver et al. 1990; Wooding and Hardisky 1992; Marchinton 1995). Availability [or lack] of denning sites, such as large trees, did not appear to be a limiting factor for bears in LA (BBCC 1997).

Since Rudis's survey two decades ago, only Garner (1996) has studied relationships between timberland and potential bear habitat in southeastern Texas. However, the objective of Garner's (1996) study was to complete HSI's for particular

expanses of timberland as related to quantifying black bear habitat quality. No research has been conducted to determine whether the area and distribution of bear habitat among timberlands has changed since the research by Rudis (1986). Therefore, our second goal was to assess relationships between timberlands and potential bear habitat, and specific objectives included adoption of a landscape perspective to (1) quantify how area and distribution of potential bear habitat and timberlands have changed since establishment of BTNP, (2) quantify the relationship between highly suitable habitat and distribution of timberlands, and how this relationship has changed over time, (3) quantify the relationship between timberlands and areas of consistent, improved, or degraded habitat quality over time, (4) compare changes in habitat quantity and quality over time among private lands with such changes among public lands, and (5) assess implications regarding changes in timberlands and how they may affect attainment of bear management goals by the Texas Parks and Wildlife Department.

Changing distribution of timberlands is a socioeconomic phenomenon, and individual attitudes and opinions are often factors in land use decisions (Rudis and Tansey 1995; McDonald et al. 2001). Timber companies in southeast Texas are extremely supportive of bear recovery and actively involved in bear management and recovery efforts. Even so, there is no guarantee that bears will remain within the boundaries of public lands or timberlands. As a result, neglecting local residents' attitudes toward bears could have negative impacts on bear recovery efforts. For example, a 30-year long recovery effort in Arkansas (1958-1990s) resulted in an increase in the black bear populations by >2,500 bears (Rogers 1973; Smith and Clark 1994). Although this may seem ecologically successful, poaching has been a constant factor in

bear population dynamics since the reintroductions (Rogers 1973; Smith et al. 1990; Shull 1994). It has been hypothesized that some poaching is directly related to the Arkansas Game and Fish Commission not seeking public input from the outset as a result of the perception that the public did not support a bear recovery (Smith and Clark 1994). During the late 1980s and early 1990s, the Arkansas Game and Fish Commission became involved in public awareness programs for bear conservation, and public involvement in bear conservation has been increasing over time (Smith and Clark 1994).

Public acceptance of wildlife is a major challenge of wildlife management (DuBrock et al. 1978; Purdy and Decker 1989; Craven et al. 1992; Burton et al. 1994; Koch 1994; Locker and Decker 1995; Lohr et al. 1996; Lauber and Knuth 1996; Riley and Decker 2000a; Riley et al. 2002). Public participation, perceptions, and acceptance are exceptionally critical to success of carnivore reintroduction efforts (Duda 1986; Reading and Clark 1996; Kellert 1985b; Enck and Brown 2000; Clark et al. 2003). Bears are considered charismatic megafauna, and are among species considered human favorites (Kellert 1985b, c; Hastings and Hammitt 1986; Sellars 1997). Because public involvement can be the deciding factor in the success (or failure) of a species recovery, stakeholder support in proximity to target reintroduction areas is critical to success of the reintroduction (Reading and Kellert 1993; Reading and Clark 1996; Clark et al. 2003). Analysis of local stakeholder values and attitudes must be completed before a reintroduction project is pursued so that outreach and public-relations programs may be custom made for the species, local culture, and geographic region (Reading and Kellert 1993). It is essential that residents of southeastern Texas tolerate bear presence,

regardless of whether they individually want bears in the area. Implementation of a resident survey allowed me to achieve the third, fourth, and fifth goals of this study.

The third goal was to determine socioeconomic factors that influence local residents' attitudes toward black bears. Specific objectives were to: 1) identify public attitudes toward black bears and a potential reintroduction, 2) determine what factors influence residents' attitudes toward recovery of black bear in the area, and 3) compare this information with attitude studies from the remainder of the Louisiana black bear's historical range. Past study has suggested that the general public holds existence and conservation value for bears, and commonly explored attitude variables include (among others) sex, age, income, education, and location of residence (Decker et al. 1981; Kellert 1994; Hastings and Hammitt 1986; Shropshire 1996; Bowman 1999; Bowman et al. 2001; Peyton et al. 2001). Even in cases of nuisance activities such as campsite pilfering (Great Smoky Mountains National Park; Pelton et al. 1976) or crop damage (Jonker et al. 1998; Bowman et al. 2001), presence of bears was viewed as an important ecological and/or economic component of the environment. Louisiana and Mississippi residents held generally positive attitudes toward black bears and population recoveries in those states (Shropshire 1996; Bowman 1999; Bowman et al. 2001; Bowman et al. 2004; Van Why and Chamberlain 2003).

Even if local residents had generally positive attitudes about black bears, popularity alone may not be enough to win public support for a reintroduction (Lohr et al. 1996). For example, in Mississippi, public support for increasing the size of the Mississippi black bear population decreased when a reintroduction was suggested (Shropshire 1996). Bowman (1999) suggested that more than 60% of both private and

corporate landowners did not support a non-assisted (i.e., bears returning on their own) black bear recovery in Mississippi. Familiarity with bears was a factor in support for increasing the black bear population in New York (Decker et al. 1983), Arkansas (Clark 1991), and Michigan (Peyton et al. 2001). Therefore, the fourth goal of this study was to further explore factors that influenced residents' selection of preferred general management strategy for black bears if a recovery occurs.

Because it is likely that a variety of attitudes toward potential management strategies exist throughout southeast Texas, spatial knowledge about attitudes may allow managers to identify locations where residents' preferred management strategies are both favorable for and threaten a reintroduction. For example, residents who want bears in the area may be more willing to adapt land use practices that favor black bear (e.g., maintenance of thick undergrowth on their property). Likewise, residents who oppose bear presence may pose risks to a successful reintroduction (e.g., shoot bears on sight, harass individual bears). In addition, if BTNP is a target for a potential bear release site, it is imperative to know whether residents near the preserve are supportive of bear recovery efforts.

Spatial analysis of particular occurrences is common in disciplines such as public health (Knox 2005), environmental valuation (Brown 2005) and wildlife ecology (Kie et al. 2002). However, spatial research involving human dimensions of wildlife has mainly focused on comparative studies (Fox et al. 1996; Merrill et al. 1999; Riley and Decker 2000; Peyton et al. 2001) or predictive statistical models (Bowman et al. 2004). I was unaware of any studies that had applied spatial analysis of attitudes to assess distribution of individual survey responses. Therefore, the fifth goal of this study was to assess the

spatial distribution of residents' selection of preferred management strategy.

Specifically, I sought to (1) ascertain the spatial distribution of residents' attitudes toward potential bear recovery strategies, and (2) determine whether distance from BTNP is a factor in resident attitudes.

Finally, I used the data described for goals #1-5 above to achieve the sixth goal of this study: to integrate ecological and socioeconomic data to determine how resident attitudes and changes in land use may affect a black bear reintroduction. Goals #1-5 provide insight into factors that may threaten the success of BTNP to provide refuge to reintroduced black bears. However, they do not allow for simultaneous evaluation of interrelationships among these factors within the system of study. The first objective to achieve this goal was to develop a systems model that incorporated bear habitat, land ownership, and socioeconomic variables that affect attitudes toward black bears in southeast Texas. Ideally, locations with a greater amount of habitat will also be more socially feasible and support a reintroduction. We evaluated our model at two future time points: (1) 10 years into the future (10 years after model parameterization, or 2010), and (2) 20 years into the future (20 years after model parameterization, or 2020). The year 2020 coincides with the end of the 15-year term of the present black bear management plan (TWPD 2005). Our second objective was, based on results of the first objective, to rank the counties within the study area in regard to both ecological and social feasibility for the planned black bear recovery. Comparing feasibility between counties will allow managers to weigh management options based on ecological and social feasibility. For example, if a particular county contained a high ecological ranking (e.g., large area of highly suitable habitat) but a low social ranking (e.g., low scores for questions about bear

knowledge), managers will know that habitat is present, but extensive public outreach will be necessary to determine if bear reintroduction into the county is truly feasible. Just the opposite, if a particular county contained a low ecological but high social ranking, managers may prefer to focus public outreach on resident land use management for improving black bear habitat.

1.5. Conceptual framework

Although black bears are considered habitat generalists (Larivière 2001), it is likely that human land use decisions and activities will be the main factors that affect bear habitat, even if a bear is reintroduced into a protected area (Figure 1.2). Human-related factors include both direct changes to habitat through land use (e.g., forestry, urbanization), and indirect drivers of habitat change (e.g., socioeconomic variables such as income or education). Important characteristics of black bear habitat include quantity (i.e., area), quality (i.e., highly suitable versus marginal), and location (i.e., spatial distribution, connectivity; Pelton 1982; Bowker and Jacobson 1995; BBCC 1997; Liu et al. 1999; Larivière 2001). If a reintroduction takes place, changes in bear habitat from season to season may result in bears directly affecting humans. For example, during a poor mast year, bears may search for food in trash bins and gardens at a greater rate than during good mast years. Increased nuisance activity may result in negative human attitudes toward bears and bear behavior.

Land use, human attitudes, local economic conditions, and human demographics can all affect (and be affected by) bear management. The intensity and location(s) of and strategies for bear management can have direct effects on land use that may, in turn,

affect bear habitat. For example, heavily managed fast-growing tree species (e.g., pine plantation) may be favored for timber production. Clearcuts can result in an extremely rigid boundary between highly suitable and unsuitable habitat, and bear managers may prefer selective harvest of particular size stands that maintain growth of hardwood mast-producing species (Weaver et al. 1990). Human support for bear management policies may be affected by personal attitudes toward black bear, which may result from knowledge (or lack thereof) about bear, or concern about how bear management policies may affect individual human land use. Land use decisions may affect local economies. For example, federal mandates for bear habitat conservation may prohibit particular industries (e.g., timber management, petroleum extraction) from implementing a preferred management practice. Prevention of an industry from carrying out business may cause angst among local residents, who depend daily on local industry. As a result, local residents may be less likely to invest income or other resources into species conservation on their land.

Completion of this research is critical to the study of wildlife, species reintroductions, and nature reserves because it (1) develops a systems model to integrate data of different disciplines that are important to successful wildlife and land use management, and (2) demonstrates an innovative method for application of spatial technologies (e.g., remote sensing data) with system modeling tools to integrate, analyze, and simulate complex relationships that exist between humans and nature. Land cover and land use data spatially illustrate the relationships of human activity in relation to potential bear habitat. The survey data provide insight into specific mechanisms of human activity in relation to bear habitat. Linking these data through use of a systems

model increases the ability to understand how humans both directly and indirectly affect wildlife habitat. Texas Parks and Wildlife Department can use the systems model to refine management goals, plan public information forums, and ascertain the potential for bear reintroduction and management over the long term.

Southeast Texas provides a unique opportunity to evaluate a scenario in which it is known *a priori* that human activity will be a major influence on a potential black bear reintroduction and a protected area that may offer refuge to bears. By knowing this from the outset, human factors can be incorporated into bear management and planning. The relationships between humans and wildlife habitat that are found in southeast Texas are not unique to this location. As human activity expands into previously rural locations worldwide, innovative methods for evaluating changes in both humans and wildlife are necessary to meet the needs of wildlife while also considering changes in human activity.

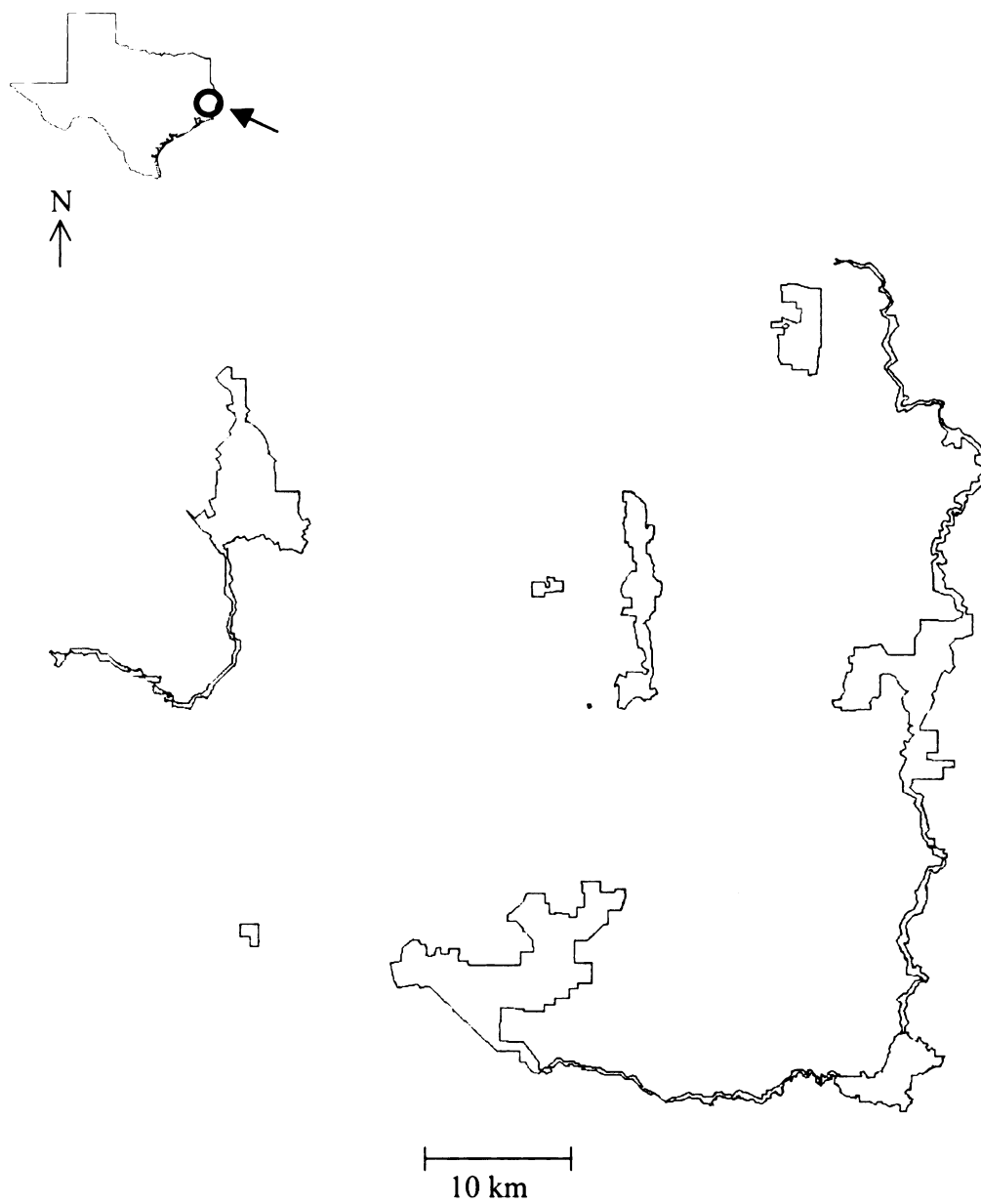


Figure 1.1. Spatial distribution of Big Thicket National Preserve's administrative units.

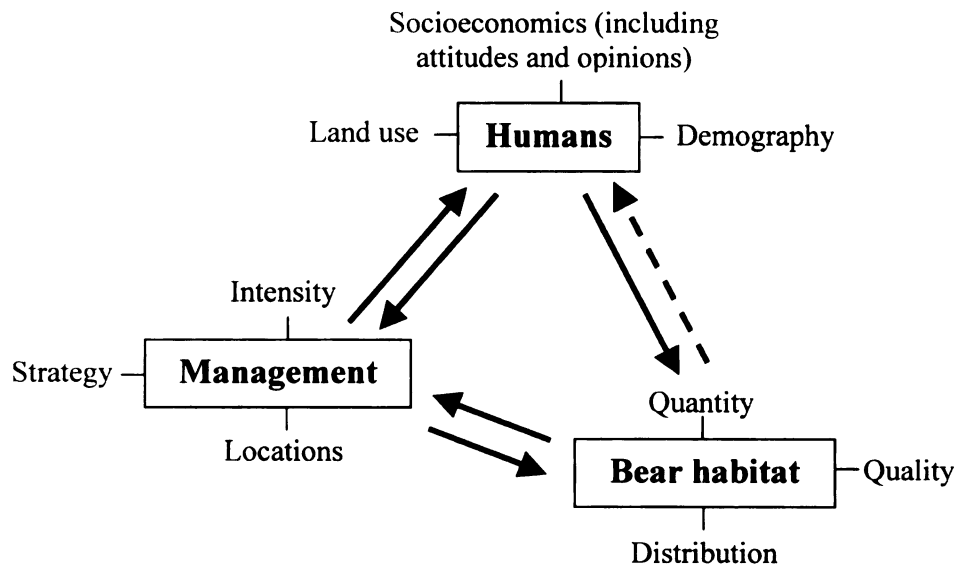


Figure 1.2. Conceptual framework for determining the feasibility of a Louisiana black bear reintroduction in and around Big Thicket National Preserve, Texas. Solid arrows indicate relationships considered in this research. The dashed arrow indicates a relationship that will likely be more pronounced if and when bears are reintroduced.

CHAPTER 2

SCALE, CONTEXT, AND HABITAT ASSESSMENT FOR ECOLOGICAL FEASIBILITY OF A SPECIES REINTRODUCTION

In collaboration with

Brian A. Maurer and Jianguo Liu

Abstract

Accurate estimates of habitat area are necessary for planning wildlife reintroductions to ensure that adequate resources are available for reintroduced individuals and their offspring. However, both the scale of analysis used and the context of habitat within the surrounding landscape can greatly affect estimates of habitat area and distribution. We incorporated variation in scale of analysis, as well as the distribution of habitat within the surrounding landscape, to assess the feasibility of a Louisiana black bear (*Ursus americanus luteolus*) reintroduction in and around Big Thicket National Preserve (BTNP), Texas. Analysis of land cover imagery revealed an estimated 1.3 million hectares of highly suitable habitat across the landscape, and 90% of land within BTNP was considered highly suitable. However, 44 times more highly suitable habitat existed beyond the preserve's boundaries. Average patch size was larger at a 1-ha scale (more appropriate for assessment of bear ecology) than at a 30-m scale (scale of raw image data) as a result of consolidated small habitat patches at the more coarse scale. Spearman rank correlations indicated a negative correlation between patch area and nearest neighbor distance between highly suitable habitat patches. Core habitat (highly suitable habitat >1 km from human activity) was only visible at the 1-ha scale, and existed primarily within southeastern and northeastern portions of the study area, as well as within BTNP. Considering both highly suitable and core habitat at the 1-ha scale, we estimated a potential population size of 290 bears within BTNP, and 2,256 for the whole study area. We believe that a bear reintroduction is ecologically feasible, particularly if land beyond the preserve is considered.

2.1. Introduction

While the area of habitat for many large carnivore species is decreasing, there is increasing recognition that these animals are valuable members of the ecological community (Sillero-Zubiri, C., & M.K. Laurenson 2001). As a result, efforts are increasing to recover populations of locally extirpated species (Reading and Clark 1996). As human development rapidly expands into previously rural areas, reserves and other public lands are playing a more important role than public land alone as habitat for species conservation and recovery initiatives (Woodroffe 2001a). Unfortunately, because reserves are often not large enough to adequately protect the species for which they were established (Liu et al. 2001; Gurd et al. 2001; Gurd and Nudds 1999; Soulé and Simberloff 1986), recovery is often difficult for larger species requiring large and contiguous areas of habitat, which may no longer exist as a result of human activity or are currently under private ownership (Pelton 1986; Meffe and Carroll 1996; Woodroffe 2001b).

A particular concern for reserve managers is conflict with humans when wildlife travels beyond reserve boundaries (i.e., beyond “islands of habitat;” Newmark 1985; Newmark 1995; Woodroffe and Ginsberg 1998; Hansen and Rotella 2002). Knowledge about interactions between wildlife and the landscape surrounding a reserve are essential for management of the reserve and its species (Harcourt et al. 2001). The idea of cross-boundary management for reserves is well documented in the conservation planning literature (Pickett and Thompson 1978; Schonewald-Cox and Bayless 1986; Means and Greene 1987; Schonewald-Cox 1988; Schonewald-Cox et al. 1992; Shafer 1999; Hamin 2001; Harcourt et al. 2001). However, few studies have quantified in detail the

magnitude of difference that cross-boundary management can potentially make in assessing habitat for a particular species. Even more challenging than managing already existing species is predetermining habitat for use by a reintroduced species. For a reintroduced species, if habitat is overestimated resources may be too few to meet population needs. On the other hand, it is possible that underestimating resources may lead to unexpected overpopulation of a species (Hamilton 1999).

To determine ecological feasibility of a reintroduction, knowledge of two major items is essential for estimation of a potential target population: (1) the quantity and quality of available habitat that exists, and (2) distribution of the habitat within the landscape (Reading and Clark 1996). Because many ecological factors are not easy to measure, even estimates of habitat area may vary dramatically depending on analysis tools used and selection of parameters for estimation (Miller et al. 2004; Osborne et al. 2001). In this study, we sought to determine whether methods of analysis (in regard to scale and context) would lead to varying estimates of habitat quantity and distribution for a proposed species reintroduction.

Scale is a spatial or temporal dimension characterized by grain (smallest quantitative unit of area analysis) and extent (e.g., size of the study area; Turner et al. 2001). In recent years, many studies have challenged the issue of how to determine the best scale of analysis for a species (Norris et al. 2002; Mazerolle and Villard 1999; Peterson and Parker 1998). For example, Bailey et al. (2002) suggested that distributions of birds and mammals appeared correlated at a scale related to the landscape level, whereas plants and butterflies were more sensitive to variables at scales associated with patches. In fact, many studies have concluded that ecological analysis must take place

across many scales (Karl et al. 2000; Stern 1998). Researchers have also suggested appropriate scales for studying ecological characteristics of species, such as those cited above, or have explored the effects of changing scale of analysis (Turner et al. 1989). Because many researchers from different disciplines (e.g., wildlife management, forestry) may be involved with a species reintroduction, each may unintentionally use different scales of analysis for different types of data (e.g., 30m scale for land cover data versus per-hectare number of a particular resource important for a species). Knowledge about how differences in scale of analysis may greatly affect measurement of habitat for a species targeted for reintroduction.

Less emphasized in the ecological literature than scale, but also important, is context. Context is the consideration of surrounding landscape characteristics in relation to, and how they affect, the feature of interest. Past research has identified the importance of context, for example, in estimating bird densities among forest fragments, wetlands, salt marshes, and as related to nest predation (Shriver et al. 2004; Brotons et al. 2003; Riffell et al. 2003; Donovan et al. 1997). Effects of landscape characteristics on habitat are also of interest in relation to locations of varying land jurisdictions. For protected areas, landscape context may involve isolated areas of habitat that are surrounded by an inhospitable human-modified matrix (Gilpin and Diamond 1980), which is logically equivalent to the issue of cross-boundary management.

Through use of land cover and habitat analysis, we applied the ideas of habitat area estimation and cross-boundary management to study how scale and context affect estimates of available habitat for a reintroduction. Our goal was to estimate the ecological feasibility of a Louisiana black bear (*Ursus americanus luteolus*)

reintroduction in and around Big Thicket National Preserve (BTNP), Texas. In the southeastern United States, black bear habitat includes hardwood, mixed hardwood-pine forest, and bottomland areas that contain a variety of mast-producing tree species (e.g., oak, hickory; Dobey et al. 2005; Larkin et al. 2004; Maehr et al. 2003; BBCC 1997; Bowker and Jacobson 1995). Older-growth forests in remote areas (i.e., core habitat, or locations >1 km from human activity; Linnell et al. 2000) are more likely than younger forest to contain large trees for denning (Larivière 2001; Pelton 1982), although southern bears often den in slash piles, excavated ground tree cavities and ground depressions (Hellgren and Vaughan 1989b; Weaver et al. 1990). Early successional undergrowth containing many fruit-bearing herbaceous species is considered high quality habitat (Anderson 1997; Marchinton 1995; Nyland 1995; Hellgren and Vaughan 1991). Specific objectives were to: (1) quantify how much habitat is available within the preserve, and how this estimates of habitat changes when the preserve is considered within the context of the surrounding landscape, (2) estimate changes in habitat area as a result of changing the scale of analysis, (3) assess how changing the scale of analysis affects estimated connectivity of habitat, (4) identify and quantify core areas (see Methods) of habitat, and whether their distribution change as scale of analysis changes, and (5) based on habitat area, estimate black bear population size that may exist within the study area.

2.2. Methods

2.2.1. Background

The Louisiana black bear once existed throughout all of Louisiana, southeast Texas, and southern Mississippi (BBCC 1997). With one of the historically densest

populations of bears, early settlers of the region relied on bear as a source of food (Truett and Lay 1984). Overharvest and habitat destruction led to near demise of this subspecies during the early 1900s (BBCC 1997). During the second half of the 20th century, only two small remnant populations of the subspecies existed, both in eastern Louisiana. An extensive public outreach campaign during the 1990s led to recovery efforts for Louisiana black bear in Louisiana, as well as the creation of two management plans that focused on recovery throughout the species historical range (BBCC 1997; Bowker and Jacobsen 1995). Thus far, recovery in Louisiana has been successful (Van Why, 2003) and feasibility analyses have been completed for Mississippi (Bowman 1999; Shropshire 1996).

In eastern Texas, the number of black bear sightings has increased during the past decade (N. Garner, Texas Parks and Wildlife Department (TPWD), *personal communication*). Because no breeding population of bears is known to exist in Texas, it is likely that these bears are transients from Arkansas, Oklahoma, or Louisiana that wander into Texas. The sightings have prompted creation of an East Texas black bear management plan. Objectives of the management plan for the next 15 years include public coordination, communication, outreach and information dissemination, habitat management, and research (TPWD 2005). The ultimate goal is to restore habitat for the purpose of reestablishing black bear as a viable ecosystem component in southeast Texas (TPWD 2005).

2.2.2. Study area

Our study area consists of the 39,285-ha BTNP in southeastern Texas (Lat./Long. –94.36/30.38; Figure 2.1) and 12 counties that include and surround the preserve. BTNP is unique in that it consists of 12 disjunct management units (Figure 1.1), seven of which are river corridors that connect larger non-corridor units. This distribution makes BTNP an ideal location in which to study human impacts on wildlife and nature reserves.

Approximately 500,000 residents live within the study area (US Census Bureau data). Much of the area is rural, with numerous small towns throughout and one larger community (City of Lufkin) along the northwestern boundary. More than 75% of the land is managed for timber or owned by the Federal government (i.e., BTNP and four national forests). The southern edge of the study area, which is also the most densely populated location, consists of suburban development from the cities of Houston and Beaumont.

2.2.3. Habitat classification

Land cover classification was derived from 2002 Landsat™ ETM+ (30m resolution) multispectral imagery. We selected images from November and March to maximize availability of cloud-free images, and selected training sites (i.e., ground-reference points from which land cover data were collected) that would be easily and consistently identifiable on imagery through all seasons. During the summers of 2002 and 2003, used a Garmin™ hand-held global positioning system (GPS) to ground-truth 255 training sites to use as a basis for supervised imagery classification. Applying these data to imagery classification, we identified seven general land cover categories: urban

(including residential), water, sand, agriculture (including livestock pastures), pine forest (both plantation and natural), mixed (pine and hardwood) forest, and bottomland forest (hardwood forest within bottomland areas; adapted from Harcombe and Callaway 1997).

To identify black bear habitat, we recoded land cover data to derive four habitat classes: highly suitable, suitable, marginal, and unsuitable. Assignment of each of the seven land cover classes to one of the four specific habitat classes was based on past research on black bear ecology for the south-central US (Larkin et al. 2004; Maehr et al. 2003; Marchinton 1995; Weaver et al. 1990; Wagner 1990; Pelton 1982). Highly suitable habitat included mixed and bottomland forest. Common species within mixed forest included oaks (*Quercus* spp.), hickory (*Carya* spp.), magnolia (*Illicium* spp.), beech (*Fagus* spp.), and pine (*Pinus* spp.). It is believed that beech-magnolia-loblolly pine (*P. taeda*) was the historical climax community of the region (Peacock 1984; Marks and Harcombe 1981; Harcombe and Marks 1977) before many areas were replaced with faster regenerating pine plantations. Bottomland forest included cypress (*Taxodium* spp.), American holly (*Ilex opaca*), tupelo (*Nyssa* spp.), sweetgum (*Liquidambar styraciflua*) and lowland oak, hickory, maple (*Acer* spp.), birch (*Betula* spp.), sycamore (*Platanus occidentalis*), and ash (*Fraxinus* spp.) species. Mast and fruits related to these forest types may be important food sources for bears.

Suitable habitat included recent clearcuts containing downed slash and young regenerating forest. These areas contained thick layers of early successional vegetation and saplings dominated by honeysuckle (F. Caprifoliaceae) and poison ivy (*Toxicodendron radicans*). Throughout the south-central US, bears use slash within regenerative areas for denning, and corresponding vegetation would be among prime

foraging habitat (Larkin et al. 2004; Anderson 1997; Marchinton 1995; Nyland 1995; Wagner 1990; Weaver et al. 1990). If managed for seedling species often present in natural regeneration (e.g., oak), these areas may become highly suitable in the future until the next scheduled harvest. Although regenerating forest and clearcuts may contain favorable vegetation and denning sites for bears, we classified such areas separately from older growth forest because of uncertainty related to management.

Sandy areas and pine forest were defined as marginal habitat. Sand included sandbars along rivers and areas of arid-environment plants (e.g., yucca, cactus; Peacock 1984). Bears may forage among these plants, but are not likely to spend large amounts of time in such sun-exposed areas (Weaver 1992). Pine included slash pine (*Pinus elliottii*) plantations, as well as longleaf pine (*Pinus palustris*; Peacock 1984), that were managed for removal of deciduous undergrowth.

Agricultural and urban land cover were designated as unsuitable habitat. Only along the southern boundary of the study area (i.e., Gulf Coastal Plain) was row crop agriculture prevalent, and consisted of millet and rice among other products. Throughout the remainder of the study area, row crop agriculture was sparse and livestock rearing was widespread. Most livestock pastures were fenced in with barbed wire, which may ultimately deter bears (Jonker et al. 1998). Finally, because specific urban characteristics (e.g., low-density residential versus high-density residential) were difficult to disseminate using 30-m resolution imagery, we classified all identifiable human infrastructure (e.g., houses, buildings) as urban. We removed large water bodies of water from analysis.

2.2.4. *Habitat analysis*

Using Imagine 8.7 (Leica Geosystems GIS & Mapping, LLC, St. Gallen, Switzerland), we grouped contiguous pixels of the same land cover class to represent patches of a similar habitat type. To account for classification errors and ecological characteristics of black bears, we adapted imagery analysis to simulate landscape analysis at different scales. First, unfiltered data were used to simulate a 30-m (0.09-ha) scale, equivalent to the grain of unmanipulated image analysis.

Second, we assessed habitat at a scale relevant to bear ecology and behavior. We applied a moving window filter to image data to reclassify each image pixel based on the most common habitat class of surrounding pixels. This method was similar to placing a grid of a particular grain over the landscape and applying the most common land cover within a particular quadrant to the quadrant (Chapin et al. 1998). The results simulated patches of particular habitat classes at a predetermined scale. We determined scale of analysis based on information from previous studies of black bears to incorporate land cover data into habitat estimates. Estimation of habitat at the scale of a black bear home range would be ideal, but individual bear home ranges can range from fewer than five to hundreds of square kilometers (Garshelis and Pelton 1981; Pelton 1982; Hellgren and Vaughan 1990; Marchinton 1995; Rudis and Tansey 1995; Wooding et al. 1994b; Wagner 1990; Anderson 1997; Beausoleil 1999; BBCC 1997; Larivière 2001; Maehr et al. 2003), and vary by season (Garshelis and Pelton 1981; Hellgren and Vaughan 1990). Within fragmented forest areas of eastern Louisiana, bear home ranges within the Atchafalaya River Basin were approximately 340 km² for males and 42 km² for females (Marchinton 1995), and 33 km² and 15 km² for males and females, respectively with the

Tensas National Wildlife Refuge (Wagner 1990). In exploratory analysis, we manipulated imagery to simulate habitat at the scale of one kilometer, and observed the elimination of several features (e.g., entire small towns) that are likely important for determining habitat distribution. Therefore, we resolved that our selection of scale should be based on distances of bear movement rather than home range.

A majority of bear movement estimates are based on estimated average interlocation distance from radiotelemetry observation, which typically occurs at intervals of one hour to 24 hours depending on the method of data collection (i.e., aerial versus ground; Garshelis and Pelton 1981; Hellgren et al. 1991; Marchinton 1995; Nyland 1995; Wagner 1990). Average movement-related interlocation distances from past southeastern black bear studies have ranged from several hundred meters to more than five kilometers, with females often moving shorter distances than males (Reynolds and Beecham 1980; Marchinton 1995; Wagner 1990; Eastridge 2000). Basing our selection on a conservative daily movement distance (0.25 km/24 hour period; Marchinton 1995; Wagner 1990; Eastridge 2000), we adapted a comparative scale of analysis of 0.01 km, or approximately movement of within one hectare per hour. It is important to note that we divided movement distance across a 24-hour period because bear activity varies depending on time of day, and several hours are spent resting (Garshelis and Pelton 1981; Pelton 1982; Larivière 2001). For both scales of analysis (i.e., 30-m/0.09-ha and 1-ha), and all four habitat classes (i.e., unsuitable, marginal, suitable, and highly suitable), we made three habitat calculations: (1) total area of each habitat class throughout the study area, (2) area of habitat within the preserve, and (3) total area of habitat outside of the preserve.

Rudis and Tansey (1995) suggested at least 7,580 ha are necessary for a population of 50 bears (or approximately 150 ha/bear). However, Marchington (1995) suggested denser bear populations within fragmented bottomlands of Louisiana of approximately 50 ha/bear. Similar to bear habitat in Louisiana, BTNP and the surrounding area contain fragmented land cover with heterogeneous land use. We evaluated all highly suitable habitat patches >50 ha across the study area, and identified “patch” as a contiguous area of the same habitat classification (Turner et al. 2001).

2.2.5. Habitat connectivity

Several researchers have addressed the importance of habitat connectivity for species movement and dispersal (Fahrig and Merriam 1985; With et al. 1997; Wiegand et al. 1999), and appropriate measures of connectivity (Schumaker 1996; Tischendorf and Fahrig 2000a,b; Moilanen and Hanski 2001; Turner et al. 2001). Black bears have been known to travel large distances within their home range both across areas of perceivably unsuitable habitat, as well as through woodland corridors (Marchinton 1995; Wagner 1990). Therefore, although we are uncertain as to whether connectivity of highly suitable habitat will be important for bear movement in and around BTNP, we quantified connectivity of highly suitable habitat.

We used Patch Analysis 3.1 (Elkie et al. 1999) to determine connectedness of highly suitable black bear habitat both within BTNP and across the study area. Because of the large size of land cover imagery files and resulting processing difficulties, we divided the study area into equal sized hexagonal polygon regions. After experimenting with polygon regions of various sizes, we selected polygons (440 total) with an area of

1000 ha that allowed for both consideration of large habitat fragments that may be important to bear (Rudis and Tansey 1995; Linnell et al. 2000) and image processing within a reasonable amount of time. We hypothesized a negative relationship between highly suitable habitat per hexagon and habitat connectivity. In other words, as area of highly suitable habitat per hexagon increased, the more likely that habitat patches would be closer together with a smaller mean nearest neighbor distance. Assuming that suitable habitat may also be important for bear refuge and foraging, we completed connectivity analyses for highly suitable and suitable habitat, as well as a combination of both.

Using ArcView GIS 3.2 (Environmental systems Research Institute, Inc.), we selected mean nearest neighbor distance to measure connectivity of bear habitat. Mean nearest neighbor distance is a measure of patch isolation, and calculated by the average nearest neighbor distance for habitat patches within each hexagon (Elkie et al. 1999). After plotting the data, which revealed that it did not meet assumptions of normality, we applied Spearman rank-order correlations to assess relationships between habitat area and nearest neighbor distance (Dytham 2003). Significant results at both the 90% and 95% were reported.

2.2.6. Core area analysis

Results from past studies of black bear ecology and management have suggested that presence of large areas of remote forest (core habitat) is an important feature of black bear habitat (BBCC 1997; Pelton 1982). Rudis (1986) defined “remote” as forest at least 0.8 km from human activity. Core habitat has also been described as a contiguous forest tract >1,000 ha (Rudis and Tansey 1995). Linnell et al. (2000) suggested that bears

tolerate human activity that is at least one kilometer away from dens. Therefore, we identified remote as highly suitable habitat at least one kilometer away from human activity (unsuitable habitat), based on the Euclidian distance from unsuitable habitat.

2.2.7. Estimation of potential black bear population size

In the southeastern United States, estimated black bear population densities have ranged from 0.008 – 3.6 bears/km² (Smith 1985; Wooding et al. 1994b; Hellgren and Vaughan 1989a; Marchinton 1995; Rudis and Tansey 1995; Wagner 1990). The densest estimates were found within the Tensas River Basin, which consists of fragmented forest surrounded by agriculture fields (Marchinton 1995). Because these estimates vary greatly, we developed an estimated population size for a range of densities, from a conservative 0.005 bears/km² to 3.6 bears/km² at intervals of 0.05 bears/km². Assuming a 1:1 sex ratio, estimated population size at each density was a factor of total highly suitable habitat area divided by hypothetical bear density. Because our core area analysis focused on areas >1 km away from human activity, we also re-calculated estimated potential bear population capacity based on area of highly suitable habitat that was >1 km away from human activity.

2.3. Results

2.3.1. Estimation of total potential habitat area inside and outside the preserve

At the scale of image classification (30 m), the mixed forest was the land cover class with the greatest area, occupying approximately 40% of the study area (Table 2.1). Pine (11.68%), clearcut/regeneration (18.42%), and bottomland forest (9.52%) each

covered approximately 10% or more of the study area. Urban, grass/pasture, sand, and water all contained <10% of the area.

Water existed mainly within three large reservoirs (Sam Rayburn Reservoir, Toledo Bend Reservoir, and Lake Livingston). Eliminating water from further analysis, area of the seven remaining land cover classes translated to 391,952 ha unsuitable, 310,393 ha marginal, 485,981 ha suitable, and 1,296,101 ha highly suitable habitat. Of the total land area (water eliminated; 2,484,427 ha), this was equivalent to 15.78%, 12.49%, 19.56%, and 52.17% respectively. Most of the unsuitable habitat was located along the southern and northwestern portions of the study area (Figure 2.2). Marginal and suitable habitat classes were well distributed, with concentrations of both in eastern and central portions of the study area. Highly suitable habitat was scattered, with large concentrations within the south central, western, and central portions of the study area.

A majority of area within BTNP was identified as highly suitable habitat (Table 2.2), and the remaining three habitat classes each consisted of <10% of preserve area. Excluding BTNP, approximately half of the study area was identified as highly suitable, with each of the remaining habitat classes making up <20% of the remaining area. Total area of all habitat classes as well as percent of unsuitable, marginal, and suitable habitat were approximately the same across the whole study area as compared to outside of the preserve (Table 2.2).

2.3.2. Estimation of habitat area based on scale of analysis

Area of each land cover class varied based on scale of analysis (Table 2.3). Area of urban, pine, sand, and bottomland forest classes decreased as scale increased.

Grass/pasture and mixed forest area increased as scale decreased. Clearcut/regeneration and water decreased slightly as scale increased. For habitat classification, area of unsuitable, marginal, and suitable habitat decreased as scale of analysis increased, whereas area of highly suitable habitat increased as scale of analysis increased.

At the scale of 1 ha, 90% of land within BTNP was classified as highly suitable, and increase in percent area from the 30m scale. Area of suitable habitat decreased to six percent of the total. Marginal and unsuitable habitat decreased to less than three and one percent, respectively, of total land within the preserve.

2.3.3. Variation in patch quantity and size across scales

Excluding all patches with <50 m in area, average patch size was larger at the 1 ha scale than at the 30m scale (Table 2.4). Median patch size was similar across both scales, which is likely a result of, although large patches were unchanged, smaller patches were consolidated into larger patches. Within each scale of analysis, marginal and suitable habitat contained the on-average smallest patches, whereas highly suitable habitat contained the on-average largest patches.

Frequency of habitat patches of various areas differed between scales (Figure 2.3). Variation in the number of patches of each size class existed between habitat types, but differences were insignificant based on the overlapping of standard error bars. In general, the total number of patches for a particular interval increased as scale increased for marginal and suitable habitat, and minimally for unsuitable habitat. However, the opposite relationship existed for highly suitable habitat. Highly suitable habitat contained

a greater frequency of larger patches, whereas suitable habitat contained a greater frequency of smaller patches.

2.3.4. Habitat connectivity

Spearman rank correlations for habitat connectivity varied between habitat classes and scales (Table 2.5). At both scales, suitable habitat within BTNP, combined suitable/highly suitable habitat within BTNP, highly suitable habitat across the whole study area, and combined suitable/highly suitable habitat across the study area had significantly negative correlations with mean nearest neighbor distance. However, highly suitable habitat within BTNP at both scales, suitable habitat across the study area at the 30m scale, and combined suitable/highly suitable habitat at the 1 ha scale were positively correlated with mean nearest neighbor. Therefore, greater areas of habitat were more likely to be located closer together.

2.3.5. Distribution of core habitat area

Presence of core habitat varied between scales. There was complete lack of core habitat at the 30 m scale, even within BTNP (Figure 2.4). However, large areas of core habitat existed at the 1 ha scale, totaling approximately 225,626 ha. These core areas existed primarily within the southeastern and northeastern portions of the study area, along the eastern boundary of the study area, and within BTNP.

2.3.6. Estimation of potential black bear population size

Assuming a direct relationship between population size and habitat area, estimates of the potential black bear population size across the study area varied based on scale of analysis. At a density of one bear per square kilometer and considering all available highly suitable habitat, estimated bear population sizes are approximately 12,000 and 15,000 at the 30 m and 1 ha scales, respectively. However, these estimates are likely too high. With an estimated 29,000 hectares of highly suitable habitat (290 km²) within the preserve, we estimated that BTNP offers enough habitat for approximately 290 bears, with a density of 1 bear per square kilometer, but we reiterate that this was a total estimate for all 12 disjunct preserve management units. When potential bear population size was recalculated for the 225,626 ha of core area only, at a density of 1 bear/km², the result was an estimated 2,256 bears for the entire study area, and 290 within the preserve. This is likely a more reasonable population estimate for bear management goals, as it takes into account both area of highly suitable and core habitat.

2.4. Discussion

Most of the land within the preserve (81%), and half (50%) of the land outside of the preserve was classified as highly suitable at the scale of unmanipulated imagery (30 m). Based on the size of BTNP (39,256 ha, or 392.6 km²), the large concentration of highly suitable habitat within the preserve may provide adequate refuge for approximately 290 black bears. However, it is important to reiterate that BTNP's 12 units are disjunct and, therefore, the preserve cannot be thought of as one contiguous unit of habitat. Black bear home ranges and habitat use can vary widely based on sex,

location, season, and distribution of resources (Larivière 2001; Hellgren and Vaughan 1991; Pelton 1982; Garshelis and Pelton 1981). Although estimates of black bear densities vary widely (see BBCC 1997 for a summary), assuming a 1:1 sex ratio and a density of 1 bear/km², we estimated a potential population size of approximately 290 bears in the preserve. However, this was likely an overestimation because the disjunct units of BTNP range from 58 ha (likely too small for even one black bear) to 11,000 ha. In other words, even though a majority of the preserve contains highly suitable habitat, each individual preserve unit alone may not be large enough for viable black bear population. As a result, we expect that bears will travel beyond the preserve boundaries for foraging and mating. This may not be considered ideal for nature reserve design theory (Higgs 1981; Diamond 1975), but the reality of this situation emphasizes the importance of considering landscape context.

Considering the preserve within the context of the surrounding landscape, there is an estimated 1.3 million ha of highly suitable habitat. This is greater than 44 times more habitat than within the preserve alone, but less forested area than estimated by Rudis and Tansey (1995) ten years prior. Estimated potential black bear population size for the whole area then becomes much greater than 290 bears (Rudis and Tansey 1995; Hellgren and Vaughan 1989a) for two main reasons besides the simple fact that we are considering a much larger area. First, black bear home ranges can overlap by 20-50% throughout the year; females, particularly related individuals, may overlap exclusively (Hellgren and Vaughan 1990; Marchinton 1995). Second, we considered the distribution of only highly suitable habitat for population estimation. If bears use suitable or marginal habitat, then estimates of habitat and potential population size should be reevaluated. This may be

necessary, as colonizing individuals of species, including dispersing bears (Rogers 1987), often explore a larger area of habitat than individuals within a larger population (Diamond 1975). Regardless, because no data are available for comparing bear movements with estimated habitat for our study directly, use of our estimates should be made with caution and be re-evaluated as movement data become available.

Many areas of highly suitable habitat run along rivers, and may provide connectivity between preserve units and other large patches of highly suitable habitat. In fact, four of the BTNP units (Figure 2.1) are preserve-managed river corridors that link larger preserve units. Positive relationships between area of highly suitable habitat and nearest neighbor distances for BTNP land were likely an artifact of the preserve's distribution. Results from our connectivity analyses suggested that across the study area, habitat connectivity increased as the amount of highly suitable habitat per unit area increased. Research that has explored the utility of habitat connectedness by wildlife corridors has been met with mixed results (Haddad 1999; Beier 1993; Simberloff and Cox 1987). Results from Beausoleil (1999) and Anderson (1997) suggested that bears within a fragmented landscape in Louisiana showed preference for forest fragments and corridors and avoidance of agricultural fields. In fact, >50% of bears from the same studies used corridors for movement between forested tracts. However, Marchinton (1995) suggested that bears often ventured across open agricultural fields rather than remaining within the cover of forested corridors. Unfortunately, bear telemetry data were not available for our study, but we suggest that wildlife managers maintain habitat along river channels and among private lands between units of BTNP for monitoring bear movement. It is also important to note that because of the coarse analysis of land cover

used, finer landscape features (e.g., roads) were not considered beyond identification through imagery classification and must be further evaluated. Therefore, to address our first and fourth research questions, when considering the preserve within the context of the larger landscape, there is adequate habitat for a black bear population and we conservatively estimated a potential population of >8,000 bears based on an average density of one bear/km². However, initial population estimates should be made with caution because pioneer individuals may initially use habitat differently than members of a larger population in the future.

Across the landscape, changing the scale of analysis from 0.09 ha (30-m pixel) to a 1-ha scale resulted in different estimates of available highly suitable habitat across the study area and within the preserve. In fact, across the study area there was a >12% (1,730 km²) increase in highly suitable habitat when moving from the 0.09-ha to the 1-ha scale of analysis, which affected our estimates of potential black bear population size (Figure 2.5). Therefore, scale of analysis that is adopted by management will affect estimated habitat (Stern 1998). Regardless of scale, managers must determine through monitoring whether locations used by bears are consistent across scales. For example, Chapin et al. (1998) observed that habitat used by adult martin corresponded to grid cells containing a greater percentage of forested cover and larger forest patches across four spatial scales. As in our study, however, the overall geographic distribution of habitat across the study area in Chapin (1998) did not change across scales. An increase in habitat corresponding to an increase in scale does not hold true for all of our habitat classifications. For suitable and marginal habitat, the area of habitat increases as scale decreases from one hectare to 0.09 ha by 12% and 42%, respectively. Area of unsuitable

habitat remained relatively the same across scales, which supports the suggestion that utility of remote sensing imagery for consistent identification is better for some landscape features than others (Allnutt et al. 2002; Cardillo et al. 1999). As is the case for using any remotely sensed data, researchers and managers must consider reliability of classification, and how reliability varies as image data are manipulated to represent various scales. Aggregating pixels to a more coarse scale than raw (30-m) classification reduces spatial heterogeneity and how a potential bear population is estimated.

Maintaining a finer scale accounts for landscape heterogeneity and results in a more conservative bear population estimate. Therefore, estimates of highly suitable habitat area does change based on scale of analysis. For instance, if managers assess habitat at a scale of 1-ha, but habitat analysis by researchers uses a 0.09-ha scale, then total area of highly suitable habitat will be underestimated, whereas suitable and marginal habitat will be overestimated. Regardless, when selecting a scale for analysis, researchers and managers must seriously consider drawbacks of manipulating image data (e.g., pixel aggregation) when selecting a consistent scale for analysis.

Average and median patch size increased as scale of analysis increased for all four habitat classes. This is likely because more coarse scales resulted in the combination of similarly classified pixels into larger groups. Because the resolution of this imagery is 30-m, the lower possible range of patch sizes will, using a smaller scale, result in a larger number of smaller patches than what will be determined at a larger scale. Many single pixels of a particular habitat classification become reorganized into a more prominent habitat type.

As distance from the nearest unsuitable habitat increases, the total area of highly suitable habitat increased drastically, and then decreased. For both scales, the greatest area of habitat existed at a distance of 150 m from the nearest unsuitable habitat. The distribution is relatively the same for the 1-ha scale, both quantitatively and spatially. Existing remote areas correspond with location of BTNP, National Forests, and river corridors. At the 30-m scale, public lands are identified as further from unsuitable habitat than other locations across the study area, but no remote areas exist. Similar to change in patch size across scales, many erroneous single pixels of unsuitable habitat are incorporated into larger patches of other habitat types when the data are clumped to simulate the larger scales. Therefore, the identification and quantification of core areas and whether their existence is consistent across scales, existence of core areas (defined according to results from Linnell et al. 2000) depends on scale of analysis. For the 1-ha scale, core areas exist mainly in relation to distribution of public lands and along river corridors. However, focusing on core areas only could only be completed at the 1-ha scale, and the estimated potential population size of bears decreased greatly to 2,256 bears. This is a more accurate measure of the region's bear carrying capacity as there are likely factors that will affect bear populations that we did not consider in this study (e.g., annual mast crop output).

The implications of these results as related to ecological feasibility of a black bear reintroduction in southeast Texas are several. First, the disjunct distribution of BTNP may be considered spatially well done by general reserve planning recommendations (Diamond 1975). Enough highly suitable habitat existed within BTNP for a small black bear population (potentially as many as 290 bears). However, because of the preserve's

small size, disjunct distribution, and as-discussed habitat needs of black bears, BTNP cannot be thought of as a single large preserve that can self-sustain a black bear population. With 44 times more habitat existing beyond the preserve's boundaries, bear managers must assume that activities beyond the preserve's boundary will be used by bears and critical to a successful bear recovery (Parks and Harcourt 2002). Because the goal of this study was to estimate the area of potential habitat, whether island biogeography theory (Diamond 1975) is sufficient for meeting bear habitat-area needs will not be determined if and when bears are released. If the preserve is considered within the context of the surrounding landscape, adequate area of highly suitable habitat exists for a viable bear population.

Second, highly suitable habitat is well distributed across the study area. River channels, particularly those that are within boundaries of the preserve, may become critical habitat that bears use for foraging, denning, and moving between preserve units. Where highway overpasses exist over rivers, river channels may become important as underpasses under highways for bears moving from location to location. Such was the case in Florida, where bears often used highway underpasses within their home range (Foster 1995). However, rivers themselves may be impediments to bear movement (White et al. 2000). As mentioned, additional fine scale analysis is necessary to determine where roads and other individual elements of human activity may hinder bear movements.

Third, large patches of highly suitable habitat exist, but the area of highly suitable habitat decreases with increasing distance from unsuitable habitat. Linnell et al. (2000) suggested that bears selected dens >1 km away from human activity and tended to not

tolerate activity at less than this distance. Use of the 1-ha scale allowed us to identify areas of highly suitable habitat that meet this criterion. Such remote areas were distributed mainly among public lands and river channels, and it is important to note that presence of remote areas disappeared entirely at the 30-m scale of analysis. Therefore, adoption of a 1-ha scale of analysis and a more conservative estimate of a potential bear population (2,256 bears) may be more appropriate for initial bear recovery goals. When conducting fine scale analysis, managers should make note of unsuitable habitat at the 0.09-ha scale that is eliminated at more coarse scales of analysis, and determine whether these locations offer infrastructure that may threaten the well being of bears that move beyond core habitat areas.

From our coarse scale analysis, and when the preserve is considered within the context of the surrounding landscape, we believe that a black bear reintroduction is ecologically feasible, but additional fine scale analysis may uncover elements within the study area that must be considered in management planning. However, the landscape of southeastern Texas will likely experience major changes that present threatening uncertainty to the quantity and quality of black bear habitat. Much of the private land throughout the study area is owned and managed by timber companies (see Chapter 2). As a result of a land divestment of >600,000 hectares by one timber company, large areas of habitat may be lost to human development. Proposals have been made to build water management structures to supply water to Texas's growing cities. In addition, plans have been suggested to build an eight-lane superhighway that would bisect units of BTNP, and could potentially act as a barrier to wildlife movement between preserve units. Knowledge about the distribution of bear habitat may aid resource managers and

development coordinators to meet the needs of both regional wildlife and human development.

Table 2.1. Area and percent of total area of the eight land cover categories derived from classification of remotely sensed imagery (30-m scale) for estimation of black bear habitat in and around Big Thicket National Preserve, Texas.

Land cover classification	Total area (1,000 ha)	Percent of total area ^a
Urban	188.3	7.1
Grass/pasture	203.7	7.7
Pine	308.2	11.7
Sand	2.2	<0.1
Clearcut/regeneration	486.0	18.4
Mixed forest	1,045.0	39.6
Bottomland forest	251.1	9.5
Water	154.3	5.9

^aTotals >100% are a result of rounding.

Table 2.2. Area of unsuitable, marginal, suitable, and highly suitable bear habitat across the whole study area, within Big Thicket National Preserve (BTNP), and outside of BTNP at the scale of imagery classification (30 m).

Extent	Area of habitat (1,000 ha; percent of total area ^a)			
	Unsuitable	Marginal	Suitable	Highly suitable
Entire study area (collectively)	391.95 (15.8)	310.39 (12.5)	485.98 (19.6)	1,296.10 (52.2)
Preserve only	1.2 (3.4)	2.4 (6.7)	3.0 (8.4)	29.0 (81.6)
Non-preserve	487.8 (19.1)	308.0 (12.1)	484.4 (19.0)	1,267.7 (49.8)
				2,484.4
				35.5
				2,547.9

^aTotals not equal to 100% are a result of rounding.

Table 2.3. Area (and percent change) of land cover classes and corresponding black bear habitat at 30-m (0.09-ha) and 1 ha scales.

Classification		Area (1,000 ha)		
		0.09 ha	1 ha	Percent change
Land cover	Urban	188.3	135.5	-28.0
	Grass/pasture	203.7	311.4	65.4
	Pine	308.8	236.4	-52.9
	Sand	2.2	1.1	-50.0
	Clearcut/regeneration	486.0	471.4	-3.0
	Mixed forest	1,045.0	1,244.2	19.1
	Bottomland forest	251.1	186.3	-25.8
	Water	154.3	151.4	-1.9
Habitat	Unsuitable	488.9	479.3	-2.0
	Marginal	310.4	211.2	-32.0
	Suitable	487.4	430.6	-11.6
	Highly suitable	1,296.7	1,470.0	13.4

Table 2.4. Mean ($\pm$ SD) patch size of black bear habitat at 30-m (0.09 ha) and 1 ha scales.

Scale	Habitat category	N	Mean ($\pm$ SD; ha)	Median patch (ha)
0.09 ha	Unsuitable	666	438.2 (3356.8)	97.8
	Marginal	291	100.9 (102.2)	73.4
	Suitable	1,265	121.9 (158.2)	81.3
	Highly suitable	1,460	1,593.3 (16,903.7)	116.2
	Total	3,682	554.3 (8,547.0)	89.5
1 ha	Unsuitable	744	506.5 (4,004.1)	97.3
	Marginal	448	116.4 (137.7)	78.9
	Suitable	1,627	142.0 (199.9)	87.8
	Highly suitable	470	2,984.2 (49,281.2)	114.1
	Total	3,289	627.1 (18,735.4)	90.6

Table 2.5. Spearman rank correlation values (r_s)^a for nearest neighbor analysis of suitable and highly suitable black bear habitat connectivity at 30m and 1 ha scales within Big Thicket National Preserve (BTNP) and across the whole study area.

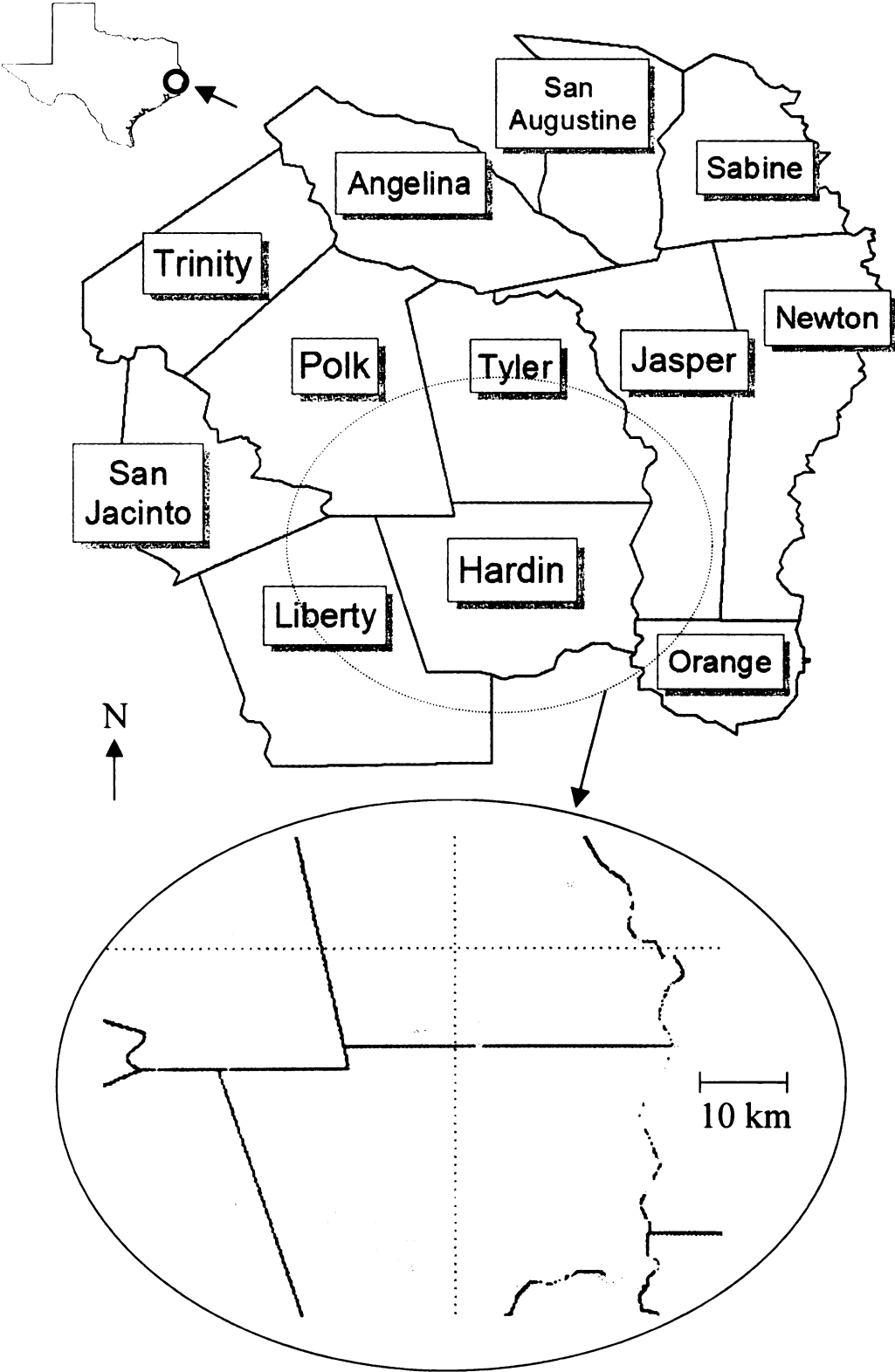
Habitat class	r_s	
	30 m	1 ha
BTNP – suitable	-0.554*	-0.374**
BTNP – highly suitable	0.325	0.238
BTNP – suitable and highly suitable	-0.380*	-0.353*
Whole area – suitable	1.000*	-0.567*
Whole area – highly suitable	-0.272*	-0.460*
Whole area – suitable and highly suitable	-0.426*	0.389*

^a*Significant at the 0.05 level (2-tailed)

**Significant at the 0.01 level (2-tailed)

Figure 2.1. The 12-county region in southeastern Texas used to evaluate land cover and potential habitat for a black bear reintroduction. These counties include and surround Big Thicket National Preserve (shaded areas in oval).

Figure 2.1.



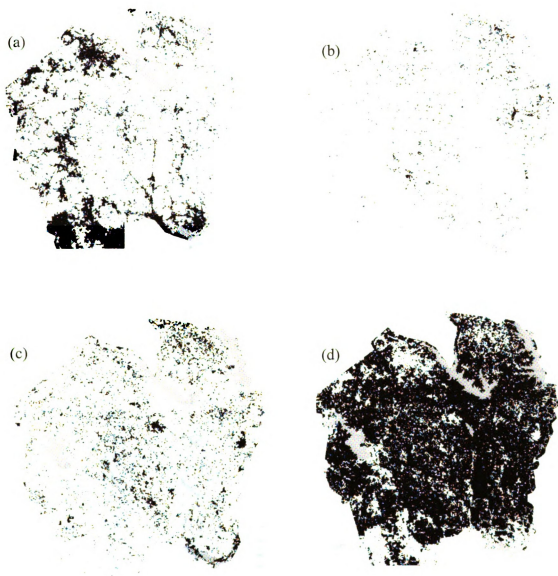
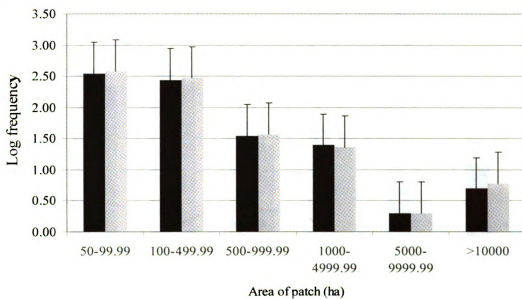


Figure 2.2. Distribution (shown in black) of (a) unsuitable, (b) marginal, (c) suitable, and (d) highly suitable black bear habitat throughout the study area in southeastern Texas. Large water bodies are shaded in light gray.

(a)



(b)

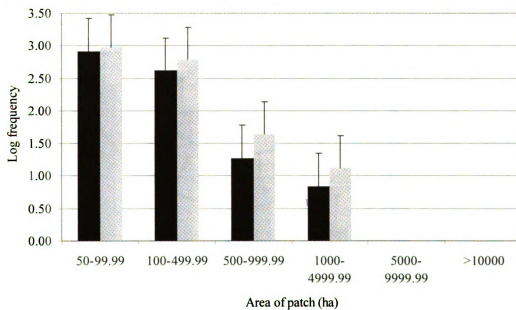
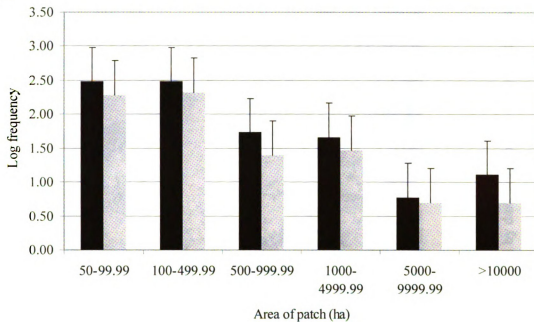


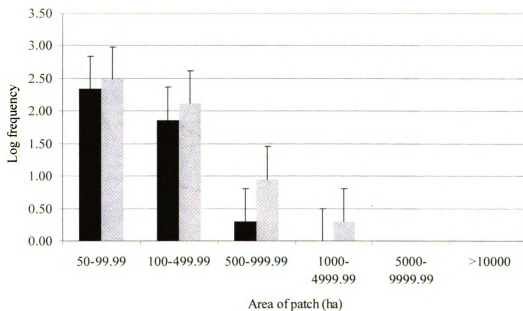
Figure 2.3. Distribution (log frequency) of (a) unsuitable, (b) marginal, (c) suitable, and (d) highly suitable patches of black bear habitat by area (ha). Confidence intervals were defined at the 95% level.

Figure 2.3. (Cont'd.)

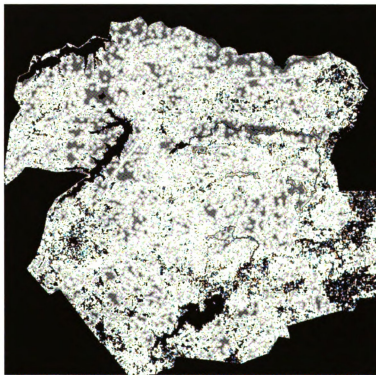
(c)



(d)



(a)



(b)

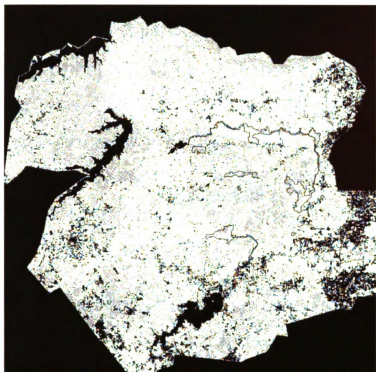


Figure 2.4. Distribution of core habitat area at (a) 1 ha and (b) 30 m scales, designated by dark gray shaded areas. Note that no core habitat exists at the 30 m scale, even within BTNP (outline).

CHAPTER 3

IMPORTANCE OF PRIVATE LAND CONSERVATION FOR A BLACK BEAR RECOVERY

In collaboration with

Jianguo Liu

Abstract

Although most land within the US is privately owned, wildlife conservation efforts have largely focused on public land. In the south-central US, privately owned timberlands have helped maintain extensive areas forest that are important as wildlife habitat. The objective of this study was to assess the importance of regional private timberlands on a Louisiana black bear reintroduction in and around Big Thicket National Preserve (BTNP), Texas. Since establishment of BTNP in 1974, the overall area of highly suitable habitat has decreased, as well as the total area of timberlands. The percentage of highly suitable habitat among timberlands has increased, and, in 2002, >30% of highly suitable habitat across the study area was contained among timberlands. Furthermore, timberlands contained approximately half of all land within the study area that has been consistently highly suitable since establishment of BTNP. Although the area of highly suitable habitat has also increased among regional public lands, an expanding bear population will require more highly suitable habitat than exists only among public lands. Therefore, we emphasize the importance of maintaining highly suitable habitat among timberlands, particularly in proximity to public lands. Although future changes in land use will likely affect changes in land cover and timberland ownership, it is critical that areas needed for meeting bear habitat management and conservation goals be quickly identified and prioritized.

3.1. Introduction

Sacredness of protected areas is a result of the perception of them as exceptional models for both biodiversity conservation and wilderness protection (Pimm and Lawton 1998; Soulé and Sanjayan 1998). However, increasing human activity on private lands near protected areas is resulting in a decrease in the area and quality of wildlife habitat for many species that travel beyond protected area boundaries. In fact, human activity on private land in proximity to protected areas is considered one of the greatest threats to wildlife populations, and particularly to large mammalian species (Woodroffe and Ginsberg 1998; Liu et al. 2001). As a result, species management on private lands is becoming increasingly important for wildlife conservation to ensure the availability of additional habitat when public lands alone do not adequately accommodate species.

Although private lands dominate the United States, conservation efforts have focused primarily on public lands (Norton 2000). Approximately half of all listed species occur exclusively on private lands, as do portions of ranges of almost all federally listed species. Consequently, species conservation on private lands is as important as or even more important than public land conservation (Knight 1999). However, private land use can sometimes act as a barrier to species conservation agendas. For example, McDonald et al. (2001) surveyed landowners in proximity to a national wildlife refuge to determine whether offering incentives would successfully allow refuge managers to acquire land parcels adjacent to the existing refuge. Without incentives, <50% of proposed acquisition parcels would be purchasable within the next 20 years and, ultimately, US Fish and Wildlife Service goals for land acquisition would not be achieved (McDonald et al. 2001).

In the south-central US, timber management on private lands has helped retain extensive forested areas that are also important as wildlife habitat (Rudis and Tansey 1995). Throughout North America, research results have suggested that particular timber management regimes can be either beneficial or detrimental to particular species and overall species richness (Fisher and Wilkinson 2005; Hagar et al. 2004; Anderson and Crompton 2002). At present, as efforts are underway to recover many locally extirpated species (Reading and Clark 1996), a challenge to wildlife researchers is determining how land use, such as timber management, may affect species targeted for recovery.

In southeast Texas, management for recovery of the Louisiana black bear (*Ursus americanus luteolus*) is heavily dependent upon habitat conservation among private lands where timber management is the predominant land use. The Louisiana black bear's range has been greatly reduced since the early 1900s. During the 1990s, bear interest groups and wildlife managers initiated a campaign to recover bear populations in Louisiana. Two management plans were created, one for Louisiana (Bowker and Jacobsen 1995), and another for the bear's collective historical range of Louisiana, southern Mississippi, and southeastern Texas (BBCC 1997). To date, recovery efforts in Louisiana have been successful (Van Why 2003), and support for recovery exists in Mississippi (Shropshire 1996; Bowman 1999). Although no breeding bear population exists in southeastern Texas, the number of bear sightings within the region has increased during the past decade. This is likely a result of transient bears from Arkansas, Oklahoma, and Louisiana that wander into Texas. In Texas, black bears are listed as "threatened" (Bowker and Jacobsen 1995) and recent sightings have prompted the creation of a Texas black bear management plan (TPWD 2005). The goal of the plan is to restore habitat for the purpose of reestablishing

black bear as a viable ecosystem component in southeastern Texas (TPWD 2005).

More than 75% of land in southeastern Texas is privately owned by timber management companies or publicly administered by the USDA Forest Service or National Park Service. Public lands such as Big Thicket National Preserve (BTNP), which was established in 1974 as the nation's first National Preserve to protect the unique ecosystems found within the area, are potential target areas for bear population recovery (Garner 1996; BBCC 1997; Epps 1997). However, total area and distribution of public lands alone are not large enough for maintaining a viable black bear population. If bears are released into BTNP, the preserve's disjunct distribution may result in increased movement of bears between preserve units (see Section 3.2.1). As a result, private lands will play an important role in the success of a bear recovery. Unfortunately, in 2002 a large number of timberlands within southeastern Texas were divested because of an economic decision by the Louisiana-Pacific Corporation (LP), which could cause acceleration of forested land conversion to other uses (e.g., residential development). The purpose of this study was to determine relationships between timberlands and potential bear habitat, and how divestment of timberland may affect area and distribution of potential bear habitat if timberlands are converted from forest to other land uses (e.g., residential development). Therefore, our objectives were to: (1) quantify how area and distribution of potential bear habitat and timberlands have changed since establishment of BTNP, (2) quantify the relationship between highly suitable habitat and distribution of timberlands, and how this relationship has changed over time, (3) quantify the relationship between timberlands and areas of consistent, improved, or degraded habitat quality over time, (4) compare changes in habitat quantity and quality over time among

private lands with such changes among public lands, and (5) assess implications regarding changes in timberlands and how they may affect attainment of bear management goals by the Texas Parks and Wildlife Department.

3.2. Methodology

3.2.1. Study area

Our study area included 12 counties in southeast Texas (Figure 3.1a). These counties include and surround the >37,000 ha BTNP (Lat./Long. –94.36/30.38; Figure 3.1b), portions of the Sam Houston, Davy Crockett, Angelina, and Sabine National Forests, and extensive timberlands (see Results). The southern portion of Liberty County was excluded from analysis because of absence of timberlands and almost complete unsuitable habitat as a result of extensive row-crop agricultural and residential land use along the Gulf Coastal Plain. The landscape is mostly rural, but scattered with numerous small towns and one larger city (Lufkin). Approximately 500,000 residents live within the study area (US Census Bureau data), but mostly along the southern edge within suburban fringes of Houston and Beaumont.

3.2.2. Imagery classification

Recent land cover.--Using Imagine 8.7 (Leica Geosystems GIS & Mapping, LLC, St. Gallen, Switzerland), we derived present land cover classification from 2002 Landsat™ ETM+ (30m resolution), multispectral imagery. The study area included portions of four 2002 Landsat™ scenes. We initially sought images from November because of the typical lack of cloud cover in southeast Texas during late autumn.

However, because no cloud-free late-autumn images for all four scenes were available, we supplemented November images with March data. To minimize impact of using image data from different months, training sites were selected such that land cover was easily and consistently identifiable across seasons. During June 2002 and 2003, we used a Garmin™ hand-held global positioning system (GPS) to ground-truth 255 training sites for application of land cover data to imagery classification. Training sites were grouped into seven general land cover categories: (1) urban-residential, (2) water, (3) sand, (4) agriculture-grazing, (5) pine forest (both plantation and natural), (6) mixed (pine-hardwood) forest, and (7) bottomland forest (hardwood forest within bottomland areas; adapted from Harcombe and Callaway, 1997).

We recoded land cover data into four black bear habitat classes: highly suitable, suitable, marginal, and unsuitable. Assignment of land cover to a specific habitat class was based on black bear ecology for the south-central U.S. (Pelton 1982; Weaver et al. 1990; Marchinton 1995; Larkin et al. 2004). For example, hardwood, mixed hardwood-pine, and bottomland hardwood forests within the southeastern US contain a variety of mast-producing species (e.g., acorns) that are often consumed by black bears (Bowker and Jacobson 1995; BBCC 1997) and were designated as highly suitable habitat.

Clearcuts and downed slash were designated as suitable habitat because early successional vegetation often contains berry-producing species for foraging, and thick vegetation for cover (Pelton 1982; Weaver et al. 1990). Marginal habitat was identified as pine plantations and open sandy areas that may be traversed by bears moving between more suitable habitat, but likely not inhabited for long periods of time. Urban and agricultural areas were identified as unsuitable because of high probability of contact

with humans. Please refer to Chapter 2 for complete detailed description of habitat classes and associated vegetative species.

Past land cover.--To determine how potential bear habitat has changed over time, we classified imagery at approximately 10-year intervals since establishment of BTNP. Although we attempted to be consistent between time periods, limited availability of cloud-free imagery led us to use the following imagery data: (1) 1970s: December 1974 and March 1975, (2) 1980s: October and November 1986, and (3) 1990s: October and May 1997, and (4) November and March 2002, the first year of this study. Because classification of past imagery from the 1970s-1990s based on present ground-truthing data (2002 and 2003) was impossible, we based supervised classification of 1970s, 1980s, and 1990s imagery on comparisons to areas of unchanged land cover from 2002 image data (Liu et al. 2001).

Analysis of land cover change.--We used Imagine's MODELER function to assess how bear habitat has changed over time. MODELER incorporates Spatial Modeler Language (SML) into GIS and image processing operations. We identified all combinations of habitat changes that could take place between the four time steps used. With four habitat classes and four time periods, this resulted in 256 possible combinations of habitat change. We grouped the 256 combinations of habitat change into three categories: (1) consistent habitat, or pixels of consistent habitat class for all four imagery time periods, (2) habitat improvement, or pixels consisting of classes that suggested an increasing trend in the quality of habitat between the 1970s and 2002, and (3) habitat degradation, or pixels consisting of classes that suggested a decreasing trend in the quality of habitat between the 1970s and 2002. For example, one possible

combination was that a pixel might have been classified as marginal (habitat) during the 1970s, suitable during the 1980s, highly suitable during the 1990s, and highly suitable in 2002. The overall temporal trend for this example suggested improvement in habitat quality over time.

Analysis of habitat among timberlands and public lands.--Using Imagine, we georeferenced and digitized available timberland ownership maps from approximately 1970 (Acme Map Company, Tyler, Texas), 1990 (Temple-Inland, Inc.), and 2002 to derive the distribution of timberlands across the study area. These maps did not match time periods of imagery perfectly, but provided us an estimate of how much habitat is related to distribution of timberlands. Similarly, we used public lands data available for ArcView GIS 3.2 (Environmental Systems Research Institute, Inc., Redlands, California, USA) to identify locations of public lands within the study area. We used MODELER to select areas of specific land cover (i.e., bear habitat) that corresponded to presence of timberlands and public lands for each respective time period.

3.3. Results

3.3.1. Changes in area and distribution of bear habitat and timberlands over time

Total area of highly suitable habitat across the study area has decreased overall by approximately 150,000 ha since 1974 (Figure 3.2). However, the area of highly suitable habitat has increased over the past decade. Suitable habitat area has remained relatively the same, whereas marginal habitat has increased after a steep decline from the 1970s to 1980s. Area of unsuitable habitat increased through the 1990s, but decreased

dramatically between the 1990s and 2002, corresponding with increases in highly suitable habitat.

During the 1970s, timber management companies owned 696,754 ha (27%) of lands within the study area (Figure 3.3), which were distributed mostly across the northwestern portion of the area (Figure 3.4a). By the 1990s, the distribution of timberlands was more extensive (Figure 3.4b), and included 1,203,820 ha (47%) of the area. A 10% decrease in timberland to 944,739 ha between the 1990s and 2002, which mostly affected central and eastern portions of the area (Figure 3.4c), resulted from Louisiana Pacific's land divestment. The divestment affected approximately 25% of timberland within each habitat class (Figure 3.5), and was distributed between units of BTNP and along the Texas-Louisiana border (Figure 3.4d).

3.3.2. Relationship between timberlands and highly suitable habitat over time

In 2002 (post LP divestment) approximately one third of highly suitable (36%), suitable (31%), and unsuitable (36%) habitat, as well as 27% of marginal habitat, found throughout the study area was contained within timberlands (Figure 3.3). This is an general overall increase of these three habitat classes since the 1970s when 23%, 18%, 26%, and 26% of timberlands were highly suitable, suitable, marginal, and unsuitable habitat, respectively, but a decrease from the 1990s of 41%, 52%, 47%, and 39% for the same classes. Therefore, during the 1970s when timberlands consisted of 27% of the area, a relatively proportional amount of each habitat class was found among them, as was also the case during the 1990s and 2002.

3.3.3. Relationship between timberlands and changes in habitat quality

Timberlands contained almost half of all land within the study area that was consistently highly suitable habitat, and >30% of consistently highly suitable habitat since establishment of BTNP (Table 3.1). In addition, timberlands also contained approximately 30% of land that has either improved or degraded in habitat quality since the 1970s (Table 3.2). Therefore, presence of timberlands has played an important role in the maintenance of highly suitable habitat over time. The 2002 timberland divestment involved >10% of all consistently highly suitable and marginal land across the study area, but <10% of suitable and unsuitable area. Because a greater proportion of LP lands improved, rather than degraded, in habitat quality over time, there is uncertainty as to whether the 10% of highly suitable habitat directly affected by LP's divestment will remain highly suitable in the future. More land that has improved in habitat quality over time (9%) is potentially lost as a result of divestment than land that has degraded in habitat quality (3%) over time.

3.3.4. Changes in habitat area and quality among public lands

Total area of public lands within the study area was 175,070 ha, of which 37,000 ha is BTNP. Thus, post-LP investment, public lands constitute approximately 18% of the total study area. Since establishment of BTNP, the area of highly suitable habitat among public lands (i.e., BTNP and National Forests) has increased (Figure 3.6). In 2002, area of suitable habitat was approximately equivalent to that in the 1970s. Area of marginal land has decreased during the past decade, whereas area of unsuitable land has remained

relatively consistent. In 2002, the area of highly suitable habitat was more than three times the area of any of the other three habitat classes.

3.4. Discussion and conclusions

As humans develop areas surrounding public lands, private lands are playing an ever-increasing role in wildlife conservation. Within the eastern US (as compared to the western US), small reserves have presented a constant challenge to wildlife conservation (Kulhavy and Conner 1986). Rudis and Tansey (1995) concluded that, throughout the southeastern US, reserves alone were too small to conserve large carnivore species.

One objective of the Louisiana black bear restoration plan is to establish five subpopulations of bears within one metapopulation, and maintain corridors for immigration and emigration between subpopulations (BBCC 1997). BTNP and the Middle Neches River area (which includes portions of BTNP) were identified as potential bear release sites for subpopulation establishment in southeast Texas (Garner 1996; Epps 1997). Because home ranges and movement distances of black bears can range from <10-100+ km² (Pelton 1982; Weaver et al. 1990; BBCC 1997; Larivière 2001), BTNP's potential as bear refuge will likely force bears traverse private lands as they move among the preserve's relatively small disjunct units. Even when considering National Forests along with BTNP, public land as a percentage of total area is relatively small (<20%).

Bears are adaptable to timber management as long as forests fragmented by harvest remain accessible and provide bears with vegetative species for foraging and slash piles for denning (Hillman and Yow 1986; Weaver et al. 1990). For bear recovery goals in southeast Texas, temporal change in distribution of highly suitable habitat among

timberlands is likely as critical as potential permanent widespread loss of forestland. Since establishment of BTNP, area of highly suitable habitat across the region has remained fairly constant, with a net loss of <10%. Regardless of the high concentration of highly suitable habitat among them, because public lands make up a relatively small portion of the study area there are likely few locations that will indefinitely be immune to changes in land use. In fact, BTNP is relatively small compared to the National Forests, and the effect of land use change (e.g., conversion of timberlands to residential development) on BTNP will likely be more pronounced than on National Forests. Bear managers may also want to explore the possibility of National Forests as potential locations for bear population recovery.

Timberland distribution changed dramatically between the early 1970s and mid-1990s. Almost half of consistently highly suitable habitat was located among timberlands, as well as a relatively equal proportion of land that has experienced improvement or degradation in habitat quality. Therefore, the mere presence of timberlands has likely been an important factor in general maintenance of high quality bear habitat across the study area. Even after divestment by LP in 2002, >400,000 ha of highly suitable bear habitat existed among remaining timberlands. This includes almost 90% of habitat that has remained highly suitable since establishment of BTNP. The potential loss of >150,000 ha of forest is disappointing from an environmental standpoint, but the distribution of divested lands is likely of greater significance to bear recovery and management goals. The LP divestment affected large areas of forested lands in proximity to BTNP, particularly between the northernmost preserve units (Figure 3.4c). Potential loss of timberland in this area may decrease the ability of bears to move between preserve

units, and also between BTNP and National Forest land to the north. Therefore, we suggest that bear managers seek to conserve bear habitat between units of BTNP, as well as between BTNP and National Forest lands.

Private land in the northern portion of the study area will potentially be important for bear dispersal and movement between public lands. However, maintaining forested areas along the region's eastern edge (Louisiana border; Figure 3.4c,d) will be even more critical for bear movement between Louisiana and Texas, which is one of the black bear recovery plan metapopulation objectives (BBCC 1997). Southern portions of divested land may be prone to residential development, as this area is within a moderate commuting distance from towns within Orange County. Timberlands along the eastern edge of the region are dispersed among bottomland hardwood and cypress forests along the Sabine River's floodplain (the Sabine River forms the border between Texas and Louisiana). If bears are released into BTNP, they must travel unimpeded through this area to emigrate to Louisiana populations, and vice versa. As a result, we also suggest bear habitat conservation efforts focus on divested lands along border of Texas and Louisiana.

Timber managers in southeastern Texas have made efforts to practice harvesting methods that promote maintenance of natural hardwood and herbaceous species for wildlife habitat. Although this is extremely commendable from a conservation perspective, it may not be enough to maintain bear habitat in southeast Texas over time. Like many locations worldwide, the human population and number of households within southeastern Texas are growing rapidly (US Census Bureau data), and uncertainty exists over future land use decisions. In 2004, the National Parks Conservation Association

(NPCA) identified BTNP among “America’s Ten Most Endangered National Parks” (NPCA 2004). Besides loss of nearby timberlands, other challenges facing regional conservation efforts include proposed residential development of luxury homes, increased petroleum extraction, and water use projects (e.g., dam construction and improvements). In addition, planning for a Trans Texas Corridor Project includes expansion of a US highway, which passes through the preserve, into a 366-meter wide eight-lane interstate superhighway that would eventually connect Chicago to Brownsville (NPCA 2004). Completion of this project would likely result in escalating pollution and development and additional (and potentially almost impassible) fragmentation to forested areas. Threats such as these to biodiversity conservation are a regular occurrence in proximity to both public and private lands, and that conservation within public lands are not always enough for meeting management goals. We advocate awareness of the difference that conservation management on private lands can make, and suggest incorporation of private land initiatives into conservation planning.

Table 3.1. Area of land (ha; percent total area) that has remained consistently within a single habitat class since establishment of BTNP, and area of land (ha; percent of total area) that was affected by divestment of land by Louisiana-Pacific (LP).

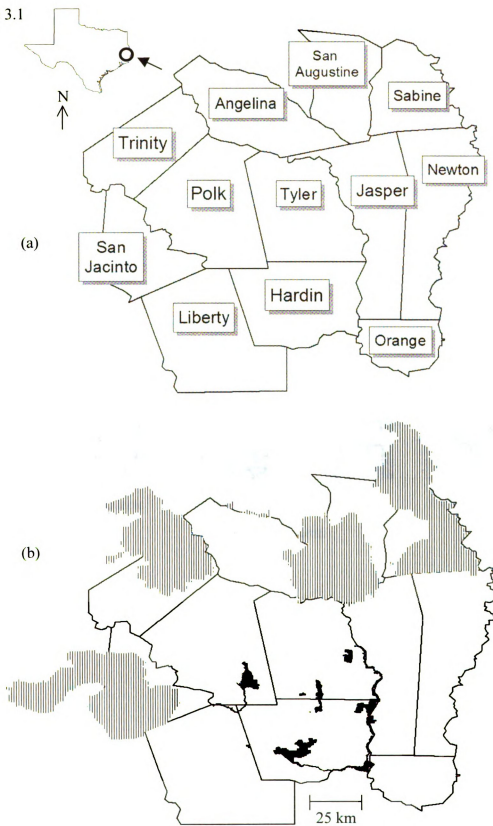
Habitat class	Whole area	Timberland 2002	LP divestment
Highly suitable	257,965	122,353 (47%)	29,120 (11%)
Suitable	9,168	2,894 (32%)	560 (6%)
Marginal	11,122	6,115 (55%)	1,528 (14%)
Unsuitable	55,241	3,089 (56%)	624 (1%)

Table 3.2. Area of land (ha; percent total area) that has improved or degraded in habitat quality since establishment of BTNP, and area of land (ha; percent of total area) that was affected by divestment of land by Louisiana-Pacific (LP).

Land area	Improvement	Degradation
Whole area	168,885	360,485
Timberlands	50,674 (30%)	102,716 (28%)
LP divested lands	15,535 (9%)	11,407 (3%)

Figure 3.1. (a) The 12-county study area in southeastern Texas. The southern portion of Liberty County was excluded from analysis because of absence of timberlands and almost complete unsuitable habitat as a result of extensive agricultural and residential land use. (b) USDA proclamation boundaries for the Sam Houston, Davy Crockett, Angelina, and Sabine National Forests (striped; clockwise from bottom left) and Big Thicket National Preserve (dark shaded).

Figure 3.1



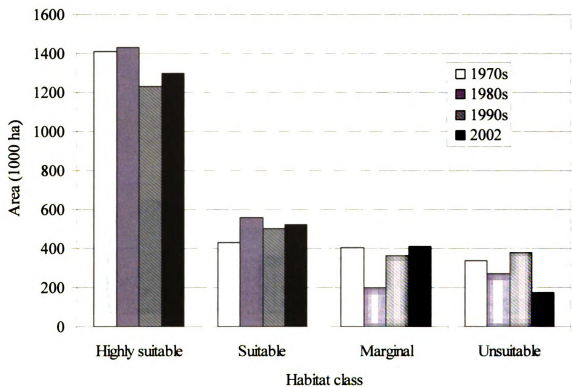


Figure 3.2. Area (1,000 ha) of highly suitable, suitable, marginal, and unsuitable bear habitat at 10-year intervals since establishment of BTNP.

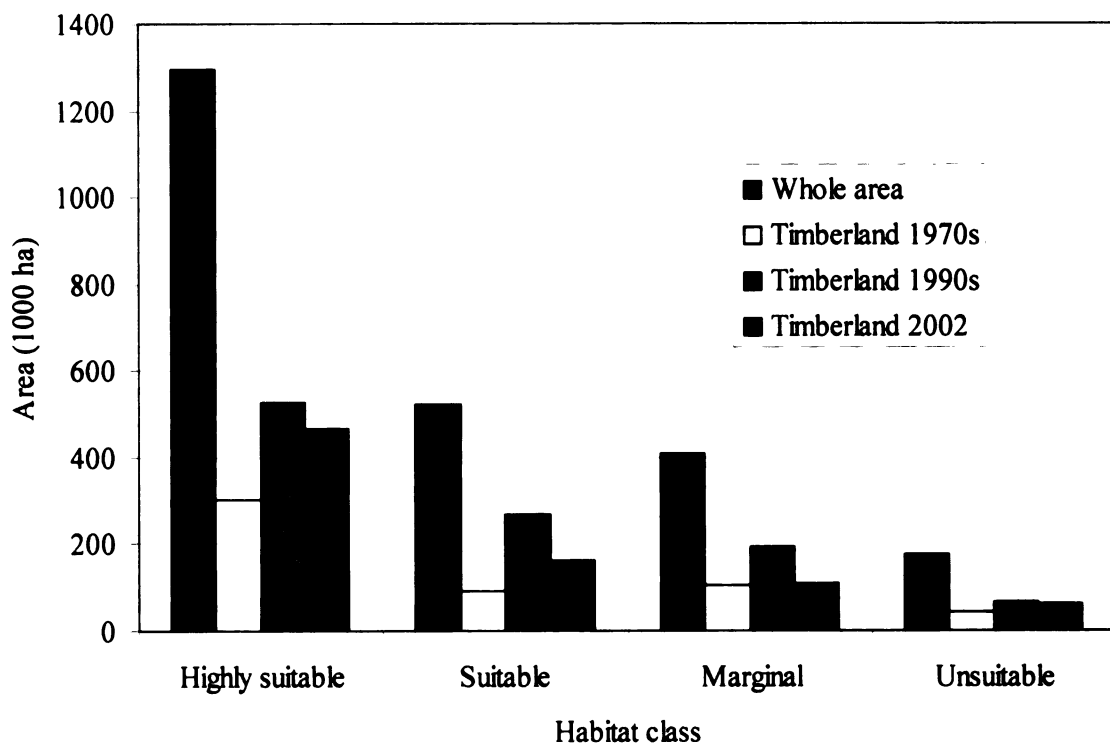


Figure 3.3. Area (1,000 ha) of land within each habitat class across the study area compared to land contained within timberlands since establishment of BTNP.

Figure 3.4. Changes in distribution of timberlands (red) across the study area, since establishment of BTNP, based on available timberland ownership data. Also illustrated are public lands including Big Thicket National Preserve (blue) and USDA National Forest proclamation boundaries (green). (a) During the late 1960s, before establishment of BTNP, timberlands were concentrated within the northwestern portion of the study area. (b) During the 1990s, timberlands became more evenly distributed across the study area. (c) Orange areas illustrate land divested by Louisiana-Pacific in 2002, which are largely concentrated in the central and eastern portions of the study area. (d) Remaining timberland in 2002 after divestment of lands owned by Louisiana-Pacific. County boundaries are designated by black lines.

Figure 3.4

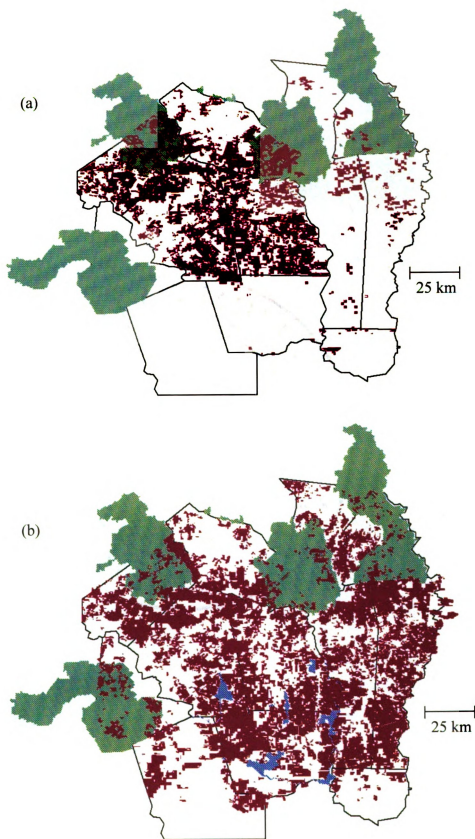
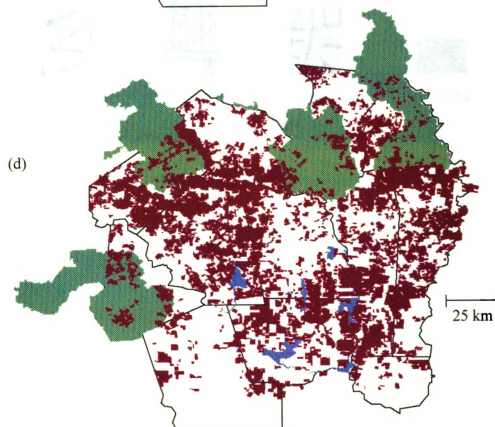
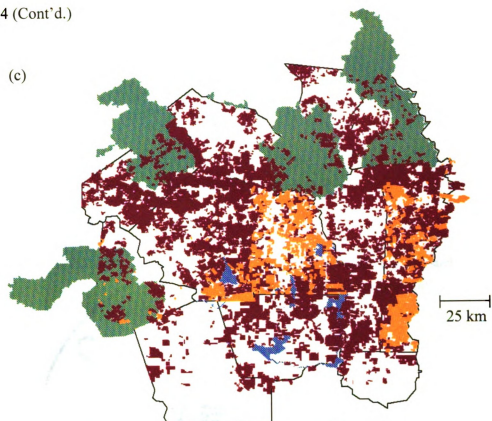


Figure 3.4 (Cont'd.)



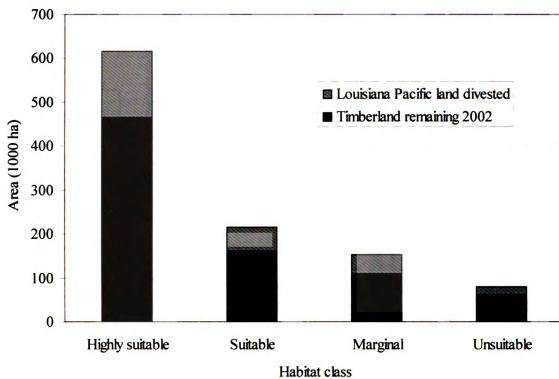


Figure 3.5. Area (1,000 ha) of land divested by Louisiana Pacific, Inc., in 2002. Among timberlands, divestment affects approximately 20-25% of land within each habitat class.

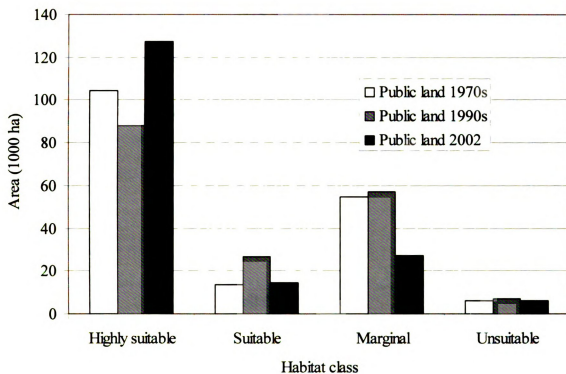


Figure 3.6. Area (1,000 ha) of public land within each habitat class across the study area since establishment of BTNP.

CHAPTER 4

ATTITUDES AFFECTING SUPPORT FOR A PROPOSED BLACK BEAR REINTRODUCTION IN EAST TEXAS

In collaboration with

Angela G. Mertig, Jianguo Liu, and Nathan Garner

Abstract

Socioeconomic knowledge about local residents is critical for survival of reintroduced species in human-occupied locations. Our study provided a unique opportunity to assess public attitudes prior to an anticipated black bear reintroduction. We surveyed 3,000 residents of East Texas (40% response rate) to evaluate attitudes toward 1) black bears, 2) wildlife managers, and 3) a potential increase in the black bear population. Positive attitudes toward all three were related to more frequent participation in passive-appreciative activities related to wildlife (e.g., observing or reading about wildlife) and greater knowledge about bears. Men, younger residents, and individuals who own fewer acres of land had more favorable attitudes toward both black bears and increasing the bear population. Respondents who have lived in the area for a shorter amount of time also had more positive attitudes about bears. Urban residents and individuals who own fewer acres were more confident in the ability of wildlife managers to manage bears. Lack of knowledge about bears was the most commonly stated reason why respondents were unsure about increasing the bear population. Distributing information about bear ecology and behavior may foster additional support for a reintroduction. Just as important, managers must understand particular reasons for resident support or opposition, and whether specific incentive may result in tolerance of bear presence regardless of attitudes.

4.1. Introduction

While the amount of wildlife habitat decreases, increasing recognition of carnivores as valuable members of the ecological community has resulted in efforts to recover populations of locally extirpated species (Reading and Clark 1996, Sillero-Zubiri and Laurenson 2001). Recovery is often difficult for large species, such as black bear (*Ursus americanus*), that require large areas of habitat that may no longer exist as a result of human activity, or are under private ownership (Pelton 1986, Meffe and Carroll 1997, Woodroffe 2001a). For species reintroduction programs in human-occupied locations, socioeconomic knowledge about humans who reside in or make use of an area is vital for ensuring long-term survival of a resident species. Although wildlife management has traditionally focused on ecological dynamics of extant wildlife populations, substantially more attention has recently been placed on the needs and wants of humans who may be affected by management decisions (Kleiman 1989, Riley et al. 2002).

Reintroduction-related management has evolved as a result of past policy failures (Kellert 1991, Reading and Kellert 1993). Large species with negatively perceived consequences (e.g., danger to humans) have provoked negative feelings in humans for several reasons, such as fear, unfamiliarity, negative personal experiences (e.g., nuisance activity such as pilfering through garbage), or negative hearsay (Kellert et al. 1996). Consequently, maintaining a socially suitable environment (i.e., human acceptance of a species) is often more challenging than maintaining a biologically suitable environment for a species.

In North America, negative attitudes and opinions are often associated with carnivores, such as black bear and wolves (*Canis lupus*). The process of reintroducing

wolves to Yellowstone is probably the most publicly visible and well-known recent reintroduction program. Knowledge about wolves, land use association (e.g., rancher, wildlife activist), age, and location of residence (i.e., rural or urban) were factors that influenced attitudes toward wolf reintroduction, although this information was not directly used to determine reintroduction feasibility (Bath and Buchanan 1989). Beyond Yellowstone, local ranchers were greatly influential in reintroduction planning for Mexican gray wolves (*Canis lupus baileyi*) in Arizona (Schoenecker and Shaw 1997). In Michigan, although more knowledgeable about wolves than Lower Peninsula residents, Upper Peninsula ranchers and farmers were more likely to oppose wolf restoration (Kellert 1991). More-educated respondents, women, self-expressed animal lovers, urban residents, and residents with most knowledge about wolves were more likely to support a wolf reintroduction in New Brunswick (Lohr et al. 1996). These results implied that particular demographic and economic variables influence attitudes toward, and opinions about, wolf restoration. Such findings may be applied to reintroductions of other species.

Like wolves, black bears have often garnered a wide array of public reactions. In Arkansas, no public input was sought regarding a black bear reintroduction during the 1960s because the Arkansas Game and Fish Commission perceived that the general public would not support the program (Smith and Clark 1994). Although black bear population recovery in Arkansas was biologically successful, release of bears without public input would be unacceptable by today's wildlife management standards, of which public accountability is an important component (Smith and Clark 1994). Several studies have been conducted to address management for potential black bear population increases (Decker et al. 1981, Decker et al. 1983, Decker and O'Pezio 1989, Bowman et

al. 2001, Peyton et al. 2001; Van Why and Chamberlain 2003; Bowman et al. 2004) and biological feasibility of population recovery (van Manen 1991, Garner 1996, Epps 1997). Fewer studies have addressed social feasibility of black bear reintroductions.

Black bear reintroduction efforts, where evaluated, have been met with mixed support, but overall attitudes toward black bears have been generally positive. Kellert (1994) reported that North American positively perceived bears as intelligent and aesthetically appealing. In a survey of visitors to Great Smoky Mountain National Park, most respondents indicated that bears were an important component of the park even if a negative encounter was experienced (e.g., property damage, Pelton et al. 1976). In both Massachusetts (Jonker et al. 1998) and Mississippi (Bowman et al. 2001), some bear damage to agricultural products was considered tolerable. In fact, Massachusetts residents believed that presence of bears held aesthetic, ecological, and economic value (Jonker et al. 1998). In New York, approximately one-third to one-half of survey respondents wanted to see a black bear on their property (Decker et al. 1981). Any successful reintroduction will depend upon social acceptance among local residents (Clark et al. 2002).

4.1.1. Return of the Louisiana black bear

The Louisiana black bear (*Ursus americanus luteolus*) is one of the sixteen subspecies of American black bear (Pelton 1982). Its historical range included Louisiana, East Texas, and southern Mississippi. Overharvest and habitat destruction led to the near demise of the subspecies by the mid-1950s (BBCC 1997). Bear populations in southeast Texas were extirpated by the early 1900s. At the end of the 1980s, only two small

populations of the Louisiana subspecies remained, both in eastern Louisiana. During the 1990s, extensive public outreach led to recovery efforts in Louisiana and creation of recovery plans throughout the subspecies' historical range (Bowker and Jacobson 1995, BBCC 1997). Recovery in Louisiana has been deemed successful thus far (Van Why 2003, Benson 2005) and feasibility analyses have been completed in Mississippi (Shropshire 1996, Bowman 1999). Our study, coupled with recent attitude surveys in Louisiana and Mississippi, enables comparison of attitudes toward the Louisiana black bear's recovery across its entire historical range.

In East Texas, the number of black bear sightings has increased during the past decade. Because there is no known breeding population present, it is likely that these sightings are transients from Arkansas, Oklahoma, and Louisiana. This increase in sightings has prompted the creation of a black bear conservation and management plan for Texas. Objectives of the plan for the next 10 years are public coordination, communication, outreach/information dissemination, habitat management, and research (TPWD 2005). The ultimate goal, through partnerships with other resource management organizations and members of the general public, is to restore habitat for the purpose of reestablishing black bear as a viable ecosystem component in East Texas (TPWD 2005).

This study represents a unique opportunity to assess public attitudes toward black bears prior to an anticipated reintroduction. This research reports social survey information regarding public attitudes toward the Louisiana black bear in the southern portion of East Texas. Our objectives were to (1) identify public attitudes toward black bears and a potential reintroduction, (2) determine what factors influence residents'

attitudes toward recovery of black bear in the area, and (3) compare this information with attitude studies from the remainder of the Louisiana black bear's historical range.

4.2. Methods and measurements

4.2.1. Study area

Our study area consisted of 12 counties (Area = 25,371.63 km²) within the southern portion of East Texas (Figure 4.1). Approximately 500,000 residents live within the study area, and approximately 368,000 of residents were adults in 2000 (≥ 18 years of age; U.S. Census Bureau data). Much of the area is considered rural, but dotted with numerous small towns and one larger community (the city of Lufkin, with approximately 50,000 people). More than 75% of the land is privately managed for timber or owned by the Federal government (Big Thicket National Preserve and the Davy Crockett, Sabine, Angelina, and Sam Houston National Forests). The more-densely populated southern edge of the area includes suburban development related to Houston and Beaumont.

4.2.2. Survey design

Based on the distribution of the human population within the area, as determined by data from the 2000 Census, we divided the study area into three strata: 1) rural = residents residing in rural areas, as determined by comparing population density between zip codes using ArcView GIS 3.2 (Environmental Systems Research Institute, Inc., Redlands, California, USA), 2) urban = residents residing in towns with $>2,500$ people and the City of Lufkin, and 3) south = residents residing in suburban areas along the southern portion of the study area. In January 2004, we mailed a questionnaire to 3,000

residents among the three strata: 2,000 rural, 600 urban, and 400 south (Appendix). Our target sample of 3,000 residents was based on funding, and the number of residents sampled per stratum was based on the proportion of the study area's population within each stratum. Assuming that rural residents will likely have the greatest probability of contact with bears (based on black bear ecology; Pelton 1982), we adjusted our sampling proportions in order to over sample, and therefore adequately represent, the rural stratum, which also contained the fewest residents. Name and address information were purchased from Survey Sampling, Inc. (Fairfield, CT), a company that assembles representative survey samples from telephone directory listings. A modified version of the "Tailored Design Method" (Dillman 2000), which uses multiple contacts and careful attention to survey details to increase response rate, was applied to survey design and implementation.

4.2.3. Dependent variables

We used exploratory factor analysis (principal components analysis; Babbie 1990) to define two dependent variables based on a series of questions related to black bears (Table 4.1): 1) attitudes toward black bears, and 2) attitudes toward wildlife managers. A third variable, attitude toward population change, measured attitudes related to whether the black bear population in East Texas should increase (i.e., more bears in the area), decrease (i.e., no bears in the area), or remain the same (i.e., allow transients to move through). Questions related to all three dependent variables were asked in Likert-scale format, a five-response scale ranging from strongly agree to strongly disagree (5 = strongly agree, 4 = agree, 3 = unsure, 2 = disagree, 1 = strongly disagree; Babbie 1990).

Each of these variables reflected important elements of social acceptance of black bears in East Texas and helped determine the potential for a socially successful reintroduction of black bears.

Attitudes toward black bears. Seven statements, related to respondent perceptions of and emotional feelings about black bears, grouped together in factor analysis (Table 1). These statements included whether the existence of black bears 1) is a sign of a healthy environment and 2) would increase their (resident's) quality of life in East Texas as well as 3) near their home; 4) whether bears have the right to exist wherever they occur; whether a resident 5) felt personally at risk if black bears exist and 6) was afraid of black bears; and 7) their opinion as to whether black bears commonly harm humans. To accommodate missing data, respondents who answered <75% of questions related to attitudes toward black bears were eliminated from analysis. If a respondent answered $\geq 75\%$ of questions, any missing data were assigned the average value across all respondents for that item. Items were coded so that larger values reflected greater support for black bears and then summed. A test for internal consistency (or reliability) among responses resulted in a Cronbach's alpha score of 0.86 (Cortina 1993).

Attitudes toward wildlife managers. Two questions relating to management loaded on an additional factor (Table 1). First, we asked whether respondents agreed with the statement that wildlife managers know how to manage bears. Second, we asked whether participants agreed that wildlife managers understand landowner concerns about bears. The management variable consisted of a summation of these two items. Larger numbers reflected greater confidence in managers. Pearson's correlation between the two items was 0.691. Any cases with missing data were deleted.

Attitudes toward population change. Participants were asked to respond to the statement, “The black bear population in East Texas should be increased.” Larger values derived from Likert scale format reflected greater support for a black bear population increase.

4.2.4. Independent variables

We selected 17 independent variables for our analysis (Table 4.2). Although we measured race/ethnicity, it was not included because 95% of the respondents were white/Caucasian. This underrepresented members of racial and ethnic minority populations, which constituted 23.7% of the total population of the area (U.S. Census Bureau data). Based on findings and reasoning from similar studies, we hypothesized that males, younger respondents, more-educated respondents, those with higher incomes, and respondents who were more knowledgeable about bears would be more likely to support black bears and an increased bear population. We also expected that members of urban communities, people who have seen bears in the wild, newer residents to the area, members of a wildlife-related organization, and residents who participate more frequently in activities related to wildlife would have more positive attitudes toward bears wildlife managers, as well as be more supportive of increasing the bear population. Finally, we hypothesized residents with children, pet owners, large-tract landowners, members of the rural stratum, and individuals who tend livestock would be less amicable toward bears, wildlife managers, and increasing the bear population. Four of the independent variables (described below) are composites of separate items from our survey.

Activities. We asked respondents to report participation in 16 activities that may put them in contact with bears and other wildlife (Table 4.3). Results from factor analysis suggested data reduction to three activity categories: utilitarian, passive appreciative, and work-related. Utilitarian activities included camping, boating, all-terrain vehicle use, hunting large game, hunting small game, and fishing (Cronbach's $\alpha = 0.84$). Passive appreciative activities included reading about wildlife, watching TV shows or movies about wildlife, and observing wildlife (Cronbach's $\alpha = 0.79$). Work-related activities included working on a farm or for the timber industry ($r = 0.31$). Hiking, running, biking, canoeing, and working for the oil industry did not factor into one of the above categories and were eliminated from further analysis. For each set of activities retained for analysis, respondents who answered <75% of the related questions did not receive an activity score. If a respondent answered $\geq 75\%$ of the related questions, any missing data were assigned the average value for that item across all respondents. For each set of activities, a scale score was derived by summing up responses for each item, with larger values reflecting greater levels of participation in the activities.

Knowledge. Respondents were asked to indicate (yes or no) for each of the following five factual statements about black bears in the region: 1) until the early 1900s, eastern Texas contained a large population of black bears, 2) the number of black bear sightings in eastern Texas has increased during the past decade, 3) black bear populations are increasing in size in Arkansas, Louisiana, and Oklahoma, 4) black bears in Texas are protected by both federal and state legislation, 5) black bears exist throughout most of the United States and North America, and 6) black bears are mainly vegetarians. A score of 1 was given for each "yes" indicated by the respondent, which assumed indication that

the respondent was knowledgeable about the particular fact. A score of 0 was given for each “no.” Scores were then summed to create an overall knowledge score for each individual. Respondents who answered <75% of the related questions did not receive a knowledge score. If a respondent answered $\geq 75\%$ of the related questions, any missing data were assigned a 0. A knowledge score was derived by summing up responses for each item.

4.2.5. Non-response follow-up

Because our response rate was <50%, we completed a non-response follow-up for all individuals ($n = 1,600$) within the survey sample who did not return a survey minus those who indicated that they did not wish to participate as well as those for which we had incorrect addresses. We asked 10 questions, similar to those in the actual survey, in an effort to determine whether there was a significant difference in responses between survey respondents and individuals who completed the non-response questionnaire.

4.2.6. Statistical analysis

We used SPSS 12.0 for Windows software to complete statistical analyses (SPSS, Inc., 2003). Because we oversampled rural residents, we applied weights to descriptive (univariate) analyses to more accurately represent the entire area; sample weights were not used for bivariate or multivariate analyses (Babbie 1990). For bivariate analyses (statistical tests comparing two variables), one-way ANOVA (F test) and Pearson's r were used to compare sample means and test relationships between variables, respectively (Babbie 1990, Sokal and Rohlf 1995). Multivariate analyses (tests using

three or more variables) were completed using ordinary least squares regression for each dependent variable (Babbie 1990, Sokal and Rohlf 1995). All alpha values were defined at the 95% confidence interval. After accounting for multiple comparisons in bivariate analyses (17 tests per dependent variable) with a Bonferroni correction, the *P* values were considered significant at the level of 0.003.

4.3. Results

The overall response rate was 40% ($n = 1,006$) after removing incorrect addresses and those considered ineligible to respond (see also Morzillo et al. 2005). For each stratum, the response rate was 41%, 35%, and 40% from rural, urban, and south areas, respectively. Overall results from the survey did not differ significantly from those for the non-response follow-up ($n = 163$). As indicated by the non-response follow-up survey, the most common reasons for not completing the original survey, as indicated by respondents, respondents had little or no knowledge about black bears (45.3%) or did not like answering surveys (23.7%).

Detailed results of univariate analyses of independent variables (Table 4.2) suggested that more than half of all respondents resided in rural areas or small towns, owned pets, were male, and had a household income of $\geq \$40,000$. There was, on average, less than one child per household ($SD = 1.03$), and the average age of respondents was >50 years old ($SD = 15.11$). Respondents had lived in East Texas, on average, for >38 years ($SD = 19.25$). Eleven percent of respondents indicated that they belong to a wildlife-related organization. Respondents indicated a relatively high level of participation in utilitarian and passive-appreciative activities, and low participation in

work-related activities. Respondents own 22 acres of land, on average ($SD = 84.14$), and 14% of landowners indicated that they tend livestock on their land. Twenty-three percent of respondents indicated that they have seen a black bear in the wild. Twenty-eight percent of respondents had high school diplomas as their highest level of formal education and another quarter (26%) had at least a college degree. Respondents averaged a knowledge score of 2.48 ($SD = 1.77$) questions answered correctly out of a possible six questions.

For descriptive results of dependent variables (Table 4.4), attitudes toward bears were generally positive, but many respondents were unsure whether the presence of bears would increase their overall quality of life (46%). Disagreement existed as to whether bears commonly harm humans (mean = 3.72, $SD = 0.83$), and many respondents (28%) indicated that they are afraid of bears. Although 41% of respondents were unsure, only 18% believed that the black bear population in East Texas should not be increased.

Results of bivariate analyses (Table 4.5), after Bonferroni adjustment, suggested that respondents with significantly more positive feelings toward bears included males, those with greater household incomes, more frequent participants in utilitarian and/or passive-appreciative activities, newer residents to the area, those more knowledgeable about bears, and those who have seen a black bear in the wild. More frequent participants in passive-appreciative activities and those more knowledgeable about bears were more likely to agree that wildlife managers know how to manage bears and understand landowner concerns. Respondents with a greater number of children <18 years of age, males, younger respondents, those with higher incomes, members of wildlife-related organizations, more frequent participants in utilitarian or passive-

appreciative activities, those who were more knowledgeable about bears, and those who have seen a black bear in the wild were more supportive of increasing the bear population.

Multivariate analyses yielded a regression model for each dependent variable (Table 4.6). Those with significantly more positive attitudes toward black bears included men, younger respondents, more frequent participants in passive-appreciative activities, newer residents to the area, those more knowledgeable about bears, and those who have seen a bear in the wild. More positive attitudes toward management were significantly more likely among respondents who reside in more-urban communities, participate more often in passive-appreciative activities, own fewer acres of land, were more knowledgeable about bears, and reside within the urban stratum. Attitudes supporting a bear population increase were significantly more likely among men, younger respondents, more frequent participants in passive-appreciative activities, those who own fewer acres of land, and those more knowledgeable about bears.

4.4. Discussion

Similar to results from Decker et al. (1981) and Kellert (1994), our respondents indicated generally positive attitudes toward bears. This is also consistent with Enck and Brown (2002), Kellert (1994), and Clark et al. (2002) in that there was general support for an increase in the black bear population size. In fact, only six percent of our respondents indicated that black bears should not exist at all in East Texas (Morzillo, unpublished data). This is a much lower percentage than in Mississippi where 16.8% and 51% of the general public and landowners, respectively, opposed an increase in the black

bear population (Shropshire 1996, Bowman 1999). Support for a bear population increase in our study was much greater than that for wolves in Arizona (Schoenecker and Shaw 1997). However, support for wolves in Yellowstone was high among respondents excluding those respondents who were members of the Stock Growers Association (Bath 1989). Farmers were the only respondent group with unfavorable attitudes toward a wolf reintroduction in Minnesota (Kellert, 1985a). Although livestock owners in our study had significant positive attitudes toward bears before Bonferroni adjustment, further analysis is necessary to determine whether particular user groups are supportive of bear population increases.

In general, our regression models were relatively successful at explaining the variance of our dependent variables (Table 4.6). The lower R-squared value for management attitudes is undoubtedly related to the initial lower variation in this measure. We assumed that rural residents would have a greater chance of contact with bears and may be less supportive of a bear population increase. With all else constant, our results suggested that more-urban communities were more confident in wildlife managers, but differences among communities in support for a bear population increase across different communities were not significant. Lohr et al. (1996) found that residents in larger communities typically had more positive attitudes toward wolves in Minnesota, as did Bowman (1999) with bears in Mississippi. However, Peyton et al. (2001) indicated that residents in more populated areas of Michigan preferred limited bear presence. The demographic characteristics of our study area are changing as many residents of the area are originally from other locations throughout the United States (Morzillo unpublished data). In addition, many individuals are moving out of nearby cities and into more-rural

areas for a better quality of life (e.g., cheaper housing). The mix of urban and rural environmental attitudes may balance regional positive and negative attitudes toward bears and increasing the population, which may be supported by the fact that in our survey newer residents to the area and younger respondents were more supportive of increasing the bear population. Similarly, Schoenecker and Shaw (1997) reported that the average residency for people with pro-wolf attitudes in Arizona was 19 years, and 24 years for those with anti-wolf attitudes. Past research suggested generally positive local attitudes toward wildlife managers (Duda and Brown 2001), and our results suggested no difference.

Rural landowners may be concerned that the presence of an endangered species will result in government restrictions on land use (Kellert 1991, Enck and Brown 2002). In our study, although opposite from Bowman (1999), individuals who owned more land had more-negative attitudes toward both black bear and resource managers. Open-ended comments on our survey revealed only four respondents who felt “government is intrusive,” or “agencies can’t manage” as reasons for not supporting an increase in bear population size. Considering a generally positive relationship between landowners and wildlife managers (Duda and Brown 2001), there are likely additional reasons why large-area landowners have negative attitudes toward both bears and managers, which should be sought in future research.

Respondents in households with a greater number of children <18 years of age were more supportive of increasing the bear population, but only in bivariate analysis. While we suspected that respondents might be concerned about safety of children, only 12 respondents indicated (elsewhere on the survey) that they feared for the general safety

of children. However, several respondents indicated that they would like their children to have the possibility of seeing bears, or that their children were very interested in wildlife. Two older respondents indicated that they feared for their grandchildren's safety, but it is possible that this concern is related to older respondents' more-negative attitudes toward bears and a bear population increase as compared to younger respondents.

As in past studies (e.g., Kellert 1994, Bowman, 1999), bivariate results suggested that respondents with greater household incomes were more likely to have more positive attitudes toward black bears and support an increase in black bear population size, but these relationships did not hold true when holding all other variables constant. Income was not a significant variable in Louisiana bear studies either (Shropshire 1996, Bowman et al. 2004), and, in our study, insignificance of this variable may be related to insignificance of other variables such as education (assuming that more educated individuals have greater incomes). We were rather surprised to find that level of education was not a significant predictor in any analysis, as results from many other studies have indicated higher levels of education directly relate to greater support for carnivore conservation and environmental protection in general (Kellert 1985b, Kellert 1994, Lohr et al. 1996, Bowman 1999).

Respondents were knowledgeable about the black bear's past and present status in Texas, but less aware of black bear population dynamics within the greater region. "I don't know anything about bears" was the most cited reason ($n = 79$) for indicating both an *unsure* response related to a bear population increase, and for survey non-response (45%), as indicated on the non-response follow-up. Because a completed East Texas black bear plan was not yet available to the public at the time of this survey, we do not

know whether many respondents were aware of its preparation. However, Van Why and Chamberlain (2003) reported that <60% of hunters were aware of a recovery plan in Louisiana, and we estimate that knowledge of preparation of an East Texas bear recovery plan was much lower. It would be interesting to compare our results to attitudes after exposure to and marketing of the East Texas plan to see if attitudes change if respondents become aware that the beginning stages of planning for a bear population recovery are underway. Regardless, greater knowledge about bears was significantly positively related to all three dependent variables in both bivariate and multivariate analyses, suggesting that a greater understanding of the species by residents may be an important ingredient of recovery efforts.

Respondents who had seen a bear in the wild were more likely to have positive attitudes toward bears, which suggests that personal familiarity with the species fosters positive attitudes toward it. Consequently, seeing a bear in the wild may cultivate an observer's desire to learn more about the species as a result of the observation experience. Shropshire (1996) suggested that support for increasing the Mississippi bear population was positively related to both knowledge about bears and whether landowner respondents had seen a bear. However, the positive relationship between knowledge and whether a respondent had seen a bear did not hold true for the general public. Similarly, attitudes toward and knowledge about wolves have been important predictor variables for overall support for wolf restoration (Bath 1989, Enck and Brown 2002), even though they may not guarantee support for reintroduction (Lohr et al., 1996). Even so, greater knowledge about black bears is an important element in gaining support among the general public and residents of the area targeted for reintroduction efforts. Our results

highlight the importance of information dissemination and outreach from natural resource agencies.

More frequent participation in passive-appreciative activities was significantly related to all three dependent variables in all analyses, which suggests that participants in these activities were more knowledgeable about and interested in the presence of wildlife for their enjoyment. In fact, there was a significant and positive relationship between knowledge and participation in passive-appreciative activities related to wildlife ($F = 34.472$, $df = 6, 925$, $P < 0.001$). However, when controlling for all other variables participation in utilitarian activities was not significant. This may suggest that respondents participate in utilitarian activities for reasons other than those with a wildlife focus such as hunting, such as camping to spend time with family. In other studies, participation in activities related to wildlife was a significant factor related to attitudes toward predators in general (Kellert 1985b), and wolves in particular (Lohr et al., 1996). In fact, “self-professed lover of animals and nature” was a reason for supporting a wolf reintroduction in Arizona (Schoenecker and Shaw 1997). More than 78% of sportsmen in Louisiana supported an increase in bear populations (Van Why 2003). Although some people may not desire the utilitarian use of a species, mere chance to observe a species may bring them personal fulfillment.

In our study, members of wildlife-related organizations were more likely to have positive attitudes toward a bear population increase, but only in bivariate analysis. One reason for an insignificance of organization membership at the multivariate level may be an underlying relationship between membership and income. Most wildlife-related organizations require annual membership dues, which may unintentionally discriminate

against the ability of lower-income respondents to join such organizations. In fact, a significant positive correlation existed between organization membership and income ($r = 0.126$, $P < 0.001$). The most frequently listed organizations of membership included Ducks Unlimited, the National Rifle Association and the National Audubon Society. As indicated within their mission statements (on the organization's websites), Ducks Unlimited and the National Audubon Society are dedicated to the conservation of species and ecosystems. Although the primary mission of the National Rifle Association is to protect individuals' rights to buy, own, and use firearms, the organization is also involved in issues that are linked to firearms, which include hunting and wildlife conservation.

In social science literature related to wildlife, it is common for the respondent pool to consist of a majority of males, and for attitudes to differ between the sexes. Shropshire (1996) reported that 91.8% of responding landowners were male. Our results were less lopsided in that 71.9% of respondents were males, as were 70% of the non-response follow-up participants. This is likely influenced by the fact that we acquired our respondents' names and addresses from telephone listings, on which males are more likely to be listed than females (Koval and Mertig 2004). Even if a female's name was listed, she may give the survey to a household male if the survey topic is of greater interest to him. Our analyses suggested significant differences between the sexes in respect to attitudes toward black bears and a population increase, with men being more supportive than women. This was consistent with Kellert (1985c), but opposite of Lohr (1996) for wolves and Peyton et al. (2001) for bears. Shropshire (1996) indicated no significant differences between men and women as to whether the bear population should be increased. Our results may be attributed to significantly greater male participation and

interest in hunting bears, as indicated elsewhere on the survey (Morzillo, unpublished data). Consistent with Kellert (1985c, 1991) and Bowman (1999), males and respondents who hunt had higher knowledge scores than females and non-hunters (Morzillo, unpublished data). Concerns about children or belief that bears are dangerous animals may be reasons for female respondents' less positive attitudes toward bears. However, in our study, there was no significant difference in attitudes toward black bears between females in households with and without members <18 years old ($F = 3.54$, $df = 1,93$, $P = 0.630$). Regardless, future research in this study area must include more females.

Younger respondents were more likely to have positive attitudes toward bears and support a bear population increase. Older respondents may be less supportive because of safety concerns or resistance to change, which is consistent with results of surveys about other carnivores (Kellert 1985b, Bath 1989, Kellert 1991). Bowman's (1999) results suggested greatest support for a bear reintroduction among respondents 25-49 years of age. Several of our older respondents noted, in the general comments section of the survey, that they remember their elders speaking of negative encounters with bears and bears killing livestock. Such tales may have instilled a negative perception about bears among the current elders if bears in the past were regarded as nuisances or dangerous (Reading and Kellert 1993).

Concerns about livestock safety are often a reason for opposition toward carnivores. In fact, this was the most-cited reason for opposition toward a wolf reintroduction program in Arizona (65% of respondents who opposed reintroduction; Schoenecker and Shaw 1997). Bath (1987) found similar results related to the wolf reintroduction in Yellowstone, as did Enck and Brown (2002) in the Adirondacks.

Surprisingly, in our study, respondents who tended livestock held more positive attitudes toward black bears, but only for pre-Bonferroni adjusted results at the bivariate level. Very few respondents ($n = 5$) noted concern of livestock safety as a reason why they opposed a black bear reintroduction. This simply may be because bears have seldom harmed livestock in East Texas, and respondents may recognize this. Residents who tended livestock were also more likely to be hunters (Morzillo, unpublished data). But results did not suggest a greater interest in hunting bears among hunters who do versus do not tend livestock. Future research should focus in greater detail on specific stakeholder groups.

4.5. Conclusion and implications

Little information is available about public attitudes toward reintroduction of large mammals, especially for species often perceived as threatening. The information that does exist with regard to black bears appears to imply generally positive feelings toward bears and public acceptance of black bear reintroductions, with more likely support among younger, more educated, wealthier, and urban, respondents, as well as respondents who have more recently relocated to the area. In addition, residents who have seen a black bear in the wild, are members of wildlife-related organizations, and participate in activities related to wildlife also have been found to hold more positive attitudes about black bears and increasing the bear population size. Many of our results were consistent with past studies. We conclude that our respondents held generally positive feelings toward black bears, and broad (but not all-inclusive) support exists for increasing the bear population size. In particular, greater knowledge about bears and

more frequent participation in passive-appreciative activities were consistently and positively related to support for black bears and an increase in their population. For other factors that influenced attitudes, some differences existed between bivariate and multivariate analyses; i.e., controlling for other variables modified the original bivariate relationship. Although managers must be aware of these differences, further analysis of these factors is certainly warranted, as the fact that their impact varies in the presence of other variables may make it more difficult for managers to precisely determine the individual relative importance of each factor. Overall, a key to improving support for black bears in East Texas, just as in Louisiana and Mississippi, is enhancing the knowledge base (about bears) of residents through expanded outreach efforts and encouragement of outdoor activities that promote appreciation of wildlife.

In Louisiana, where bear restoration is already taking place in various locations across the state, survey data about attitudes toward black bears are limited to sportsmen. Although these individuals comprise an important stakeholder group, there are other groups of people whose voices need to be heard, if only to know how they might react if they encounter a bear. Survey data that include the general population of Louisiana would be useful to bear recovery efforts in Texas. Such information could aid public outreach efforts in all three states (Texas, Louisiana, and Mississippi). Further, it is advisable that managers in all three states cooperate in efforts to collect consistent information from residents. This will improve the ability of wildlife managers to manage effectively at the geographic scale of the Louisiana black bear's range.

Survey research from Mississippi showed high support for increasing the black bear population size and for enactment of land use restrictions in an effort to insure bear

protection. We do not know yet whether residents in East Texas will support land use restrictions. Based on the information discussed above there is good cause for optimism that the Louisiana black bear may someday be accepted throughout its historical range.

Table 4.1. Results of factor analysis (principal components analysis with varimax rotation) used to define dependent variables^a for analysis of attitudes toward black bears (N = 982) in East Texas.

Statement from survey	Factor loadings for dependent variables (Percent variance explained)		
	Attitudes toward black bears (44.2%)	Attitudes toward wildlife managers (14.0%)	Other ^b (11.1%)
The presence of black bears is a sign of a healthy environment	0.757	0.112	0.082
Black bears would reduce the size of wild hog populations	-0.107	-0.508	0.517
Black bears in East Texas would increase my quality of life	0.723	0.232	0.421
Black bears near my home would increase my quality of life	0.738	0.225	0.423
Black bears have the right to exist wherever they may occur	0.642	0.053	0.068
I would feel personally at risk if black bears exist in East Texas	0.787	-0.413	-0.070
I am afraid of black bears	0.765	-0.428	0.022
Black bears commonly harm humans	0.731	-0.411	-0.075
Wildlife experts know how to manage black bears	0.129	0.885	0.153
Wildlife experts understand landowners' concerns about black bears	0.098	0.891	0.161

^aAll initial variables were displayed on the survey in Likert scale format (5 = strongly agree, 4 = agree, 3 = unsure, 2 = disagree, 1 = strongly disagree) and were coded for analysis so that greater values indicated greater support for bears. Highlighted values indicate variables that factored together.

^bEliminated from further analysis.

Table 4.2. Independent variables used and descriptive results (percentages and mean $\pm$ SD)^a for analysis of attitudes toward black bears, wildlife managers, and an increase in the black bear population in East Texas.

Variable (<i>n</i>)	Survey question	Coding of measurement	Descriptive results ^a
Community type (985)	In what type of community do you currently live?	Large city (>50,000 people) = 1 Small city (10,001 - 50,000 people) = 2 Suburb = 3 Large town (5,000 – 10,000 people) = 4 Small town (<5,000 people) = 5 Rural, farm = 6 Rural, non-farm = 7 Integer provided by respondent	Large city = 0% Small city = 22.6% Suburb = 5.6% Large town = 13.4% Small town = 20.4% Rural, farm = 12.4% Rural, non-farm = 25.6% Mean = 0.67; SD = 1.03
Number <18 (979)	How many individuals in your household are <18 years old?	Yes (1), or No (0)	Yes = 70.6%; No = 29.4%
Pets (985)	Do you have any pets?	Female (1), or Male (0)	Male = 71.9%; Female = 28.1%
Sex (984)	Are you male or female?	Respondent provided year of birth; difference between 2004 and that year	Mean = 54.0 years; SD = 15.11
Age (962)	In what year were you born?	Primary school (grade 8) = 1 High school or equivalent (e.g., GED) = 2 Vocational or trade school = 3 Some college = 4 Associate's or two year degree = 5 College graduate = 6 Graduate or professional degree = 7 Less than \$20,000 = 1 \$20,000 to \$39,999 = 2 \$40,000 to \$59,999 = 3 \$60,000 to \$74,999 = 4 \$75,000 or more = 5 Yes (1), or No (0)	Primary school = 3.1% High school or equivalent = 28.4% Vocational or trade school = 9.2% Some college = 25.8% Associate's degree = 7.5% College graduate = 17% Graduate or profess. degree = 9.0% Less than \$20,000 = 14.3% \$20,000 to \$39,999 = 24.7% \$40,000 to \$59,999 = 24.4% \$60,000 to \$74,999 = 14.9% \$75,000 or more = 21.6% Yes = 11.1%; No = 88.9%
Education (977)	What is the highest level of formal education that you have completed?	Often (3), Sometimes (2), or Never (1) (Six activities total)	Range = 1–18; Mean = 10.87; SD = 3.52
Income (895)	What was your gross household income before taxes in 2003?	Often (3), Sometimes (2), or Never (1) (Three activities total)	Range = 1–9; Mean = 7.02; SD = 1.64
Organization member? (981)	Are you a member of a wildlife-related organization?		
Utilitarian activities ^b (905)	Does the respondent participate in utilitarian activities related to wildlife?		
Passive-appreciative ^b (938)	Does the respondent participate in passive-appreciative activities		

Table 4.2. (Cont'd.)

Work-related activities ^b (918)	related to wildlife? Does the respondent participate in work-related activities related to wildlife?	Often (3), Sometimes (2), or Never (1) (Two activities total)	Range = 1–6; Mean = 2.66; SD = 0.99
Time in area (974)	How many years have you lived in East Texas?	Integer provided by respondent	Mean = 38.78 years; SD = 19.25
Livestock (957)	Does the respondent tend livestock?	Yes (1), or No (0)	Yes = 14.4; No = 85.6
Acres owned (974)	How many acres of land do you own?	Integer provided by respondent	Mean = 22.13 acres; SD = 84.14
Knowledge (995)	Base on responses to six questions about bears	Yes (1) or No (0) for each question Sum = total knowledge; range=0-6	Mean = 2.48 correct (max. = 6); SD = 1.77
Stratum (1,006)	Based on sample stratum	Rural (3), Urban (2), or South (1)	Rural = 66.7%; Urban = 20.0%; South = 13.3%
See bear (987)	Have you ever seen a black bear in the wild?	Yes (1), or No (0)	Yes = 23.4%; No = 76.6%

^aDescriptive results were weighted to account for oversampling of rural residents.

^bAssignment of particular wildlife-related activities to each variable was based on factor analysis, the results of which are displayed in Table 3.

Table 4.3. Results of factor analysis (principal components analysis with varimax rotation), used in data reduction, for grouping activities related to wildlife that respondents may participate in (N = 972).^a

Participation in Activities and factor loadings for data reduction (Percent variance explained)					
	Utilitarian	Passive- appreciative	Work-related	Other ^b	Other ^c
Activity	(32.4%)	(9.2%)	(8.2%)	(7.3%)	(6.4%)
Hiking	0.175	0.330	0.120	0.575	-0.121
Running	0.009	0.018	0.168	0.740	0.276
Biking	0.097	0.022	-0.060	0.782	-0.055
Camping	0.699	0.152	0.128	0.090	-0.143
Boating	0.796	0.056	-0.064	0.148	0.062
Canoeing	0.385	0.088	0.028	0.345	-0.503
All-terrain vehicle use	0.521	0.118	0.431	0.157	0.287
Read about wildlife	0.202	0.809	0.126	0.085	0.051
Watch wildlife-related TV or movies	0.143	0.832	0.040	0.028	0.074
Observe wildlife	0.173	0.766	0.142	0.137	-0.002
Hunt big game	0.601	0.287	0.432	-0.100	0.348
Hunt small game	0.582	0.279	0.376	0.017	0.371
Fish	0.749	0.251	0.069	0.043	0.059
Work on a farm	0.115	0.229	0.674	0.087	0.006
Work for the timber industry	0.051	-0.007	0.782	0.033	-0.143
Work for the oil Industry	0.208	0.087	-0.101	0.142	0.669

^aRespondents were asked to indicate “often” (coded as 3), “sometimes”(2) or “never” (1) based on individual participation in each activity. Highlighted values indicate variables that factored together.

^{b,c}Eliminated from further analysis.

Table 4.4. Descriptive results (Percentages and mean $\pm$ SD) of dependent variables^a (weighted to account for oversampling of rural residents) used to assess attitudes toward a black bear reintroduction in southeastern Texas.

Variable	Survey question	N	Percentage (%) of responses				Mean (SD)	
			Strongly agree (5)	Agree (4)	Unsure (3)	Disagree (2)		Strongly disagree (1)
Black bear attitudes	Presence of black bears is sign of a healthy environment	963	1.6	46.1	31.8	4.4	1.1	3.73 (0.83)
	Black bears in East Texas would increase my quality of life	975	3.1	17.8	46.0	26.1	7.0	2.84 (0.90)
	Black bears near my home would increase my quality of life	977	2.8	13.5	37.5	32.5	13.7	2.59 (0.98)
	Black bears have a right to exist wherever they occur	975	17.1	45.3	17.0	16.1	4.4	3.55 (1.09)
	I would feel personally at risk if black bears exist in East Texas*	984	3.9	11.2	22.9	44.0	18.1	3.61 (1.02)
Management attitudes	I am afraid of black bears*	973	6.8	21.7	20.0	35.8	15.8	3.33 (1.15)
	Black bears commonly harm humans*	973	1.1	4.0	33.5	42.8	18.6	3.72 (0.83)
	Wildlife experts know how to manage black bears	971	12.7	51.1	30.9	4.3	1.0	3.70 (0.78)
	Wildlife experts understand landowners' concerns about black bears	976	9.4	50.7	34.2	4.8	0.9	3.63 (0.76)

Table 4.4. (Cont'd.)

Population increase attitudes	The black bear population in East Texas should be increased	915	13.4	27.7	40.9	13.8	4.2	3.32 (1.01)
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^aLikert scale values (in parentheses under answer categories) were used to calculate mean and standard deviation values, with higher values indicating more favorable attitudes toward black bears. Survey questions, for which coding (for consistency such that higher values indicate more favorable attitudes toward black bears) was reversed, are indicated by an asterisk (*).

Table 4.5. Results for bivariate statistical analyses^a for variables used in southeastern Texas black bear attitudes survey.

Independent variable	Dependent variable					
	Attitudes toward black bear		Attitudes toward managers		Attitudes toward population increase	
	Test statistic	df	P	Test statistic	df	P
Community type	$r = -0.052$		0.259	$r = -0.048$		0.133
Number <18	$r = 0.148$		0.001*	$r = 0.063$		0.053
Pets	$F = 6.150$	1, 473	0.013*	$F = 2.299$	1, 960	0.130
Sex	$F = 23.222$	1, 472	$\leq 0.001^{**}$	$F = 0.000$	1, 958	0.987
Age	$r = -0.239$		0.051	$r = -0.264$		0.051
Education	$r = 0.083$		0.073	$r = 0.018$		0.573
Income	$r = 0.149$		0.002**	$r = 0.017$		0.610
Organization member?	$F = 5.425$	1, 470	0.020*	$F = 12.884$	1, 915	0.183
Utilitarian activities	$r = 0.239$		$\leq 0.001^{**}$	$r = 0.096$		0.004*
Passive-appreciative activity	$r = 0.300$		$\leq 0.001^{**}$	$r = 0.175$		$\leq 0.001^{**}$
Work-related activity	$r = 0.023$		0.625	$r = 0.120$		0.726
Time in area	$r = -0.089$		$\leq 0.001^{**}$	$r = -0.089$		0.006*
Livestock	$F = 5.301$	1, 461	0.022*	$F = 0.032$	1, 934	0.391
Acres owned	$r = -0.066$		0.074	$r = -0.068$		0.067
Knowledge	$r = 0.344$		$\leq 0.001^{**}$	$r = 0.173$		$\leq 0.001^{**}$
Stratum	$F = 1.051$	3, 476	0.369	$F = 4.329$	3, 972	0.005*
See bear	$F = 8.963$	2, 471	$\leq 0.001^{**}$	$F = 1.142$	2, 959	0.320
				$F = 19.664$	2, 919,	$\leq 0.001^{**}$

^a(*) denotes significance at the 95% confidence level, and (**) denotes significance after Bonferroni adjustment.

Table 4.6. (Cont'd.)

^aStandardized coefficients reported. An (*) denotes significance at the 95% confidence level.

^b $R^2 = 0.269$ (*Adj.* $R^2 = 0.236$), $F = 8.159$, $P \leq 0.001$

^c $R^2 = 0.084$ (*Adj.* $R^2 = 0.063$), $F = 3.982$, $P \leq 0.001$

^d $R^2 = 0.258$ (*Adj.* $R^2 = 0.246$), $F = 21.213$, $P \leq 0.001$



Figure 4.1. The 12-county region in southeastern Texas used to identify attitudes toward black bears, wildlife managers, and increasing the black bear population. Survey participants were selected from these counties.

CHAPTER 5

SOCIOECONOMIC FACTORS AFFECTING SUPPORT FOR BLACK BEAR RECOVERY MANAGEMENT STRATEGIES

In collaboration with

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Abstract

Many studies have assessed public reaction to various wildlife management scenarios. However, few have specifically focused on public opinion toward a reintroduction versus a non-assisted (i.e., “let nature take its course”) recovery of a species. We surveyed 1,006 residents throughout southeast Texas in an effort to determine variables that influence opinion of preferred management strategy for recovery (or non-recovery) of black bears. The general desire to have black bears in the area had the greatest influence on selection of preferred management strategy. Concern (worry) about problems that bears may cause was also of great influence. Most importantly, there was a difference in predictive variables for two strategies involving human assistance that differed only in their wording, but not their meaning to wildlife management. Therefore, managers must be very clear when explaining details of a management strategy in an effort to minimize miscommunication and confusion between managers and residents.

5.1. Introduction

During the past decade, increasing attention has been given to public attitudes toward wildlife. A number of studies have assessed public attitudes toward different management scenarios regarding human-wildlife interactions, and have provided managers with information about how to best minimize negative outcomes of conflicts between humans and wildlife. Examples of recent research include hunting versus non-hunting in urban areas for managing elk (Lee and Miller 2003), accountability for damage by geese (Coluccy et al. 2001), managing for predators to enhance prey recruitment (Messmer et al. 1999), attitudes and behaviors toward feral cats and preferred methods of control (Ash and Adams 2003), acceptability of management actions as a result of different types of encounters by mountain lions (Manfredo et al. 1998), defining policy for black bears based on attitudes and opinions of residents (Peyton et al. 2001), and ascertaining variables that determine preferred predator management practices (Teel et al. 2002). Studies of acceptance by humans who have experienced damage or injury by a particular species are also common (e.g., black bears; Pelton and Scott 1976; Jonker et al. 1998).

Such knowledge is extremely pertinent to improving wildlife management practices. Many studies have addressed public opinion about particular species involved in potential reintroduction strategies (Bath 1987; Lohr et al. 1996), but fewer data are available regarding public attitudes comparing management alternatives in such instances. Regardless, it is almost impossible to determine how residents of an area will react to human-wildlife interactions after a species is present, especially if the species, such as the black bear, is perceived to be of potential negative consequence (i.e.,

perceived danger to humans). It is therefore essential to collect as much information as possible to determine particular variables that may contribute to public reaction, and provide managers with baseline data for comparison with post-reintroduction public attitudes.

The Louisiana black bear (*Ursus americanus luteolus*) was extirpated, as a result of over-harvest and habitat destruction, from most of its historical range in Louisiana, southern Mississippi, and southeast Texas by the early 1900s (BBCC 1997). At the beginning of the 1990s, only two small remnant populations remained in eastern Louisiana. An extensive public outreach and information campaign took place in Louisiana recently to build public support for bear recovery throughout the state. Two recovery plans were created (Bowker and Jacobson 1995; BBCC 1997), and recovery has been successful thus far (Van Why, 2003). To date, feasibility analyses have also been completed in Mississippi (Shropshire 1996; Bowman 1999).

In eastern Texas, there has been an increase in the number of confirmed black bear sightings since the early 1990s. At this time, there is no known breeding population in eastern Texas, and sightings are most likely transient bears from Arkansas, Oklahoma, and/or Louisiana populations who wander into eastern Texas. The increased number of sightings in Texas has prompted the creation of a Texas black bear conservation and management plan. Objectives of the plan for the next 10 years include public coordination, communication, outreach/information dissemination, habitat management, and research (TPWD 2005). The ultimate goal, through partnerships between natural resources organizations and the general public, is to restore habitat for the purpose of reestablishing black bear as a viable ecosystem component in East Texas (TPWD 2005).

The objective of this research was to ascertain public attitudes toward management for recovery of the Louisiana black bear in southeast Texas by comparing support for alternative management strategies, and to determine the socioeconomic variables of greatest import for understanding these attitudes. We assess support for three general management options for black bears (described in methods section): (1) human-assisted reintroduction, (2) natural (non-assisted) recovery, and (3) no bear recovery.

5.2. Methods

5.2.1. Study area and survey design

Please refer to Sections 4.2.1 (including Figure 4.1) and 4.2.2 for descriptions of the study area and survey design, respectively.

5.2.2. Dependent variables

We selected four dependent variables to represent three different potential management strategies. Two of the scenarios, human-assisted and restocking, were conceptually equivalent to us, but we sought to determine whether vernacular used would affect responses. For the first three variables (discussed below), we asked participants whether they support, do not support, or are unsure about the specified strategy. These three questions were coded such that higher scores indicated more support for a particular management scenario (support = 3, unsure = 2, no support = 1). For the *Natural* and *Assist* variables, we asked respondents to also volunteer reasons for their selection (i.e., support, not support, unsure). We then categorized similar responses to quantify rationales for each selection.

Natural. —Respondents were asked whether they supported the following strategy: “Do you think black bear populations in East Texas should increase naturally (i.e., without assistance from a natural resource agency)?”

Assist. —Respondents were asked whether they supported the following strategy: “Do you think that natural resource agencies should assist in increasing the black bear population size in East Texas?” Specific means of assistance were not provided.

Restock. —Respondents were asked whether they supported the following strategy: “Would you support the restocking of black bears into suitable habitats in East Texas by natural resource agencies?” The *Assist* and *Restock* variables both sought essentially the same information, but used different terminology. *Restock* is a management term closely associated with game harvest (Bolen and Robinson 1999), whereas *Assist* is a more general and widely used term related to species reintroductions. We compared the results for both *Assist* and *Restock* to determine whether vernacular differences between terms would result in differences in support.

No bear. —Respondents were asked whether they agreed or disagreed with the statement “black bears should not exist in southeast Texas.” This management strategy would involve the complete exclusion of bears from the area, and was asked using a Likert-scale format. Responses were coded so that higher values indicated more support for excluding bears from the area (1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, 5 = strongly agree).

5.2.3. *Independent variables*

We selected 21 independent variables for our analysis. Seventeen of these variables were the same as those described in Chapter 4 (Table 4.2), and four additional variables were used (Table 5.1). Based on findings and reasoning from similar studies, we hypothesized that male, younger, more-educated, higher-income, and more knowledgeable (about bears) respondents would be more likely to support a human-assisted means of recovery (*Assist* and *Restock*). We expected that members of more heavily populated community types, as well as those who live in the south and urban strata, people who have seen bears in the wild, respondents who want bears in East Texas, newer residents to the area, respondents who are interested in wildlife, members of a wildlife-related organization, residents who participate in activities related to wildlife more frequently, and residents who have lived in areas where black bears are present were also more likely to support human-assisted means of recovery. Finally, we hypothesized that residents with children, pet owners, large-tract landowners, respondents who would worry about the problems that bears may cause, and individuals who tend livestock would be more supportive of natural or no bear strategies.

5.2.4. *Non-response follow-up*

Please refer to section 4.2.4 for discussion of the non-response follow-up survey.

5.2.5. *Statistical analysis*

Please see section 4.2.5 for descriptions of statistical analyses. Recognizing that our dependent variables are ordinal and most have only 3 categories, which technically

necessitate the use of ordinal logistic regression (Babbie 1990; Sokal and Rohlf 1995), we ran the same multivariate analyses using ordinal logical regression. We found no differences in terms of which parameters were statistically significant and in what direction. Similarly, parameter values were strikingly close in magnitude to those arrived at using regular multiple regression. Because readers are likely more familiar with multiple regression, we chose to present the results as such. All alpha values were defined at the 95% confidence level. After accounting for multiple comparisons in bivariate analyses (21 tests per dependent variable) with a Bonferroni correction, the P values were considered significant at the level of 0.002).

5.3. Results

Detailed results of univariate analyses of independent and dependent variables for all respondents are displayed in Tables 4.4, and 5.1, and 5.2, respectively (see also Morzillo et al. 2005). See Chapter 4 for a review of the 17 independent variables used in both chapters. For the four independent variables unique to this chapter, 92% of respondents indicated that they were interested in wildlife, and 65% of respondents indicated that they wanted black bears in southeast Texas. However, 34% of respondents who wanted bears worried about problems that bears may cause. Overall, half of respondents indicated that they would worry about problems that bears may cause regardless of whether they want or do not want bears in the area. Thirty-two percent of respondents have lived in a location within the present geographical range of black bears.

Pearson correlations revealed moderate statistically significant correlations between dependent variables (Table 5.2). A positive correlation existed between *Assist*

and *Restock*, which to us described essentially the same strategy, but were interpreted differently by respondents. Correlations between all other pairs of management strategies were negative. Support, non-support for, and unsure opinions about both *Natural* and *Assist* were indicated by approximately one third of respondents each (Table 5.2). Restocking the black bear population by natural resource agencies (*Restock*) was supported by 50% of respondents, whereas the remaining half was almost evenly divided between non-support and unsure. Only six percent of respondents held attitudes suggesting that black bears should not exist in East Texas, whereas >70% disagreed or strongly disagreed with the same strategy.

We completed bivariate analyses of each independent with each dependent variable (Table 5.3). *Natural* did not vary by community type, whether or not the respondent owns pets, age, education, how often the respondent participates in work activities related to wildlife, duration of residence in southeast Texas, whether the respondent tends livestock, the number of acres owned by the respondent, stratum, or whether the respondent has seen a bear in the wild. Whether a respondent was interested in wildlife, would enjoy having black bears in the area, and whether or not the respondent had lived in a location where bears are present were also insignificant for *Natural*. Respondents in households with fewer members <18 years of age, females, and those with lower incomes, were more likely to support a natural increase in the black bear population. Also more likely to support a natural increase in the bear population were members of wildlife-related organizations, respondents who participate less frequently in utilitarian and passive-appreciative activities related to wildlife, those with lower knowledge scores, and those who worry about the problems that bears may cause.

Assist did not vary by community type, number of household members <18 years of age, whether or not the respondent owns pets, education, income, frequency of participation in work activities related to wildlife, number of years the respondent has lived in southeast Texas, whether the respondent tends livestock, number of acres owned, stratum, whether the respondent has seen a bear in the wild, or whether the respondent has lived in a location where bears are present. However, females, younger respondents, members of wildlife-related organizations, more frequent participants in utilitarian and passive-appreciative activities related to wildlife, those with higher knowledge scores, those interested in wildlife, those who do not worry about the problems that bears may cause, and those who would enjoy having bears in the area were more likely to support a human-assisted bear recovery program.

Restock did not vary by community type, whether the respondent owns pets, education, whether the respondent participates in work activities related to wildlife, the length of time that a respondent has lived in southeast Texas, whether the respondent tends livestock, number of acres owned, stratum, whether a respondent has seen a bear in the wild, or whether the respondent has lived in a location where bears are present. Respondents in households with a greater number <18, females, younger respondents, respondents with higher incomes, members of wildlife organizations, respondents who participate more often in utilitarian and passive-appreciative activities related to wildlife, respondents with greater knowledge about bears, those interested in wildlife, those who do not worry about the problems that bears may cause, and those who would enjoy having bears within the area were more likely to support restocking of black bears into suitable habitat by natural resource agencies.

No bear did not differ significantly by community type, number of household members <18 years of age, whether or not the respondent had pets, sex, frequency of participation in work activities that are related to wildlife, whether respondents tend livestock, number of acres owned, stratum, and whether the respondent has lived in a location where bears are present. Older respondents, respondents with lower levels of education, respondents with lower incomes, respondents who are not members of a wildlife-related organization, those who less frequently take part in utilitarian and passive-appreciative activities, those with a longer duration of residence in southeast Texas, and respondents with less knowledge about bears, were more likely to support management calling for no bears in Texas. Respondents who have not seen bears in the wild, do not have an interest in wildlife, worry about problems that bears may cause, and would not enjoy having bears in the area were also more likely to support the no bear management strategy.

Multivariate analyses yielded a regression model for each dependent variable (Table 5.4). Households containing fewer individuals <18 years of age, respondents who are less likely to participate in utilitarian activities related to wildlife, those who own a greater number of acres, and those who are more likely to worry about the problems that bears may cause, are more likely to support a natural increase in bear populations. Men, respondents who participate more often in passive-appreciative activities related to wildlife, those who do not worry about the problems that bears may cause, and those who would enjoy having bears in the area were more likely to support a human-assisted bear recovery. Respondents who participate more often in utilitarian and passive-appreciative activities related to wildlife, were less worried about the problems that bears may cause,

and would enjoy having black bears in southeast Texas were more likely to support restocking of black bears into southeast Texas. Respondents who have lower incomes, have lived in the area for a relatively longer period of time, have less knowledge about bears, worry more about the problems that bears may cause, and would not enjoy having bears in the area were more likely to indicate that black bears should not exist in East Texas.

5.4. Discussion

Our objective was to determine whether support for particular black bear management strategies is influenced by particular demographic and socioeconomic variables. To our knowledge, this is the first study to compare how respondents' characteristics influence selection of preferred management strategy for implementation of a species recovery. The regression models performed well, predicting 17-51% the variance. Independent variables predicted approximately 17% of the variance of *Natural*. Although *Restock* and *Assist* sought the same information from a management standpoint, there were some differences in predictor variables. By asking both, however, we have learned that respondents interpret these terms (i.e., potential management strategies) differently. Respondents may have interpreted *Restock* as placing more bears into specific locations within the area, and *Assist* as a strategy that may involve more-rigid environmental regulations. For future information dissemination, wildlife managers must explain potential bear management implementation plans in detail and avoid any confusion or potential misunderstandings with local residents.

The general desire (or not) to have bears in the area, and whether a respondent worried about the problems that bears may cause, were the independent variables that most consistently influenced dependent variables, when controlling for all other independent variables. In other words, a person's general attitude toward wanting bears in the area (whether they would see them or not) had the most influence on whether a respondent supported an active (human-assisted; i.e., *Assist* or *Restock*) or *No bear* management strategy. Similarly, respondents who worried about problems that bears may cause were more likely to support the passive *Natural* strategy, or prohibiting bears from establishing themselves in southeastern Texas. Future studies must delve even deeper into the reasons why people have positive or negative attitudes toward bears in the first place, as the socioeconomic variables used here did not make the effect of these attitudes disappear.

In our study, the desire to let nature take its course, concerns about funding and/or the opinion that bear recovery was a waste of money, and the desire not to have bears in the area were most often cited by respondents as reasons why they opposed *Assist*. Conversely, the most commonly cited reasons for supporting *Assist* were that natural recovery of the bear population would take too long and respondents wanted to see or have more bears in the area ($n = 38$ and $n = 36$, respectively). If local residents want bears, they may consider the presence of bears to be a greater benefit than concerns for costs related to negative impacts (e.g. nuisance activity).

When respondents were asked to identify reasons why they might oppose *Natural*, it became clear that much of the opposition to this strategy stemmed not from opposition to bears, but rather a desire to see bears even more quickly than natural processes would

allow. Many respondents indicated that they did not support *Natural* because active recovery of bear populations was important for a better chance of survival ($n = 98$) and for the enjoyment of future generations ($n = 3$). Within the general comments section of the survey, several respondents indicated that they would like their children to experience the possibility of seeing a bear. This rationale is further supported in our bivariate analysis, in which respondents belonging to households with a greater number of members <18 years of age were more likely to prefer management strategies that involved human assistance. Just the opposite, respondents from households with fewer members <18 year of age were more likely to support the *No bear* or *Natural* management strategies. However, the number of household members <18 years of age remained significant in multivariate analysis only for *Natural*, suggesting that the effects of this variable occur through other variables included in the model. Support for a reintroduction because the area is within the historical range of black bears, and because of the significance of bears to the area's culture was mentioned ($n = 5$), but was not as prevalent as in other studies (Enck and Brown 2002).

Worry was significant for all four dependent variables. People who worried less were more supportive of human assisted recovery, whereas people who worried more were more supportive of *Natural* or *No bear* strategies, even when controlling for other variables. However, from the reasons provided by respondents in our survey, concern about problems that bears may cause was only the fourth most common reason for not supporting any of the management scenarios that would result in bear presence ($n = 17$). More often indicated were let nature take its course ($n = 86$), concern about monetary cost of a bear recovery ($n = 31$), and simply no desire to have bears ($n = 29$). Lower

income respondents, as well as respondents who have lived in the area for a longer amount of time, may be concerned about paying for bear damage that might occur on their property. In fact, lower income individuals were more likely to prefer the *Natural* and *No bear* management strategies. This may include elderly residents who live on fixed incomes and are possibly also concerned about their own safety, as our results indicated a significant correlation between age and income ($r = -0.202$, $P \leq 0.001$), as well as between worry and age ($r = 0.094$, $P = 0.008$). We also expected that respondents with pets would be worried about pet-bear conflicts. However, whether the respondent owned pets was only significantly positively related to *Restock*, and only before application of the Bonferroni adjustment, which may suggest that respondents are aware that bears are unlikely to harm pets. In fact, concern for pets was mentioned as a reason for non-support for only *Restock*, and only by one respondent.

Concerns about both direct and indirect human-wildlife conflict are not uncommon. Perceived negative effects on livestock were positively related to non-support for a wolf reintroduction in New York (Enck and Brown 2002). In Arizona, elk-vehicle collisions and feeding by humans were mentioned as potential problems with urban elk populations (Lee and Miller 2003). But human-wildlife conflict does not always result in human intolerance for a species. In Massachusetts, bear damage to crops and livestock was considered only a slightly to moderately intolerable inconvenience (Jonker et al. 1998). Even individuals who experienced bear-related damage in one study (<5% of those surveyed) considered the presence of bears as an overall positive impact on the area (Jonker et al. 1998). Wildlife managers in southeast Texas must seek to determine whether local residents' attitudes are likely to change if bear-related damage is

(or is not) experienced (i.e., Social Carrying Capacity; Peyton et al. 2001). Proactive solutions may then be established to resolve situations involving residents who experience bear-related damage (e.g., reimbursement program). For example, in Massachusetts, most bear problems involving livestock took place during the birthing season (Jonker et al. 2003). This is concurrent with the time of year when bears, which are opportunistic foragers, search for food for cubs and require extra energy for nursing and recovery after hibernation (Larivière 2001). Electric fencing was determined to be the most successful proactive means for deterring bears from livestock (Jonker et al. 2003). Therefore, regardless of management course of action, we suggest that wildlife managers incorporate suggested strategies for proactive bear deterrence (e.g., electric fencing) into public outreach efforts (Colluccy et al. 2001; Jonker et al. 2003).

Outreach by wildlife managers should also seek to increase the public's general knowledge about bears, which may assist residents in making decisions that lead to minimal bear-human conflict. Respondents with less knowledge about bears were more likely to support *No bear* in both bivariate and multivariate analysis. In our survey, lack of knowledge about bears (or not enough knowledge about bears to make a decision) was the most cited reason across all management strategies by respondents who were unsure about their preferred management strategy ($n = 156$).

Higher knowledge scores were significantly positively correlated with more frequent participation in passive-appreciative activities related to wildlife ($r = 0.422$, $P \leq 0.001$). Like respondents with higher knowledge scores, respondents who participate more frequently in passive-appreciative activities were more supportive of both *Assist* and *Restock*. Thus, the mere presence of bear may hold important existence value

(Boardman et al. 1996) or emotional fulfillment to individuals who more frequently pursue passive-appreciative wildlife-related activities. This may partly explain why more frequent participants in utilitarian activities related to wildlife were more likely (in multivariate analysis) to support *Restock*, but not *Assist*, as restock is often related to harvest (Bolen and Robinson 1999). However, enjoyment of the outdoors and observing wildlife are also common reasons for hunting (Decker and Connelly 1989). Regardless of whether passive-appreciative participants hunt or not, they may participate in other activities defined as utilitarian (i.e., camping, boating; $r = 0.467$, $P \leq 0.001$ for comparison between passive-appreciative and utilitarian participation). Respondents who participate less frequently in utilitarian activities were more likely to support *Natural*, suggesting that supporters of this management scenario may be more preservation-oriented, preferring natural recovery to any interference from humans, positive or negative (Pacelle 1998).

Several variables that we expected to be significant in multivariate analyses were not significant. First, greater knowledge about a species has been associated with both more positive (Kellert 1985b) and more negative (Mertig 2004) attitudes about the species. Our results support the former via a positive bivariate relationship between knowledge and *Assist* and *Restock*, and a significantly negative relationship with *Natural* and *No bear*. But, the negative relationship only held true between knowledge and *No bear* in multivariate analysis, possibly for the reason that knowledge about bears is correlated with the desire to have bears in the area ($r = 0.289$, $P < 0.001$), as well as participation in passive-appreciative ($r = 0.422$, $P < 0.001$) and utilitarian ($r = 0.267$, $P <$

0.001) activities related to wildlife. Unfortunately for pro-bear advocates, future efforts to increase knowledge do not guarantee changes in attitudes (Enck and Brown 2002).

Education and gender are two variables that are often associated with differences in attitudes about reintroductions and other wildlife management situations. Similar to results from other studies (Kellert 1985b; Lohr et al. 1996; Bowman 1999; Bowman et al. 2004), we expected that respondents with lower levels of education would be more supportive of *No bear*, and less supportive of the other strategies. Education was negatively significant for only *No bear*, and only in bivariate analysis. In bivariate analysis, females were more likely to support *Natural*, *Assist*, and *Restock*. However, results from multivariate analysis suggested that males were more likely to support *Assist*. We expected that males would be more supportive of all three recovery strategies that would lead to an increase in the number of bears, as males were more interested in hunting bears than females (Morzillo, unpublished data). Results have been mixed in other surveys involving carnivore reintroductions; men have been more supportive than women (Kellert 1985b), women have been more supportive of men (Lohr et al. 1996), or no significant difference between the sexes has existed (Shropshire 1999). Regardless, females were underrepresented in our sample, and their opinions should be persistently sought.

Assuming that membership in wildlife-related organizations is related to interest in wildlife, we expected that members of wildlife-related organizations would be more supportive of management strategies involving human assistance. Membership was significantly related to support for *Natural*, *Assist*, and *Restock* in bivariate analysis only. Because members of wildlife organizations were more likely to want bears in the area (X^2

= 4.985, 1 df = 1, $P = 0.026$), it is possible that the bivariate significance became masked in multivariate analyses by the strong influence of desire to have bears.

We expected respondents who tend livestock to be less supportive of pro-bear management scenarios (Bath 1987). However, tending livestock was significantly positively related to *Natural*, *Assist* and *Restock* in bivariate analyses before Bonferroni adjustment, but not significant in multivariate analysis. With no recent reporting of bear harassment of livestock in East Texas, it is possible that livestock owners do not consider bears to be a threat to livestock. Belief that bears are not dangerous (Kellert 1994) may also support bivariate results that suggested more support for *Restock* and less support for *No bear* among respondents who have seen a bear in the wild. Again, these relationships may have diminished in multivariate analysis because seeing a bear is significantly, but very weakly, related to a desire to have bears in the area ($r = 0.093$, $P = 0.007$). We expected that respondents who have lived in areas where black bears are present would be more likely to support pro-bear management strategies, but this variable was not significant in any instance. Even if a respondent has lived in an area within the black bear's present range, he/she may not have been aware of the presence of bears, particularly within urban areas, unless the local media drew attention to the presence of bears for a particular reason (e.g., sighting in an urban area). Having more detailed information about respondents' past residences (e.g., city, rural area) may allow for better evaluation of this relationship.

Neither community type nor stratum was significant in any instance. As in past studies (Lohr et al. 1996; Bowman 1999), we expected that residents of more-urban areas would be most supportive of human-assisted recovery strategies and rural residents of

anti-bear strategies. In our study area, the rural population is growing, mainly as a result of emigration from nearby cities (e.g., Beaumont, Houston). This may explain positive relationships between *Time in area* and both *Natural* and *No bear*, as well as negative relationships between *Time in area* and *Restock*, but this trend does not hold true for *Assist*.

Finally, we expected respondents who own more acres to be less supportive of a bear recovery. Kellert (1991) and Enck and Brown (2002) both suggested that rural landowners may be concerned with federal or state restrictions limiting land use as a result of endangered species presence. This may be a reason for the number of acres owned to be significantly positively related to *Natural* in multivariate analysis, but this relationship was not present in bivariate analysis. In fact, only one respondent to our survey noted government intrusion as a reason for not supporting bear recovery.

Assessment of additional demographic variables must be completed during future data collection. For example, >25% of residents within the study area are of minority race/ethnicity (US Census Bureau data). Approximately 96% of our survey respondents were white/Caucasian. This results in a severe underrepresentation of minority racial/ethnic populations in regard to management decisions that will affect these demographic groups. In addition, because almost three-quarters of our respondents were male, more attitudes data must be collected from female members of the population. Better accounting for underrepresented groups such as those mentioned above will result in a more accurate assessment of attitudes toward black bears across the study area.

5.5. Management implications

Although significant bivariate relationships existed between many of the variables discussed, controlling for all variables caused many of the significant bivariate relationships to disappear in multivariate analysis. In addition, further analyses will be needed to assess present underrepresentation of other demographic characteristics (e.g., underrepresented minority racial/ethnic groups and females). Regardless, our results provide important implications to wildlife management and more particularly to bear management. In summary, most of our respondents indicated an interest in wildlife. However, this interest does not directly transfer to a desire to have black bears in East Texas. Desire to have bears in the area and worry about the problems that bears may cause were the variables that best predicted respondents' attitudes toward each management strategy. It will be critical for managers to monitor relationships between these variables over time, particularly as initiatives for a bear recovery progress. For example, attitudes toward bears could change if the media broadcast bear-human conflicts, especially if conflict involves a resident who is not supportive of having bears in the area. At present, because of lack of bear presence, and the fact that extensive outreach between resource agencies and residents is just getting underway, residents in the area may not perceive bears as potentially influential in their lives (Enck and Brown 2002). For residents who worry about the problems that bears may cause, wildlife managers need to further determine specific reasons for these concerns. In all instances, it is essential that managers publicly explain in detail all management-related terminology because any miscommunication or confusion of expectations between managers and residents could lead to public distrust. As noted, there was a 20%

difference in support for *Assist* versus *Restock* which may lead to confusion if the terms “reintroduction” and “restocking” are used interchangeably. As another example, the term “assistance by natural resource managers” as related to a bear recovery could mean, among other things, either managing habitat only or actively releasing bears brought in from other locations. Such detailed explanation of strategies will allow for creation of management practices that consider already existing concerns about bears in attempting to minimize potential conflict between humans and bears in the context of specific land uses.

Table 5.1. Independent variables used and descriptive results^a for analysis of attitudes toward black bears, wildlife managers, and an increase in the black bear population in East Texas.

Variable (<i>n</i>)	Survey question	Coding of measurement	Descriptive results ^b
Interest	Are you interested in wildlife?	Yes (1), or No (0)	Yes = 92.0%; No = 8.0%
Worry	Would you worry about the problems that bears may cause?	Yes (1), or No (0)	Yes = 49.5%; No = 50.5%
Want	Do you want black bears in East Texas?	Yes (1), or No (0)	Yes = 64.4%; No = 35.6%
Live	In what other locations have you lived (to determine whether the respondent has lived within the present range of black bears)?	Yes (1), or No (0)	Yes = 32.1%; No = 67.9%

^a See also Table 4.2 for the 17 independent variables used in both Chapters 4 and 5.

^b Descriptive results were weighted to account for oversampling of rural residents.

Table 5.2. Descriptive results of explanatory dependent variables (weighted to account for oversampling of rural residents) used to designate particular black bear recovery strategies in East Texas.

Variable ^a (Management strategy; <i>n</i>)	Descriptive results (% respondents)
Natural (995)	Yes = 38.4; No = 30.2; Unsure = 31.4
Assist (986)	Yes = 32.1; No = 36.2; Unsure = 31.7
Restock (991)	Yes = 49.7; No = 22.5; Unsure = 27.7
No bear (981)	Strongly agree = 2.1; Agree = 4.1; Unsure = 20.8; Disagree = 41.1; Strongly disagree = 31.8

^aResults from Pearson correlation (*r*) between the dependent variables are as follows (all significant at $P < 0.001$): Natural–Assist = -0.553 ; Natural–Restock = -0.345 ; Natural–No bear = -0.120 ; Assist–Restock = 0.654 ; Assist–No bear = -0.434 ; Restock–No bear = -0.524 .

Table 5.4. Multivariate analysis predicting ordinary least squares regression model^a for assessing support for black bear management strategies.

Independent variable	Dependent variable											
	Natural ^b				Assist ^c				Restock ^d			
	β	t	P	β	t	P	β	t	P	β	t	P
Community type	-0.040	-0.820	0.413	0.002	0.052	0.959	-0.035	-0.835	0.404	0.001	0.027	0.979
Number <18	-0.171	-3.259	≤0.001*	0.051	1.042	0.298	0.082	1.798	0.073	-0.060	-1.483	0.139
Pets	0.068	1.446	0.149	-0.052	-1.189	0.235	0.001	0.033	0.973	0.002	0.066	0.947
Sex	0.092	1.819	0.070	-0.114	-2.414	0.016*	-0.018	-0.405	0.686	0.064	1.641	0.101
Age	-0.089	-1.359	0.175	-0.078	-1.273	0.204	0.003	0.051	0.960	0.048	0.953	0.341
Education	-0.002	-0.044	0.965	-0.079	-1.744	0.082	-0.036	-0.866	0.387	0.034	0.924	0.356
Income	-0.090	-1.771	0.077	0.087	1.834	0.067	0.053	1.211	0.226	-0.085	-2.169	0.031
Organization member?	-0.071	-1.460	0.145	0.069	1.514	0.131	0.048	1.145	0.253	-0.011	-0.308	0.758
Utilitarian activity	-0.138	-2.455	0.014*	0.051	1.042	0.298	0.107	2.202	0.028*	0.067	1.545	0.123
Passive-appreciative activity	-0.047	-0.829	0.408	0.149	2.863	0.004*	0.142	2.889	0.004*	-0.043	-0.989	0.323
Work-related activity	-0.072	-0.110	0.122	-0.010	-0.382	0.298	0.015	0.166	0.632	0.025	0.190	0.554
Time in area	-0.017	-0.318	0.750	0.029	0.589	0.556	-0.017	-0.381	0.704	0.097	2.372	0.018
Livestock	-0.043	-0.914	0.361	0.025	0.575	0.566	0.001	0.018	0.985	-0.070	-1.925	0.055
Knowledge	0.029	0.560	0.576	-0.059	-1.351	0.177	-0.065	-1.593	0.112	-0.170	-4.243	≤0.001*
Acres owned	0.107	2.267	0.024*	0.028	0.578	0.564	-0.073	-1.631	0.104	0.021	0.573	0.567
Stratum	-0.076	-1.493	0.136	0.039	0.828	0.408	0.069	1.562	0.119	0.005	0.118	0.906
See bear	-0.050	-1.099	0.273	0.027	0.627	0.531	0.014	0.366	0.715	0.018	0.511	0.609
Interest	-0.058	-1.205	0.229	-0.008	-0.167	0.867	0.060	1.413	0.158	0.027	0.704	0.482
Worry	0.193	4.051	≤0.001*	-0.194	-4.300	≤0.001*	-0.201	-4.868	≤0.001*	0.249	6.780	≤0.001*
Want	0.006	0.111	0.912	0.218	4.636	≤0.001*	0.425	9.728	≤0.001*	-0.475	-12.177	≤0.001*
Live	0.006	0.111	0.912	0.009	0.207	0.836	-0.031	-0.757	0.450	-0.027	-0.727	0.468

^aStandardized coefficients reported. An (*) denotes significance at the 95% confidence level.

^b $R^2 = 0.173$ (Adj. $R^2 = 0.134$), $F = 4.455$, $P \leq 0.001$

^c $R^2 = 0.281$ (Adj. $R^2 = 0.247$), $F = 8.247$, $P \leq 0.001$

^d $R^2 = 0.383$ (Adj. $R^2 = 0.354$), $F = 13.218$, $P \leq 0.001$

^e $R^2 = 0.514$ (Adj. $R^2 = 0.491$), $F = 22.285$, $P \leq 0.001$

CHAPTER 6

SPATIAL ANALYSIS OF ATTITUDES TOWARD PROPOSED MANAGEMENT STRATEGIES FOR A WILDLIFE REINTRODUCTION

In collaboration with

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Abstract

Wildlife managers regularly incorporate human attitudes into decisions involving wildlife conservation. Knowing the spatial distribution of particular attitudes may further assist managers in determining distribution of support of or threats against wildlife species. Using results from a mail survey and SaTScan 4.0, we assessed the spatial distribution (clustering) of attitudes toward several management strategies for the recovery of black bear in and around Big Thicket National Preserve, Texas. Statistically significant clustering occurred for two attitudes: 1) non-support for a natural (non-human assisted) increase in the bear population near the Angelina National Forest and 2) strong disagreement toward total exclusion of bears from southeastern Texas within the relatively urban Orange County. In addition, respondents closer to the preserve, a potential black bear release site, were more likely to support exclusion of bears. Analyses such as this can greatly assist managers in planning public outreach and evaluation of social feasibility for wildlife reintroductions.

6.1. Introduction

As the human population of previously rural areas increases, there are an increasing number of human interactions with wildlife. This escalation in human-wildlife interactions has led to a new paradigm in wildlife management; rather than focusing primarily on the ecological needs of species, managers increasingly appreciate the need to incorporate human dimensions into wildlife management decision-making (Riley et al. 2002). As a key step in understanding the human component of management, many studies have assessed socioeconomic and demographic variables that affect stakeholder attitudes toward a specific species (Bath and Buchanan 1989; Kellert 1991; Lohr et al. 1996).

Attempts to elucidate attitudes about a species are exceptionally difficult for reintroductions. Although researchers are able to identify potential habitat for a species, it is nearly impossible to determine *a priori* whether (1) a species will use habitat that is perceived as suitable, and (2) whether and how human-wildlife interactions will occur. Insights about potential habitat may be gained from other ecological research involving the target species. However, projecting results of human-wildlife interactions is much more complex, and thus can only be attempted by gathering attitudinal and (anticipated) behavioral information directly from people. Assessing human opinions of a species that is a target for reintroduction, as well as how attitudes are distributed across space, may allow researchers to identify locations where support or lack of support exists for a species reintroduction. Spatial knowledge of attitudes may permit managers to identify locations where humans' attitudes are particularly favorable for a reintroduction (e.g., supporters may adapt land use practices for habitat management), as well as potentially

hostile locations where humans may pose a threat to the success of a reintroduction (e.g., harassment of the species).

Spatial analyses of data have been used for research in many disciplines including public health (Knox, 2005), geography (Bailey and Gatrell 1995), human ecology and agriculture (Naughton-Treves 1997; Sitati et al. 2003), environmental valuation (Brown 2005), and wildlife ecology (Mather et al. 1996; Kie et al. 2002). In the case of public health, for instance, researchers seek to link morbidity rates to environmental factors. For example, Knox (2005) suggested a relationship between childhood cancers and prenatal proximity to emissions from large concentrations of industrial fossil fuel combustion in Great Britain. In another study the malaria-like infection Human Babesiosis exhibited a clumped distribution related to tick density, which may be used to predict areas of risk of human infection (Mather et al. 1996).

Variation in attitudes toward a particular species in different locations has also been explored. For example, Bowman (2001) surveyed landowners to determine whether differences in attitudes toward black bears existed between areas of large (Arkansas) and small bear populations (Mississippi). Neither demographic variables nor knowledge about bears differed between the two locations. However, respondents in Arkansas, who collectively have experienced more bear damage to crops, were less likely than Mississippians to support increasing the bear population size. Comparative spatial studies of attitudes have also been completed for wolf reintroductions (Pate et al., 1996), grizzly bear restoration (Merrill et al. 1999), red panda protection (Fox et al. 1996), black bear population expansion (Peyton et al. 2001), and cougar management (Riley and Decker 2000b). Bowman et al. (2004) used a demographic model to predict support for

black bear restoration throughout Mississippi. Each of the foregoing studies has suggested the importance of assessing attitudes in different locations. To date, however, we are unaware of any studies that have applied spatial analysis of attitudes to assess distribution of individual survey responses. Therefore, our goal is to assess the spatial distribution of attitudes in the context of a potential black bear reintroduction.

The historical range of the Louisiana black bear (*Ursus americanus luteolus*) included all of Louisiana, southern Mississippi, and southeastern Texas (BBCC 1997). Widespread timber extraction and extensive hunting led to the near extinction of the subspecies by the early 1900s. By the second half of the 20th century, only two isolated populations remained, both of which were in eastern Louisiana. Beginning in the 1990s, wildlife managers and bear conservation groups in Louisiana led an effort, through public outreach, to build public support for bear recovery in Louisiana. The Black Bear Conservation Committee and US Fish and Wildlife Service created recovery plans, an objective of which was to restore the Louisiana black bear throughout its historical range (Bowker and Jacobson 1995; BBCC 1997). To date, recovery in Louisiana has been successful (Van Why 2003), and feasibility analyses were completed for Mississippi with positive results (Shropshire 1996; Bowman 1999).

Although there is no known breeding population in eastern Texas, the number of black bear sightings has increased during the past decade. These bears are likely transients from bear populations in Louisiana, Arkansas, and/or Oklahoma. The number of increased sightings prompted the creation of a bear management plan for both eastern and western Texas by the Texas Parks and Wildlife Department. The ultimate goal of the management plan is to restore habitat for the future reestablishment of black bear as a

viable ecosystem component in eastern Texas (TPWD 2005). Short-term objectives (over the next 15 years) include public coordination, communication, outreach and information dissemination, habitat management, and research (TPWD 2005).

Big Thicket National Preserve (BTNP) is targeted for initial steps for bear recovery. BTNP was established as the nation's first National Preserve in 1974 to protect 11 unique ecosystems found within its boundaries. Since establishment, BTNP has also been designated as a UNESCO International Biosphere Reserve, an American Bird Conservancy Globally Important Bird Area (IBA), and member of the United States Man and Biosphere Program. The preserve's 12 land and river corridor management units together total 39,256 ha. Each preserve unit alone is not large enough to contain a viable black bear population, so bears that live within the preserve are likely to wander beyond the preserve's borders. Because private land and residences surround the preserve units, it is essential to determine if local residents will be tolerant of bear presence.

The objectives of this research were to: (1) ascertain the spatial distribution of residents' attitudes across the study area toward potential bear recovery strategies for the southern portion of eastern Texas, and (2) determine whether distance from BTNP is a factor in resident attitudes. We assessed support for three general management options for black bears (described in methods section): (1) natural (non-assisted) recovery, (2) human-assisted reintroduction (which included two equivalent strategies with slightly different wording were assessed), and (3) no bear recovery.

6.2. Methodology

6.2.1. Study area and survey design

Please refer to Sections 4.2.1 (including Figure 4.1) and 4.2.2 for descriptions of the study area and survey design, respectively.

6.2.2. Dependent variables

The four dependent variables described and used in Chapter 5 (see Section 5.2.2) analyses were applied to spatial analyses.

6.2.3. Non-response follow-up

Please refer to section 4.2.4 for discussion of the non-response follow-up survey.

6.2.4. Spatial analysis

We used DeLorme Street Atlas USA® 2004 (DeLorme, Yarmouth, Maine, USA) to plot approximate locations of respondent's addresses. Use of a GPS to identify location of addresses, although more precise, was not a viable option for reasons of respondent confidentiality. For addresses that were not available through use of DeLorme Street Atlas USA®, a random point was selected from within the respondent's respective zip code using ArcView GIS 3.2 (Environmental Systems Research Institute, Inc.). For spatial analysis, we converted respondent location information from Latitude-Longitude to UTM XY coordinates.

To evaluate the spatial distribution, or clustering of responses, we used SaTScan version 4.0 (Kulldorff et al. 1998). SaTScan software was designed to evaluate spatial

and temporal distribution of designated events (Kulldorff and Nagarwalla 1995; Kulldorff 1997). This software has been used to explore the spatial distribution of breast cancer (Kulldorff et al. 1997), chronic wasting disease in deer (Joly et al. 2003), bacterial infections of herbivores (Smith et al. 2000), West Nile virus (Mostashari et al. 2003), learning disabilities in children (Margai and Henry 2003), and toxic parasites (Miller et al. 2002). Because these examples all involve assessment of risk to a particular population, we determined that SaTScan could also be used for spatial assessment of human attitudes toward particular black bear population recovery strategies. This is based on the assumption that residents who are unsupportive of a recovery program may represent sources of greater risk to black bears if a recovery occurs (e.g., illegal killing).

The SaTScan's spatial scan statistical procedure involved the creation of three data input files: (1) a case file containing the unique identification number for each respondent and corresponding binary variable on which a one represented a "yes" response to a particular variable and zero equaled all other responses (i.e., no, unsure), (2) a population file containing the unique identification number for each respondent and the binary opposite to the case file (i.e., 0 = "yes" in the case file and all else = 1), which serves as a control, and (3) a geographic file containing the X and Y coordinates for each respondent. The scan statistic applied an infinite number of geographic circles to each "yes" response location (observed responses) with the maximum circle size equal to half of the total study area, and determined which circles contained a greater number of other "yes" responses than spatial randomness (expected responses). In other words, by applying geographic circles to each response, clusters of responses that were more likely to occur than by chance alone were identified. This procedure was based on the

alternative hypothesis that there is a greater rate of occurrence of a particular event (in our case a “yes” response) within a particular set of geographic circles than outside of the circles. We applied a likelihood function for a Bernoulli model, calculated as:

$$(c/n)^c (1-c/n)^{(n-c)} ([C-c]/[N-n])^{(C-c)} (1-([C-c]/[N-n]))^{(N-n)-(C-c)} I(x)$$

where C = the total number of “yes” responses (i.e., responses) across the study region, c = the number of “yes” responses within the particular geographic circle, N = the total number of “yes” responses plus controls (i.e., “no,” “unsure”) within the data set, and n = the total number of “yes” responses and controls in an identified cluster. Because our objective was to identify high rates of a particular response, $I(x) = 1$ when the geographic circle had more cases than expected for the null hypothesis (i.e., the rate of occurrence of a given response was no different from random), and $I(x) = 0$ for all other instances. The cluster least likely to have occurred by chance was identified as the main cluster, and all other identified clusters were called secondary clusters. A maximum likelihood ratio test statistic was calculated for all identified clusters. The p value for each maximum likelihood test statistic and distribution compared to the null hypothesis was calculated by repeating the same procedure under 999 random replications (SaTScan’s default number) of the same data for the null hypothesis using Monte Carlo simulation.

6.2.5. *Distance from the preserve*

We used the Nearest Features extension (version 3.8) of ArcView to calculate the distance from each respondent to the nearest boundary of BTNP. For each of the dependent variables, we used a Pearson’s correlation to determine whether distance from

the preserve boundary was related to support (or lack thereof) for particular strategies. All alpha values were defined at the 95% confidence level.

6.3. Results

Differences in support for each of the four potential recovery strategies are discussed in Chapter 5 and displayed in Table 5.2. The spatial scan statistic procedure identified 67 clusters among 14 responses (i.e., three variables with three possible responses each; one variable with five possible responses; Table 6.1). Although a main cluster was identified for each response for each variable, the number of secondary clusters varied between variables. Several secondary clusters for a particular variable had similar Log-likelihood ratios, indicating that the individual points were very close together. There were two statistically significant clusters identified (Figure 6.2): (1) non-support for *Natural* (Log-likelihood ratio = 9.88, $p = 0.043$), located in the north-central portion of the study area in proximity to the Angelina National Forest, and (2) strongly disagree for *No bear* (Log-likelihood ratio = 12.19, $p = 0.005$), located in the southeastern, and suburban, portion of the study area.

There was a negative but non-significant relationship between distance from the preserve and support for *Natural* ($r = -0.022$, $p = 0.493$), *Assist* ($r = -0.018$, $p = 0.576$), and *Restock* ($r = -0.048$, $p = 0.134$). However, a weak significantly negative relationship existed between distance from preserve and support for the *No bear* strategy ($r = -0.065$, $p = 0.045$). In other words, respondents closer to the preserve were more likely to support *No bear*.

6.4. Discussion

As noted above, short-term objectives of the Texas black bear plan include extensive public outreach. Knowing the distribution of attitudes toward potential bear strategies can provide guidance for managers when planning public information and outreach sessions. For example, if a large number of residents located in proximity to each other share antagonistic attitudes toward a reintroduction, bear managers may concentrate outreach efforts on the location to better understand why such attitudes occur.

Few significant clusters of attitudes toward particular strategies were obvious. The only statistically significant clustering that occurred here were non-support for *Natural* (non-human assisted) and strong disagreement with *No bear* (excluding bears from the area). Random chance and lack of a complete enumeration of all area residents (or even substantially higher coverage) are potential reasons why only these two clustering events occurred. Clustering of *Natural* also may be a result of: (1) the individual respondents do not want bears in the area, or (2) the individual respondents support more aggressive bear recovery strategies (i.e., reintroduction and restocking). Both of these reasons are supported. Of the 11 respondents within the statistically significant cluster, eight indicated support for either the *Assist* or *Restock* strategies, and two indicated support for the *No bear* strategy (Morzillo, unpublished data). From the same group, one respondent indicated “unsure” about both the *Assist* and *Restock* strategies, but did not support *No bear*. For respondents who supported pro-bear strategies, these results may suggest that residence near the national forest is related to an interest in nature and wildlife. In fact, for other items in our survey, all eleven respondents indicated an interest in wildlife (Morzillo, unpublished data), but only the

eight who supported a pro-bear strategy indicated that they would like to see bears in the area. Of course, generalizing from these 11 individuals to all of the residents in the area they represent is problematic because of their small number.

For *No bear*, the significant cluster of respondents who strongly disagreed (i.e., they did not support excluding bears altogether) was located within the most urbanized part of our study area. Results from both Lohr et al. (1996) and Bowman (1999) suggested that residents of urbanized communities typically have more positive attitudes toward restoration of wolves and bears, respectively. Just the opposite, Peyton et al. (2001) reported that residents in the heavily populated southern portion of Michigan preferred limited bear presence even though the Michigan bear population is expanding southward. However, results from our survey did not indicate that members of this cluster were necessarily more likely to support bear recovery. Of the 24 respondents within the *No bear* cluster, only five indicated support for *Natural*, 12 for *Assist*, and 17 for *Restock*. Between the three variables, there were also 20 “unsure” responses, which suggests that even though a commonality existed for one management strategy among individuals of these particular clusters, respondents were not in unanimous agreement about an optimum strategy.

The limited number of statistically significant clusters related to particular strategies implies that public outreach will likely be challenging. First, bear managers will likely be met with a plethora of different opinions when outreach takes place in any location, which makes generalizing results to a larger area difficult (e.g., census block groups; Bowman et al. 2004), as well as customizing outreach programs for specific locations. Second, movement of urban residents into rural areas may result in

amalgamation of urban and rural wildlife-related attitudes and values. Many residents, particularly within the southern half of the study area, make long commutes to jobs in cities such as Houston and Beaumont from rural communities. Attitudes of such residents may be similar to attitudes of residents within larger communities (e.g., more positive attitudes toward particular carnivores; Lohr et al. 1996; Bowman 1999) may be increasingly predominant among rural residents.

The negative relationship between distance from the preserve and support for *Natural*, *Assist*, and *Restock* was not significant, which further indicates a wide variety of attitudes toward bear recovery exist within the study area. But respondents closer to BTNP were significantly more likely to support the *No bear* strategy. This significant relationship, although relatively weak, is critical information, especially because BTNP is a target area for bear recovery. Bears that wander beyond the preserve's borders may be met with hostile actions from residents.

The suggestion that residents near BTNP are less supportive of a bear recovery than residents further from the preserve may initially pose a big challenge to bear recovery efforts. Bear managers must determine if conditions exist for which non-supporters near the preserve will be willing to tolerate bear presence (e.g., movement of bear if nuisance problems occur; financial incentives), or if such residents will immediately threaten a bear's well-being (e.g., shoot it immediately or use harmful agents such as poisons). Should the bear population expand its range across the whole study area, the possibility exists that attitudes across the study area will change. Having residents throughout the study area who support a black bear recovery via *Assist* or *Restock* may allow for widespread initial support for TPWD's bear management goals.

but support may decrease if bears become a nuisance at any time and in any given location. Therefore, a large management challenge is to continuously monitor local attitudes.

Unfortunately, several development proposals are threatening the ecologically fragile landscape of BTNP and the surrounding area. Decisions involving divestment of timberlands and urban development may drastically change the area's landscape. Rapidly growing cities in Texas, such as Houston, Austin, San Antonio, and Dallas-Ft. Worth, are playing a role in plans for an eight-lane superhighway and water diversion projects. These threats have resulted in BTNP's inclusion among the National Parks Conservation Association's (NPCA) ten most endangered parks in the United States (NPCA, 2004). Land use decisions that threaten ecosystems are common in areas targeted for species recovery programs. Spatial analysis of attitudes like that in the current study can provide managers with insight into where local support and non-support exist for conservation and species management goals.

Table 6.1. Analysis of attitudes toward potential black bear recovery management strategies using the spatial scan statistic.

Management strategy	Cluster ^a	Number of cases ^b (population size)	Expected risk	Actual risk	Log-likelihood ratio	P-value
Natural (support)	M	11 (13)	5.28	2.08	5.44	0.818
	S	6 (6)	2.44	2.46	5.43	0.836
	S	14 (18)	7.31	1.91	5.26	0.958
	S	8 (9)	3.66	2.19	4.63	0.972
	S	17 (24)	9.75	1.74	4.59	0.983
Natural (non-support)	S ^c	5 (5)	2.03	2.46	4.52	0.984
	S ^c	5 (5)	2.03	2.46	4.52	0.984
	S ^c	5 (5)	2.03	2.46	4.52	0.984
	M	10 (11)	3.06	3.26	9.88	0.043* ^d
	S	17 (25)	6.97	2.44	8.93	0.121
	S	6 (6)	1.67	3.59	7.72	0.307
	S	39 (86)	23.96	1.63	6.58	0.455
	S	6 (7)	1.95	3.08	5.16	0.891
	M	144 (364)	114.70	1.26	8.54	0.128
	S	6 (6)	1.89	3.17	6.97	0.507
Natural (unsure)	S	5 (5)	1.58	3.17	5.80	0.879
	M	55 (112)	35.81	1.54	8.05	0.141
Assist (support)	S	22 (36)	11.51	1.91	6.69	0.557
Assist (non-support)	M	21 (31)	11.40	1.84	6.31	0.550
	S	10 (12)	4.41	2.27	5.58	0.847
	S	8 (9)	3.31	2.42	5.37	0.871
	S	7 (8)	2.94	2.38	4.48	0.993
	S	10 (13)	4.78	2.09	4.42	0.996
Assist (unsure)	S	4 (4)	1.47	2.72	4.02	0.997
	M	94 (239)	74.70	1.26	4.67	0.963
	S	4 (4)	1.25	3.20	4.67	0.963

Table 6.2. (Cont'd.)

Restock (support)	M	17 (19)	9.33	1.82	7.17	0.304
	S	10 (10)	4.91	2.04	7.17	0.395
	S	9 (9)	4.42	2.04	6.44	0.643
	S	7 (7)	3.44	2.04	5.01	0.981
Restock (non-support)	M	9 (13)	3.20	2.81	5.81	0.711
	S	23 (50)	12.32	1.87	5.69	0.736
	S	4 (4)	0.99	4.06	5.63	0.948
Restock (unsure)	M	11 (17)	4.46	2.46	5.61	0.739
	S	4 (4)	1.05	3.81	5.37	0.845
	S	4 (4)	1.05	3.81	5.37	0.845
	S	5 (6)	1.58	3.17	4.32	0.991
No bear (strongly agree)	M	3 (6)	0.18	16.78	6.12	0.509
	S	2 (3)	0.09	22.37	5.12	0.687
	S	3 (9)	0.27	11.18	5.13	0.833
	S	2 (4)	0.12	16.78	4.38	0.900
	S	4 (23)	0.69	5.84	4.21	0.944
	S	2 (5)	0.15	13.42	3.81	0.966
	S	2 (8)	0.24	8.39	2.77	0.999
No bear (agree)	M	2 (2)	0.10	20.27	6.06	0.437
	S	2 (2)	0.10	20.27	6.06	0.437
	S	2 (2)	0.10	20.27	6.06	0.437
	S	2 (3)	0.15	13.51	4.20	0.963
	S	2 (4)	0.20	10.14	3.38	0.998
	S	2 (4)	0.20	10.14	3.38	0.998
No bear (unsure)	M	17 (41)	7.42	2.29	6.38	0.624
	S	3 (3)	0.54	5.53	5.15	0.857
	S	3 (3)	0.54	5.53	5.15	0.857
	S	3 (3)	0.54	5.53	5.15	0.857
	S	3 (3)	0.54	5.53	5.15	0.857

Table 6.2. (Cont'd.)

No bear (disagree)	S	3 (3)	0.54	5.53	5.15	0.857
	S	10 (21)	3.80	2.63	4.90	0.984
No bear (strongly disagree)	M	8 (8)	3.45	2.32	6.78	0.532
	S	19 (26)	11.20	1.70	4.94	0.988
	M	19 (24)	7.42	2.56	12.19	0.005*
	S	5 (5)	1.55	3.23	5.90	0.660
	S	5 (5)	1.55	3.23	5.90	0.668
	S	4 (4)	1.24	3.23	4.71	0.954
	S	4 (4)	1.24	3.23	4.71	0.954
	S	4 (4)	1.24	3.23	4.71	0.954
	S	4 (4)	1.24	3.23	4.71	0.954
	S	4 (4)	1.24	3.23	4.71	0.954
	S	22 (42)	12.99	1.69	4.36	0.998
	S					

^aM = Main cluster; S = secondary cluster^bNumber of "yes" responses within a particular cluster^cSecondary clusters for which statistics are similar are a result of very close location within a group^dAn asterisk (*) indicates significance at the 95% confidence level

Figure 6.1. The 12-county region in southeastern Texas used to assess the spatial distribution of resident attitudes toward potential black bear recovery strategies from which survey participants were selected. These counties include and surround Big Thicket National Preserve (shaded areas in circle).

Figure 6.1

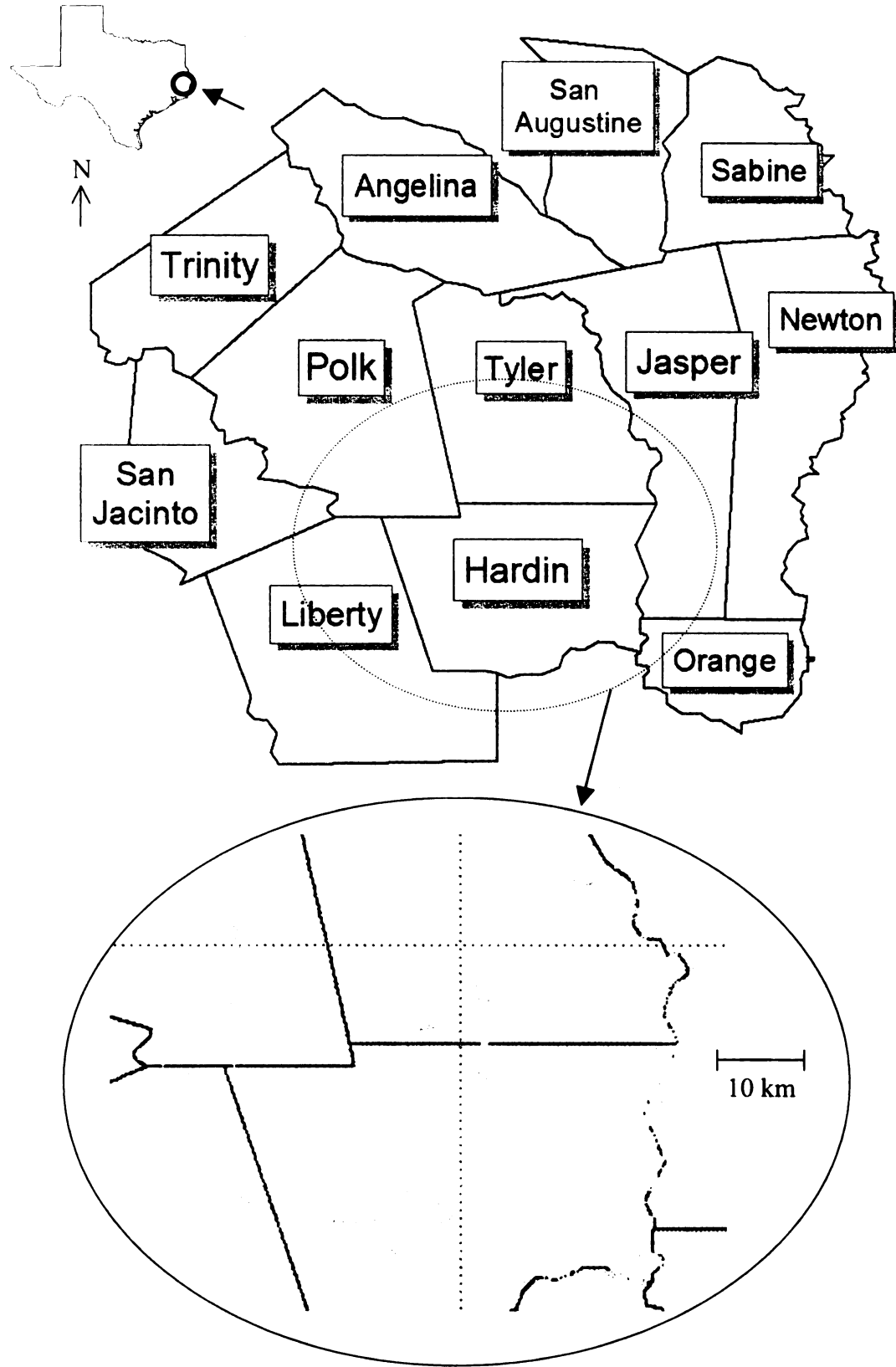




Figure 6.2. Statistically significant clusters of non-support responses for the *Natural* (solid squares) and the strongly disagree responses for *No bear* (solid triangles) strategies for black bear recovery. Also shown are the USDA proclamation boundaries for the (clockwise from bottom left) Sam Houston, Davy Crockett, Angelina, and Sabine National Forests (striped) and Big Thicket National Preserve (shaded).

CHAPTER 7

INTEGRATING ECOLOGY AND SOCIOECONOMICS FOR SPECIES REINTRODUCTIONS

In collaboration with

Jianguo Liu

Abstract

To mitigate human impacts on wildlife species and their habitat, there are increasing efforts to recover populations of locally extirpated species. Integration of ecological and socioeconomic data is necessary for species recoveries targeted for human-dominated landscapes. We developed a systems framework and model for simulating how ecological and socioeconomic processes may affect feasibility of a Louisiana black bear (*Ursus americanus luteolus*) reintroduction in and around Big Thicket National Preserve (BTNP), Texas. Based on analysis of timberland and bear habitat, as well as social survey data, model results suggested that a declining trend of timberland area over time is likely to continue in the future. This has resulted in a decrease in the area of bear habitat among timberlands over time, but the magnitudes of habitat change have varied across counties. Although the gender ratio of each county is projected to remain relatively constant, model results suggested increases in median age across the study area, ranging from an additional 3.9 to 11.8 years, by 2020. From multi-criteria analysis, Sabine, Trinity, and San Augustine Counties were identified as the most ecologically feasible for bear recovery, and Newton, Jasper, and Tyler were the most socially feasible. Areas with high ecological and social feasibility did not overlap. National forests may be better potential bear release sites than BTNP, as their locations correspond to the before mentioned counties. Public outreach aimed at increasing residents' knowledge about bears, as well as gaining insight into why residents do or do not support bear recovery are necessary before deciding whether and where bears should be released. The model framework provides a useful approach for assessing feasibility of reintroductions may be adapted for conservation programs in other locations.

7.1. Introduction

Human activity is causing major changes to the earth's ecosystems (Soulé 1991; Noble and Dirzo 1997; Vitousek et al. 1997; Chapin et al. 2000), and these can be detrimental to wildlife species and their habitat (Liu et al. 2001; Sillero-Zubiri and Laurenson 2001; Parks and Harcourt 2002). To mitigate human impacts on wildlife habitat there are increasing efforts to recover populations of locally extirpated species (Reading and Clark 1996; Breitenmoser et al. 2001; Woodroffe 2001a). Consequently, even if researchers determine that a reintroduction is ecologically feasible within a particular location (e.g., adequate habitat area; van Manen 1991), this alone may not be enough to ensure a successful reintroduction and species population establishment in areas dominated by humans.

Particularly for large and widely wandering species, an additional challenge for reintroduction programs is that species may wander into areas of human activity while in search of new habitat, members of the opposite sex, or food. Wildlife does not recognize political, management, or ownership boundaries (Soulé and Sanjayan 1998; Liu and Taylor), and movement may cause an individual to traverse land with a multitude of uses and ownerships. When species wander into human-dominated areas, there is potential uncertainty with respect to how humans will react to a species' presence (Woodroffe and Ginsberg 1998; Merrill et al. 1999). In such cases, all lands become important for conservation (O'Connell and Noss 1992).

Many researchers have studied either impacts of human activity on wildlife or human attitudes toward wildlife, but rarely simultaneously. Understanding these interactions is critical to better understand the intricacies of real world conservation

issues. Lack of integrating ecology and socioeconomics has led to many conservation failures. For example, a great quantity of ecological research has been collected about giant panda (*Ailuropoda melanoleuca*) habitat. Until recently, socioeconomic research was almost nonexistent. As a result, the Chinese government, even when providing free housing, largely failed to move residents out of Wolong Nature Reserve (established in 1975 for panda protection). This resulted from lack of understanding two important social needs: (1) elderly residents were hesitant to relocate and adapt to new lifestyles, and (2) there was no available land in proximity to the free housing on which this agriculture-based community could establish farms (Liu et al. 2001). Ability to integrate ecology and socioeconomics will increase effectiveness of policy makers' abilities to create feasible and effective solutions to meet the needs of wildlife and promote human welfare over both short and long terms (Holling and Meffe 1996; Liu et al. 1999).

Systems modeling offers a useful approach to integrate data from different disciplines that are related to factors affecting wildlife and their conservation (Liu 1993; Liu et al. 1995; An et al. 2001). Related to resource conservation, systems modeling tools have been developed for analysis of wildlife populations (Liu 1993), household level decision-making processes (An et al. 2001), and assessing the effects of different management strategies on a particular resource (Liu et al. 1994; Liu et al. 1995; Turner et al. 1995; McDonald et al. 2001).

The few systems models developed for wildlife reintroductions have focused mainly on ecological factors that may influence reintroduction success. For example, van Manen and Pelton (1997) developed a systems model to determine the probability of reintroduction success for black bears in the Big South Fork area of Kentucky and

Tennessee. Similar to results of van Manen and Pelton (1997), other studies have used models to assess how temporal changes in individual ecological factors may affect post-reintroduction species populations (South et al. 2001; Steury and Murray 2004). A major weakness of most modeling tools related to reintroductions is the lack of incorporation of how human-influenced factors that affect reintroduction feasibility. Bowman et al. (2004) used results from a landowner survey, demographic data, and spatial distribution of bear habitat to develop a spatially explicit model for predicting attitudes toward black bear restoration across Mississippi. However, this study did not seek to project how changes in demographic and ecological factors in the future may affect dynamics of support for bear restoration.

We developed a framework for simulating how ecological and socioeconomic processes may affect feasibility of a Louisiana black bear (*Ursus americanus luteolus*) reintroduction in and around Big Thicket National Preserve (BTNP), Texas. The Louisiana black bear historically existed throughout all of Louisiana, southeast Texas, and southern Mississippi (Larivière 2001). Overharvest and habitat destruction led to near demise of this subspecies during the early 1900s (BBCC 1997). During the second half of the 20th century, only two small remnant populations of the subspecies existed, both in eastern Louisiana. An extensive public outreach campaign during the 1990s led to recovery efforts for the subspecies in Louisiana, as well as the creation of two management plans that focused on recovery throughout the historical range (BBCC 1997; Bowker and Jacobsen 1995). Thus far, recovery in Louisiana has been successful (Van Why 2003; Benson 2005) and feasibility analyses have been completed for Mississippi (Shropshire 1996; Bowman 1999).

In eastern Texas, there have been an increased number of black bear sightings during the past decade (N. Garner, Texas Parks and Wildlife Department (TPWD), *personal communication*). Because no breeding population of bears is known to exist in Texas, it is likely that these sightings are transient bears from Arkansas, Oklahoma, or Louisiana that wander into Texas. Regardless, the sightings have prompted creation of an East Texas black bear management plan. Objectives of the management plan for the next 15 years include public coordination, communication, outreach and information dissemination, habitat management, and research (TPWD 2005). The ultimate goal is to restore habitat for the purpose of reestablishing black bear as a viable ecosystem component in southeast Texas (TPWD 2005).

By integrating interdisciplinary data, this systems model is designed to lend insight into the underlying mechanisms that may influence bear habitat over time. Remote forests containing a variety of fruit and mast producing species are important components of bear habitat (Pelton 1982; Larivière 2001), and changes in the area and distribution of forested land will affect habitat. A majority (>75%) of land in proximity to BTNP is managed privately for timber production or publicly by the federal government (i.e., BTNP and four national forests). In addition, there is a local population of human residents. Therefore, land use affecting bear habitat, as well as human tolerance of bear presence, will be important factors that drive bear habitat dynamics.

Our first objective was to develop a systems model that incorporated bear habitat, land ownership, and socioeconomic variables affecting attitudes toward black bears in southeast Texas. Ideally, locations with a greater amount of habitat will also be more socially feasible and support a reintroduction. Much of the bear habitat in southeastern

Texas is contained within public land and private timberland in rural areas. If more highly suitable bear habitat (Pelton 1982; BBCC 1997; Larivière 2001; see Chapter 2) is available within a particular location, there may be less chance that bears will wander and come into contact with human activity. We evaluated our model at two future time points: (1) 10 years into the future (10 years after model parameterization, or 2010), and (2) 20 years into the future (20 years after model parameterization, or 2020). The year 2020 coincides with the end of the 15-year term of the present black bear management plan (TWPB 2005). Our second objective, based on results of the first objective, was to rank the counties within the study area in regard to both ecological and social feasibility for the planned black bear recovery. We next describe the study area, model structure and methodology used for parameterization and testing of the systems model, present the results of model implementation, and discuss the implications of the results for bear reintroduction management.

7.2. Methods

7.2.1. Study area

Our study area consisted of twelve counties in southeast Texas, which includes the 39,285-ha Big Thicket National Preserve (BTNP; Lat./Long. -94.36/30.38) and four National Forests (Angelina, Davy Crockett, Sam Houston, and Sabine; Figure 1). BTNP is unique in that it consists of 12 disjunct management units, seven of which are river corridors that connect larger non-corridor units. Approximately 500,000 residents live within the study area (US Census Bureau, Census 2000 data). Much of the area is rural, with numerous small towns throughout and one larger community (City of Lufkin) along

the northwestern boundary. The southern edge of the study area, which is also the most densely populated portion of the landscape, consists of suburban development from Houston and Beaumont.

7.2.2. Model design

We adapted three principles, as defined and described by Xie et al. (1999) for model design. First, we sought to design a simple model that could easily be reproduced for other species in other locations. A large portion of the raw data may be easily collected from government agencies (e.g., land cover images), or is publicly available on the Internet (e.g., census data). Although counties may be divided into sub-counties and census blocks, we focused this study at the county level because this is the smallest standard political unit for Texas. Unlike many other states in the midwestern and western United States, the Texas cadastre does not follow the Public Land Survey System of 1785 (i.e., township and range system set from a principal meridian), which makes divisions beyond the county level (although they do exist) inconsistent and complicated.

Second, the model must predict feasibility as consistently as possible across the landscape, which will be important for minimizing bear-human conflicts. If certain locations do not contain adequate bear habitat, or contain residents with negative attitudes toward black bears, then managers may want to closely monitor bears that unknowingly wander into these areas. Conversely, if particular locations contain a greater amount of habitat and positive attitudes toward bears, these may be better locations for bear release and management.

Finally, similar to objectives of Xie et al. (1999), this model was developed for the purpose of improving bear management and policymaking. We sought to create a user-friendly model that can be used by individuals with minimum modeling experience. A graphical user interface is useful for testing and simulating how changes in each variable may affect a preferred bear management scenario for a particular county. A major assumption of the model is that the human and natural landscapes are dynamic, meaning that the presence of habitat, particular landowners, and attitudes change over time. As new data become available, as well as demographic and ecological characteristics of the region change, bear managers may add data to the model to project how changes may affect local support for bears in the area. The Texas Parks and Wildlife Department may also use the systems model to refine management goals, plan public information forums, and ascertain the potential for bear reintroduction and management over the long term.

7.2.3. Model structure and quantification

The conceptual framework for this research is illustrated in Figure 7.2. Our model consisted of four components: (1) Timberland, (2) Habitat, and (3) Social, and (4) Multi-criteria evaluation. The timber component (see Section 7.2.3.2) directly affects the habitat component (see Section 7.2.3.3.). The location of and harvest strategies used for timber management directly affect the quantity, quality, and distribution of bear habitat. For example, heavily managed fast-growing tree species (e.g., pine plantation) may be favored for timber production. However, clearcuts can result in an extremely rigid boundary and may provide limited cover until vegetation fills in the area. As a result,

bear managers may prefer selective harvest of particular size stands and enhanced management for hardwood mast-producing species (Weaver et al. 1990). Important characteristics of black bear habitat include quantity (i.e., area), quality (i.e., highly suitable versus marginal), and distribution (Pelton 1982; Bowker and Jacobson 1995; BBCC 1997; Liu et al. 1999; Larivière 2001).

The social component (see Section 7.2.3.4) was developed as a separate model entity. Human support for bear presence may be affected by personal attitudes toward black bear, which may result from knowledge (or lack thereof) about bear, or concern about how bear management policies may affect land use by local residents. For example, federal mandates for bear habitat conservation may prohibit landowners from particular activities on their lands if it is known that a mother bear and her cubs are denning nearby. Such limitations on human activities may result in negative opinions about bears and bear managers. The data from the timber, habitat, and social component of the model were entered into a multicriteria analysis (see Section 7.2.3.5), used to spatially assess and rank the ecological and social feasibility of a reintroduction across all counties in the study area. We completed a sensitivity analysis (Haefner 1996) on all independent variables to determine how changes in median age and percent male values affect model results.

Stella (Higher Performance Systems, 1997) is a multi-level, hierarchical environment for model development and implementation that allowed us to create a simple model for management purposes. The model operated on a yearly cycle (i.e., one time step = one year).

7.2.3.1. Land classification

We designed a simple method of land classification to emphasize factors that will likely be influential in bear habitat dynamics. We divided land within the study area into three categories: (1) public land, (2) private timberland, and (3) other. We created several assumptions related to land ownership to simplify model creation. First, for public land, we assumed that changes in the total area of public land would be minimal over time and public land would remain under the current jurisdiction indefinitely. Second, although >90% of land in BTNP and >75% of National Forest land was classified as highly suitable (see Chapter 2 and 3), we assumed that the area of highly suitable bear habitat among public lands would remain consistent over time. Third, because bears are adaptable to many different habitats but prefer refuge from human activity (Pelton 1982). Therefore, we assumed that the permanent designation of public land as such be of greater importance to long term maintenance of bear management than minimal changes in habitat among timberlands, which could be sold and converted to a different land use at any time. Fourth, we concentrated modeling efforts on lands within the public and private timberland categories as they are of most interest to bear managers. Therefore, we assumed that changes within the remaining approximately 20% of “other” land within the study area was, at this time, of minimal interest to bear managers compared to changes in timberlands. As a result of these assumptions, we focused our model construction on private timberlands.

7.2.3.2. Timberland component

The objective of the timberland component was to simulate changes in the area of

privately owned timberland over time. We collected timberland data from the early 1970s, 1987, 1990, and 2002 from available land ownership maps (Acme Map Company, Tyler, Texas), local timber landowners, and the USDA Forest Inventory and Analysis National Program database (USDA Forest Service, Arlington, Virginia, USA). For each time period, we determined the area of land owned by private timber companies in each county (see also Chapter 3). Based on the difference in timberland area within each county from one time period to the next (e.g., area of timberland in 1987 and then in 1990), an estimated percent rate of change of timberland area for each county was calculated. For four time periods, this resulted in three different rates of change for each county. We assumed that sale of timberland (i.e., a decrease in timberland area) would take place only if selling would be economically beneficial to the landowner.

Several private timber landowners own land in more than one county, as determined from land ownership records. Therefore, rates of timber gain or loss occurred at the level of the study area. Also assuming that any timberland lost was no longer timberland, we assessed all rates of timberland change across all counties, which ranged from a net loss of -0.057% to a net gain of 0.026% per year. Plotting these rates on a graph produced a normally distributed probability function (one-sample Kolmogorov-Smirnov $Z = 1.186$, $P = 0.120$; Figure 7.3). Using the timberland area of each county as the baseline ($t = 0$) value, a random value from the range of the probability function was drawn to simulate the percentage of timberland gained or lost for each time interval within each county. If the random number was less than the mean value of the probability function, habitat was lost for the given time interval. If the random number was greater than the mean value of the probability function, habitat was gained for the

given time interval. By multiplying the area of timberland at time t by the randomly generated rate of change value for the given time interval, we determined the change in area of timberland from t to $t + 1$. By adding (or subtracting) the area of timberland calculated at each time interval to the total area at time t , we calculated the estimated changed and new total timberland area for $t + 1$. We repeated this process for each county. Figure 7.4 illustrates the model structure of the timberland component.

7.2.3.3. Habitat component

The objective of the habitat component was to simulate changes in highly suitable, suitable, marginal, and unsuitable habitat among timberlands over time. Using ERDAS Imagine 8.7 (Leica Geosystems GIS & Mapping, LLC, St. Gallen, Switzerland), we classified land cover data from the mid-1970s, mid-1980s, mid-1990s, and 2002 based on black bear ecology for the southern United States (Pelton 1982; Wagner 1990; Weaver et al. 1990; Marchinton 1995; Maehr et al. 2003; Larkin et al. 2004; see also Chapters 2 and 3). For each time period, we determined the proportion of area of each county's timberland that contained habitat of each of the four habitat categories.

To integrate the habitat component with the timberland component and spatially allocate results of changes in timberland across the study area, the change in each county's timberland area (gain or loss) for each time interval from the model's timberland component was used to quantify simulated changes in bear habitat among timberlands (Figure 7.5). The total amount of timberland gained and lost in each time interval was used to determine the total area of habitat in each county that was affected within the same time interval. If the amount of timberland change in the timberland

component was positive, then that amount of timberland was proportioned among and added to each of the four habitat classes within the habitat component. If the amount of timberland change in the timberland component was negative, then that amount of timberland was proportionally divided among and subtracted from each the four habitat classes. Because the model does not specify the detailed locations of changing habitat, we assumed that the amount of habitat within each class that was gained or lost in each time interval (i.e., proportionally added to or subtracted from each habitat class) followed the current pattern of habitat suitability for each county. For example, timberland within Angelina County was 62.4% highly suitable habitat. If the timberland component produced a gain of 1,000 ha of timberland within Angelina County for a particular time interval, then the total amount of highly suitable habitat within Angelina County would increase by 624 ha (62.4% of the total timberland gained) as a result of the increase of timberland.

7.2.3.4. Social component

The objective of the social component of the model was to assess how changes in particular socioeconomic variables are influential as factors in predicting the feasibility of a black bear recovery across different counties (Figure 7.6). During January-March 2004, we surveyed 3,000 local residents to assess attitudes toward black bears and local support for a black bear recovery. With a response rate of 40% after removing bad addresses and names of those who did not wish to participate ($n = 1,006$), we applied ordinary least squares regression (Babbie 1990, Sokal and Rohlf 1995) to determine particular socioeconomic variables that affected attitudes toward black bears and a bear

population increase (see Chapter 4), preferred bear recovery management scenarios (see Chapter 5), and spatial distribution of attitudes toward bears (see Chapter 6). We focused only on variables that affected attitudes toward black bears for model parameterization based on two assumptions. First, because the goal of this research is to develop a framework for determining the feasibility of a black bear reintroduction, we assumed that a reintroduction would take place in the future. Second, residents with positive attitudes toward bears are more likely than those with negative attitudes to support a reintroduction in the future, although this is not guaranteed (Lohr et al. 1996). Therefore, we assumed that attempting to foster positive attitudes toward and increasing knowledge about bears is an important first step before determining a specific recovery management method.

From our survey, six variables used to measure attitudes toward black bears were statistically significant (Table 7.1): (1) gender, (2) age, (3) participation in passive-appreciative activities related to wildlife, (4) duration of local residence, (5) knowledge about bears, and (6) whether the respondent has seen a bear in the wild. We then developed criteria for incorporating variable values into the model. Because our survey data were not representative at the county level, use of survey data for model parameterization of gender and age variables (for which better data are available) would have resulted in a misleading product. Therefore, we used more-reliable US Census Bureau data for model parameterization. Some historical data for gender and age were available from the US Census Bureau. Because males were more likely than females to have positive attitudes toward black bears (based on our survey data), we determined the percent of residents that were male within each county from census data, for which such information was available from 1990 and 2000. Because only two data points were

available, we calculated the average percent of residents who were male explicitly based on these two data values. For example, in Angelina County, 47.3% of residents were males in 1990. In 2002, 48.2% of residents were males. This resulted in a 0.019% rate of change in the percent of residents who were male between 1990 and 2000 (a 10-year period), or a 0.0019% annual rate of change. The 0.0019% rate of change was used in the model as the simulated rate of change in percent males in Angelina County over time. We repeated this calculation using census data for each county, and used the historical rate of change to project how each county's percent male residents would change in the future.

We also based model parameterization for age on data available from the US Census Bureau. Because younger residents were more likely to have positive attitudes toward black bears (based on survey data), we assessed the median age of county residents from census data, available for 1980, 1990, and 2000. With three data points available, we calculated the average rate of change, based on census data, in median age over time. For example, the median age of Angelina County residents was 28.9 in 1980, 32.3 in 1990, and 34.2 in 2002. This resulted in an average rate of change of 0.088% per decade, or 0.0088% per year. We repeated this calculation using census data for each county, and used the historical rate of change to project how each county's median age would change in the future. In a sensitivity analysis, we varied the values by 10% to determine how changes in median age and percent male values affected model results.

For the remaining four variables (participation in passive-appreciative activities, duration of residence, knowledge about bears, and see bear in wild), no historical data were available for model parameterization. The only data available were those collected by survey implementation. Therefore, we assumed that the value of each of these

variables was static and equal to the average value of survey responses at the county level. For example, the average knowledge value for Angelina County respondents was 2.7 bear knowledge questions answered correctly out of a possible six. For model parameterization, we assumed that the value of 2.7 was constant, but varied variable values by 10% in sensitivity analysis to determine how changes in each variable affected overall model response. This process was repeated for the remaining three variables and for each county.

7.2.3.5. Multi-criteria evaluation

A multi-criteria evaluation (Voogd 1983) was used to spatially assess how individual counties rank in terms of favorability for bear recovery strategies. In other words, this component determined whether feasibility of a bear reintroduction, based on the variables used, was greater or lesser in any one county than in others. Parameters (based on variables mentioned above) may be varied, and additional variables may be added (or present variables removed) to reflect potential management activities or policies, and how the activities and policies affect and are affected by variables of interest.

The multi-criteria evaluation was divided into two components: ecological feasibility and social feasibility. This was based on the rationale that some counties may rank high ecologically, but low socially, or vice versa. The ecological component contained four variables quantified at the county level: area of highly suitable habitat (ha), area of suitable habitat (ha), area of marginal habitat (ha), and area of public land (ha). We did not include area of timberland because this was the variable from which we

derived habitat and including it would be redundant. Area of unsuitable habitat (ha) was excluded because, although we quantified its presence among timberlands and it could have a negative impact on a reintroduction, its presence is of minimal importance compared to the other habitat classes (i.e., as discussed below, unsuitable habitat would have been assigned a weight of zero). In other words, total area of highly suitable, suitable, and marginal habitat are more critical for estimating the number of bears that could live within a county. The social component consisted of the six social variables described in Section 7.2.3.4. Age and gender information were determined from Census 2000 data, and data for the remaining four variables were determined from the social survey. We evaluated county rankings for both multi-criteria components under three scenarios: (1) present, (2) 2010 (projected using model simulation), and (3) 2020 (also projected).

Variables within the procedure were assigned fixed weights (sum of weights = 1) based on the relative importance of each variable as related to feasibility. For example, of utmost ecological importance for bears are highly suitable habitat and public lands, which both may serve as refuges (see also Chapter 2). Therefore, we assigned the largest weights to highly suitable habitat and public land variables (weight = 0.35 each; cumulative = 0.7). These equal rates are the result of a tradeoff, such that large areas of highly suitable habitat exist but a large portion of it is among private lands that are not indefinitely guaranteed to exist (i.e., could be sold and used for urban development). On the other hand, public lands may not contain as much highly suitable habitat collectively, but they are more likely to exist indefinitely. Suitable habitat is likely to be used by bears (for foraging) and regularly traversed, but not likely as important as highly suitable

habitat (weight = 0.20; cumulative $0.2 + 0.7$ (from weights of highly suitable habitat and public land) = 0.9). Marginal habitat, which may be traversed but is not likely to provide long-term refuge for bears, is likely of least importance (weight = 0.10, cumulative = 1). We calculated the county rankings for each of 200 simulations to determine the frequency of individual ecological ranking for each county. To test the consistency of the results, we also calculated and compared the county rankings for the first 100 versus second 100 simulations.

Social variables were based on the magnitudes of standardized coefficients as determined from regression as a proportion of the total of all coefficient values summed (see also Chapter 4). In order of descending magnitudes of influence, the variables and resulting weights were: knowledge (0.205), participation in passive-appreciative activities (0.198), gender (0.193), age (0.162), length of residence (0.141), and whether the respondent has seen a bear in wild (0.101). The value of each variable was multiplied by the respective weight and summed across variables for each county to produce standardized ranking of counties a scale of 0-100 (Voogd 1983).

Comparing ecological and social components will allow managers to weigh management options based on ecological and social feasibility. For example, if Angelina County contained a high ecological ranking (e.g., large area of highly suitable habitat) but a low social ranking (e.g., low scores for questions about bear knowledge), managers will know that habitat is present, but extensive public outreach will be necessary to determine if bear reintroduction into Angelina County is truly feasible. Just the opposite, if Angelina County contained a low ecological but high social ranking, managers may focus public outreach on resident land use management for improving bear habitat.

7.2.4. Simulation scenarios

We ran the baseline simulation (i.e., timberland and habitat occurrence based on current land cover and land use information) 200 times to estimate projected changes in timberland and four classes of bear habitat (all four classes). After 100 simulations, the standard error was less than one percent of the mean for each simulated variable. We reran the model a second 100 times to confirm the statistical relationship between the two sets of simulations. To do this, we constructed a 95% confidence interval around the mean of all 200 simulations (sum of all runs from both sets of simulations). The mean of each set of 100 simulations was statistically similar to the pooled 200 simulations in that the 95% confidence interval of the 200 simulations contained the individual means of each set of 100 simulations.

To verify the model, we simulated timberland and habitat area for the present (2002) by using 1970s data as the baseline (i.e., projecting to the present from 1970s). We statistically compared the model predictions to the observed values of timberland area and area of each of the four habitat classes. To do so, we constructed a 95% confidence interval around the mean of the simulated model predictions. The observed versus the predicted model values were deemed to be significantly different if the 95% confidence interval around the mean predicted value did not contain the observed value.

We also sought to estimate how timberland and habitat may change in the future. Therefore, simulation results were projected to year 2010 and 2020. These time periods (year 2010 and 2020) corresponded to (1) 10 years after initial data collection and five years after initial implementation of black bear plan, (2) 20 years after data collection and 15 years after initial bear plan implementation, respectively. The year 2020 also

corresponded to the end of the time period for which the 15-year black bear plan's present form will expire (TPWD 2005). We ran baseline simulations for each variable for model verification, as well as to estimate simulated median age and percent male values for 2010 and 2020.

To assess how sensitive the overall ecological and social county rankings were to changes in individual variables (sensitivity analysis; Haefner 1996), weights that were used for multi-criteria evaluation were increased and decreased 10% for each variable. Because management activities would focus on particular variables, such as increasing residents' knowledge about bears, a 10% change in standardized variable values was also tested. However, changing the value of each county or any combination of n counties would result in an exceptionally large number of changes to be made with likely little effect on the overall interpretation of the model output. For example, we could increase the standardized value for knowledge in Angelina County alone or change the knowledge values of Angelina and Hardin Counties together, or change Angelina, Hardin, and Tyler, etc. Because bear managers are most interested in the most and least feasible locations for a recovery, standardized parameters were adjusted for the highest and lowest-ranked counties to determine if the new values would result in a significant change in rankings. Starting with a 10% change, we adjusted the weights and standardized variable values increasingly larger percentages until the changes resulted in a difference in rankings.

7.3. Results

For model verification, we used calculated rates of change to project present conditions based on past data. For timberland, the model underpredicted observed

timberland area in Angelina, Jasper, Newton, Orange, Sabine, San Augustine, San Jacinto and Trinity Counties for 2002 (Figure 7.7). Timberland area was overpredicted for Hardin, Polk, and Tyler Counties.

For verification of highly suitable habitat area, highly suitable habitat was underpredicted all counties except Tyler, which was underpredicted (Figure 7.8). Similarly, no statistically similar observed and predicted habitat values existed for suitable, marginal, or unsuitable habitat. Suitable habitat was underpredicted for all counties except Tyler (Figure 7.9). Marginal habitat was overpredicted in Angelina, Hardin, Liberty, Polk, San Jacinto, Trinity, and Tyler Counties (Figure 7.10), but underpredicted in Jasper, Newton, Sabine, and San Augustine Counties. Unsuitable habitat was underpredicted for all counties except Polk and Tyler (Figure 7.11). The magnitude of habitat overprediction or underprediction varied across counties and habitat classes. For future projections of timberland and habitat, the models for timberland and all habitat classes suggested a decreasing trend across all counties (Figure 7.12; Figure 7.13; Figure 7.14; Figure 7.15; Figure 7.16), following the decreasing trend in timberland area since the 1970s. Because the observed timberland and habitat values were within 95% confidence limits of only one projected value each (Trinity timberland, Polk highly suitable), we were unable to validate timberland and habitat data.

For the social component, verified median age data were minimally different from observed median age (Table 7.2). The only differences between observed and verified values were because of rounding. Because verified results for median age were based on a simple mathematical operation using a consistent rate of change in median age between time periods, we were not able to statistically test for significant differences between

actual and verified data or report standard errors. Simulated future changes in median age over time suggested changes in median age, on a county basis, ranging from 2.0 to 5.8 years by 2010, and 3.9 to 11.8 years by 2020.

Verified value matched observed value for Trinity County. However, the model overpredicted the observed male percent of each county's population for nine of the 12 counties (Angelina, Jasper, Newton, Orange, Polk, Sabine, San Augustine, San Jacinto, and Tyler Counties; Table 7.3). Two counties (Hardin and Liberty) were underpredicted, both by approximately 1.5%. Similar to percent male, because verified results were based on a simple mathematical operation using a consistent rate of change in percent male between time periods, we were not able to statistically test for significant differences between actual and verified data or report standard errors. The greatest magnitude of change over the next 20 years in percent male residents of a county is projected for Trinity County (change of 15.8 percent). Three counties were predicted to have a loss in the percentage of males (Jasper, San Augustine, and San Jacinto), whereas the remaining nine counties were predicted to have a gain in the percentage of male residents.

Table 7.4 shows the frequency of ecological rankings for counties within the study area. Sabine and Trinity Counties were consistently ranked as the counties where ecological feasibility of a reintroduction was the greatest, whereas Liberty and Orange Counties were most consistently ranked as the lowest. Projected rankings for 2020 contained less variability in individual county ranks than for 2010. Newton, Jasper, and Tyler Counties ranked as the three counties with the greatest social feasibility (Table 7.5) at present and as projected for the future. Trinity, Orange, and Polk were the least

socially feasible counties. Results of rank sum results suggested that no counties ranked as both high ecological and social feasibility (Figure 7.17). Regardless of whether individual counties contain a large area of highly suitable habitat among timberlands (e.g., Jasper or Newton; Figure 7.17), a relatively small amount of public land within a county would result in the county having a lower ecological ranking.

For sensitivity analyses, both the weights and standardized values from multi-criteria analysis were adjusted to determine how changes in both would affect the overall model. For ecological feasibility and with a 10% change in weights, increasing the weight of highly suitable habitat was the only change that resulted in a different ranking of counties, and with only minimal changes. San Augustine and Hardin Counties switched from 3 and 4 to 4 and 3, respectively. Liberty and Newton Counties also swapped rankings between 10 and 11. In fact, adjusting the weights for highly suitable, suitable, and marginal habitat classes by any amount of value did not result in changes to the top and bottom-ranked counties. Decreasing the weight of public land area (while increasing the weights of the other three variables in equal amounts to account for the decreased weight of public land) resulted in a change in variable rankings. The weight for public land area had to be decreased from 0.35 to 0.2 for Sabine County to be replaced by Trinity County as the most ecologically feasible, but Orange County did not move from least ecologically feasible with any change in weight. Weight of public land area also had to be decreased from 0.35 to 0.2 to result in a similar switch between Sabine and Trinity Counties for 2010 and 2020. Therefore, the habitat variables were robust to changes in weights in sensitivity analyses, but changes to public land area had the most significant effects on model's overall results.

Highest and lowest-ranked counties were also robust to 10% changes in the standardized values for variables associated with ecological feasibility. A 15% change in the standardized value of area of public land was needed for Trinity County to become the top-ranked county ecologically, but Orange County remained the lowest regardless of the change in public land. Even a 100% increase in the standardized values of habitat variables did not change the overall rank of the 12 counties.

For social feasibility, county rankings were robust to a 10% change in both weights and standardized values. Newton and Jasper Counties ranked as first and second socially, respectively, for all attempted variations in weights. Decreasing the weight of knowledge to 0.1 (a decrease of approximately 50%) did not result in a difference in the socially top ranked county, but Tyler replaced Jasper County as second. However, the county rankings were robust to changes in the remaining social variables. Social rank of Trinity County remained last regardless of changes in weights.

A 50% increase in the standardized value of knowledge was needed to replace Newton County with Jasper County as the socially top-ranked county. Similar to sensitivity of weights, Trinity County also remained last-ranked for all changes in standardized values. Changes in county rankings for 2010 and 2020 projections based on altering standardized values were consistent with changes in rankings for the present.

7.4. Discussion and conclusions

For this study, we attempted to create a simple systems simulation model to assess feasibility of a black bear reintroduction across our study area. Although our model needs to be improved in the future, it provides a creative framework that bear managers

in Texas, as well as managers involved with other species reintroduction and wildlife conservation efforts, may use to assess how both ecological and socioeconomic variables may affect feasibility of a reintroduction.

Ideally for bear recovery, counties with the highest-ranking ecological feasibility would also contain the greatest social feasibility. In general, this was not the case (Table 7.4; Table 7.5). Based on the results of this model, counties with high ecological feasibility were moderate or low socially, and vice versa (Figure 7.17). Sabine, Trinity, and San Augustine Counties contained a large amount of national forest land, as well as timberlands. In fact, these counties, as well as Angelina, Hardin, Newton, Jasper, and San Jacinto Counties, also contained large areas of core habitat (see Chapter 2). However, although Jasper and Newton Counties contained a large amount of highly suitable habitat (Figure 7.17), the small amount of public land within the same counties was highly influential in these counties receiving a low ecological ranking. Therefore, management of private land will be critical for maintaining bear habitat in Jasper and Newton Counties over time. For counties that contained a large amount of public land (e.g., San Jacinto, Sabine, and San Augustine), maintenance of highly suitable habitat is not as dependent on private land management.

Low social feasibility for high ecologically ranking counties may suggest that management efforts in these counties will be mainly people-related to ensure a healthy bear population. San Jacinto, for example, contained a large amount of national forest land although its ecological feasibility was moderate. A reason for this may be that remaining land within this county was not largely timberlands. However, with a moderate ecological feasibility and high social feasibility, management efforts focusing

on land use to enhance black bear habitat in San Jacinto County may have fast and positive results. Therefore, across the study area, tradeoffs between ecological or social management foci must be made and customized for each county.

In counties that rank high ecologically, more emphasis must be placed on social outreach agendas such as focus groups and information forums. As suggested by sensitivity analyses, knowledge about bears was the social variable to which changes in the overall rankings were most sensitive. In addition, knowledge is the most likely the variable that bear managers may exert influence (i.e., bear managers are not likely to be able to change the gender distribution of a county, or how often residents observe wildlife). Therefore, efforts to increase residents' knowledge about bears may increase overall social feasibility across counties. Just the opposite, socially high-ranking counties may seek guidance about land management for bear habitat. Because public land area was the most influential variable in ecological sensitivity analyses, bear managers may seek to encourage interested residents (or local corporations) to set aside land in conservation trusts or easements to promote bear habitat conservation. Likewise, donations of land to organizations related to land management (e.g., The Nature Conservancy) might also assist in the indefinite conservation of land as bear habitat.

Counties that contain BTNP ranked moderate ecologically, and high to moderate socially. The moderate ecological ranking is logical, as the twelve BTNP units only collectively total an area of 39,000 ha, and Tyler County has the potential to lose a large amount of forest via divestment of most of its timberlands in 2002 (see Chapter 3). The high to moderate social ranking contradicts results found in Chapter 6, specifically that residents closer to the preserve (compared to further away) were less supportive of a

black bear reintroduction. Because of this uncertainty, if BTNP is to remain a target for bear release, more intense research into local support for a reintroduction, as well as more detailed study of nearby habitat are necessary. Based on the results from this study, national forest lands may be a better and more feasible alternative for bear recovery. However, verification of attitudes toward bears in proximity to Angelina National Forest is also needed because this area was identified as a potentially supportive location for bear recovery based on spatial assessment of attitudes (see Chapter 6). Consequently, San Augustine County did not rank high for social feasibility although Jasper County, the northern portion of which is within Angelina National Forest, did rank high for social feasibility. Strategically, the location of these national forests along the northern portion of the study area may provide refuge for bears moving between populations in Oklahoma, Arkansas, and Louisiana.

We suggest two main reasons why additional data are necessary for improving verification of timberland and habitat. First, the change in timberland area from 1990 to 2002, and the resulting annual rate of change, take into account the total divestment of one timber company's lands (approximately 10% of all timberlands; see Chapter 3) in 2002. It is possible that the resulting rates for simulating change in timberland area were greatly affected by this atypical one-time loss. More specifically, the sharp rate of change from 1990 to 2002 may have resulted in unnaturally high rates of change in the simulation probability distribution. This may lend insight into the underprediction of timberland area in several counties. However, Tyler and Newton Counties were most affected by the timberland divestment (see Chapter 3) and timberland was overpredicted for Tyler yet underpredicted for Newton in model simulation (Figure 7.7). With only

three years worth of data for assessing ownership, changes within large time gaps may have went unrecorded. The large divestment of 2002 offers great opportunity to track in detail changes in land ownership, and how ownership changes affect changes in habitat.

Second, modeling efforts were focused on timberlands because of their potential to maintain large areas of bear habitat over time. Although this focus, combined with consideration of assumptions for public lands, allows us to encapsulate changes across approximately three-quarters of the study area, future addition and analysis of changes to the “other” land ownership category will further understanding of ownership and land cover changes across the study area. Adding land cover data for intermediate years may allow for identification of former timberlands that are now within the “other” category, and track both rates of change as well as before-and-after land cover characteristics in such locations. Expansion of human activity in the form of residential and urban development into timberland areas will likely be driven by precisely what timberlands are sold or not sold. In other words, presence of timberlands will constrain land use change to locations within the “other” land classification category. Therefore, the rate of change of land use within “other” locations may be greater than the general rate of land use change across the study area. Therefore, incorporation of “other” land into the model as its own component will likely produce the most accurate results.

Improvements may also be made to the social component of the model. First, the survey data used here were collected from only a small portion of area residents. Specific limitations to survey data (see also Chapter 4 and 5) included an underrepresentation of females and minority ethnic groups, as well as data collection from specific stakeholder groups such as hunters and conservation groups. Our survey respondents were

disproportionably young compared to the actual population reported in the census data. Only further data collection will provide better insight into resident attitudes. Second, this model did not incorporate demographic variables such as population and number of households. As in other locations within the US and worldwide (Liu et al. 2003), the human population of southeastern Texas has increased dramatically over the past 30 years, but the number of households has increased even more rapidly, particularly along the southern and western portions of this study's area (US Census Bureau data). However, growth is limited to the land that was classified as "other" in this model. Therefore, by adding the "other" ownership component, spatial assessments of changes in population and number of households can be incorporated into the model. Finally, the future of the southeast Texas landscape faces a number of uncertainties. As already mentioned, continued sale of timberland will not only result in extensive loss of forestland, but likely also disastrous effects on bear habitat. Several water diversion projects are proposed that could disturb the balance of natural ecosystems. Also, a proposed eight-lane Trans-Texas Corridor superhighway to connect Chicago and Brownsville would bisect BTNP and nearby forestlands (<http://www.dot.state.tx.us>). Possibilities of large-scale land use changes are making bear management planning more difficult. Although sensitivity adjustments to the model did not result in significant changes to the rankings, this does not guarantee that changes in feasibility rankings will not occur in the future. Efforts to concentrate bear recovery efforts in areas that are least likely to experience large-scale change will be critical for a successful reintroduction.

Table 7.1. Statistically significant survey variables for predicting attitudes toward black bears that were used for construction of the bear model's social component.

Variable	Relationship	Data source for model parameterization
Gender	Males were more likely to have positive attitudes toward bears than females	Percent county residents who were male; average 1990 and 2000 (US Census Bureau data)
Age	Younger respondents were more likely to have positive attitudes toward bears than older respondents	Rate of change of median age of county residents (US Census Bureau data; 1980, 1990, and 2000)
Passive-appreciative activities	More frequent participants were more likely to have positive attitudes toward bears	Average value from survey responses for each county
Duration of local residence	Newer residents to the area were more likely to have positive attitudes toward bears	Average value from survey responses for each county
Knowledge about bears	Respondents who were more knowledgeable about bears were more likely to have positive attitudes toward bears	Average value from survey responses for each county
See bear in wild	Respondents who have seen a black bear in the wild were more likely to have positive attitudes toward bears	Percent of respondents from each county from survey data

Table 7.2. Actual median age (from census data), verified median age (from simulation of present) and estimated (simulated) changes in median age of residents within counties of the study area for years 2010 and 2020.

County	Median age			
	Actual	Verified	Year 2010	Year 2020
Angelina	34.2	34.4	37.6	41.0
Hardin	36.0	36.3	40.3	44.6
Jasper	37.3	37.6	41.3	45.4
Liberty	34.0	34.1	36.5	39.1
Newton	36.9	37.3	41.5	46.3
Orange	36.1	36.7	41.9	47.9
Polk	39.3	39.6	42.0	44.5
Sabine	47.0	47.8	52.7	58.1
San Augustine	42.1	42.3	45.2	48.3
San Jacinto	40.0	40.4	44.6	49.3
Trinity	43.3	43.5	46.2	49.1
Tyler	38.9	39.2	41.0	42.8

Table 7.3. Actual percent males (from census data), verified percent males (from simulation to present) and estimated (simulated) changes in percent males of resident populations within counties of the study area for years 2010 and 2020.

County	Percent (%) of population that is male			
	Actual	Verified	Year 2010	Year 2020
Angelina	48.2	49.1	50.0	52.8
Hardin	48.4	47.0	48.1	48.3
Jasper	47.3	48.2	47.6	47.0
Liberty	47.9	46.4	44.4	40.6
Newton	52.1	56.2	59.2	66.3
Orange	48.2	49.5	48.1	48.5
Polk	54.4	60.7	65.3	76.9
Sabine	46.7	48.1	47.1	47.2
San Augustine	46.1	47.5	46.9	46.1
San Jacinto	50.3	50.9	51.2	51.0
Trinity	48.2	48.2	48.7	64.5
Tyler	53.5	59.0	47.6	74.1

Table 7.4. Present and projected (years 2010 and 2020) ecological rankings of counties for bear recovery based on two sets of 100 simulations and multi-criteria analysis.

County	<i>n</i>											
	Present				2010				2020			
	Rank	Set 1	Set 2	Total	Rank	Set 1	Set 2	Total	Rank	Set 1	Set 2	Total
Angelina	4	6	18	24	5*	96	94	190	5*	100	100	200
	5	22	13	35	6	3	1	4				
	6 ^a	68	64	132	8	1	5	6				
	7	4	5	9								
Hardin	2	1	1	2	3	21	18	39	3	1	0	1
	3*	97	98	195	4*	79	82	161	4*	99	100	199
	4	2	1	2								
	7	2	0	2	7*	100	100	200	7*	100	100	200
Jasper	9*	98	100	198								
	11*	100	100	200	10	4	0	4	10	1	2	3
					11*	96	100	196	11*	99	98	197
	10*	100	100	200	8	4	0	4	9*	99	98	197
Newton					9*	92	100	192	10	1	2	3
					11	4	0	4				
	12*	100	100	200	12*	100	100	200	12*	100	100	200
	7	16	23	39	6	5	7	12	6	1	2	3
Orange Polk	8*	84	77	161	8*	91	93	184	8*	98	96	194
					9	4	0	4	9	1	2	3
	1*	97	99	196	1*	100	99	199	1*	100	98	198
	2	3	1	4	2	0	1	1	2	0	2	2

Table 7.4. (Cont'd.)

San Augustine	3	2	0	2	3*	79	82	161	3*	99	100	199
	4*	49	43	92	4	11	16	27	4	1	0	1
	5	21	28	49	5	4	2	6				
	6	20	21	41	8	4	6	6				
	7	8	8	16								
San Jacinto	4	36	30	66	4	10	2	12	6*	99	98	197
	5*	53	57	110	5	3	1	4	8	1	2	3
	6	11	12	23	6*	92	92	184				
Trinity	1	3	1	4	1	0	1	1				
	2*	96	98	194	2*	100	99	199	1	0	2	2
	3	1	1	2					2*	100	98	198
Tyler	4	7	8	15	9	2	2	4				
	5	4	2	6	10*	98	98	196	8	2	1	3
	6	1	3	4					10*	97	97	194
	7*	70	63	133					11	1	2	3
	8	16	23	39								
	9	2	0	2								

^aAn asterisk (*) indicates the overall ranking containing the rank for the most simulations.

Table 7.5. Present and projected (years 2010 and 2020) social rankings of counties for bear recovery.

County	Present	2010	2020
Angelina	7	7	5
Hardin	9	9	10
Jasper	2	1	1
Liberty	5	6	7
Newton	1	2	2
Orange	10	11	11
Polk	11	10	8
Sabine	6	5	6
San Augustine	8	8	9
San Jacinto	4	4	4
Trinity	12	12	12
Tyler	3	2	3

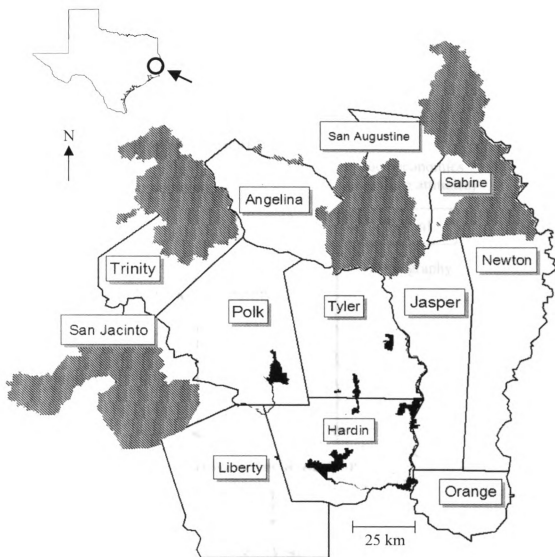


Figure 7.1. The 12 counties (outline, labeled) in southeastern Texas included within the study area, as well as BTNP (solid shaded) and proclamation boundaries of four National Forests (hatched).

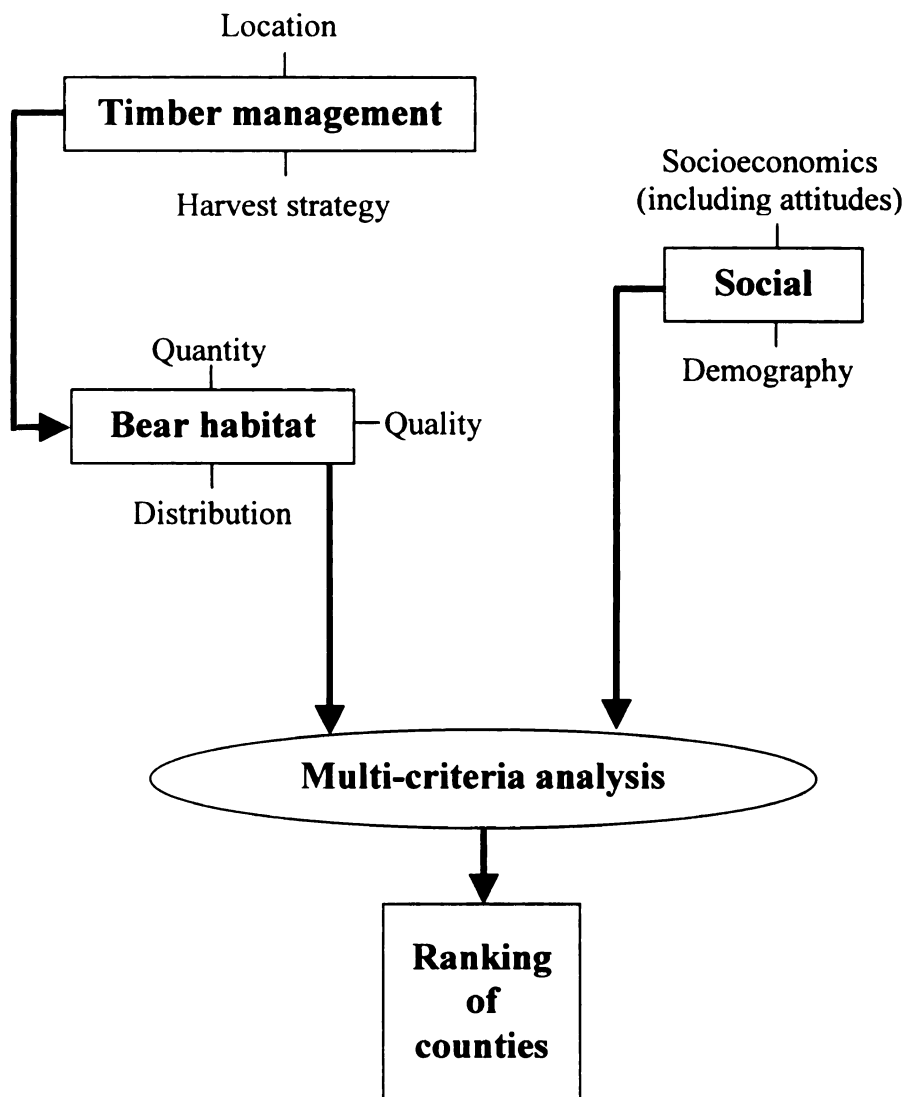


Figure 7.2. Conceptual framework for ranking counties within the study area as ecologically and socially feasible for a black bear reintroduction. Solid arrows indicate the flow of data through the framework.

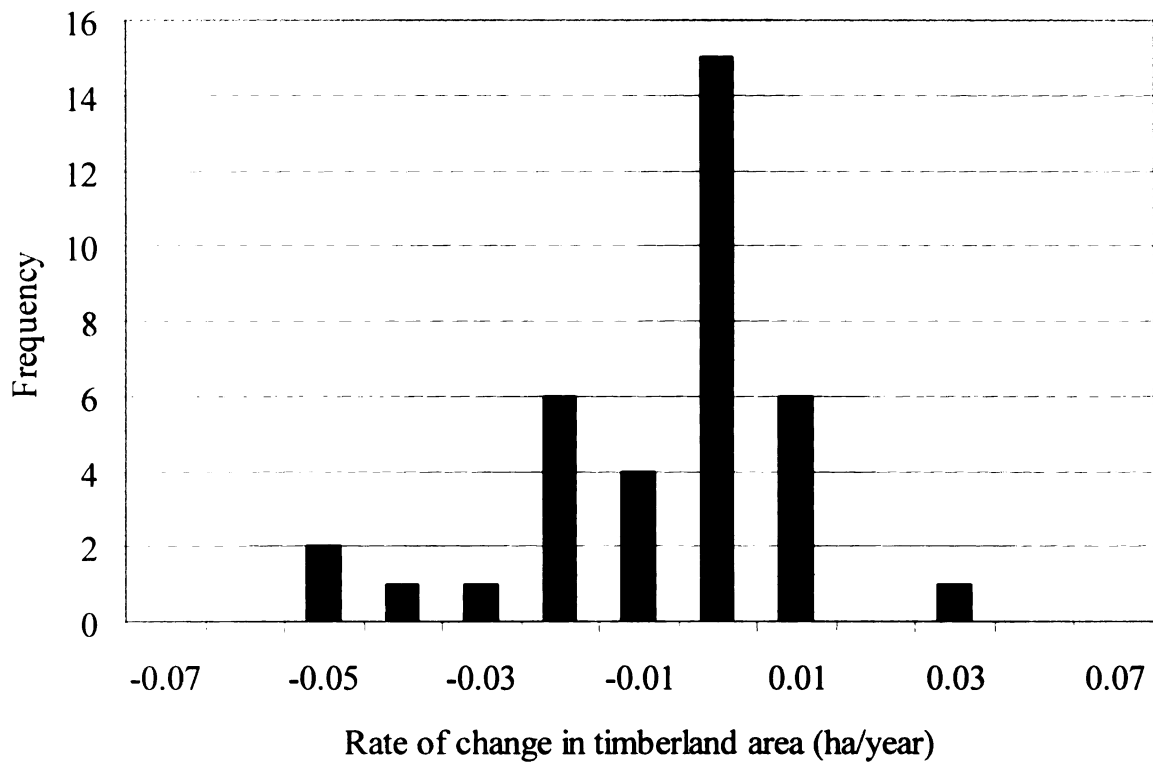


Figure 7.3. Histogram illustrating normally distributed function for rates of timberland gains and losses across counties of the study area.

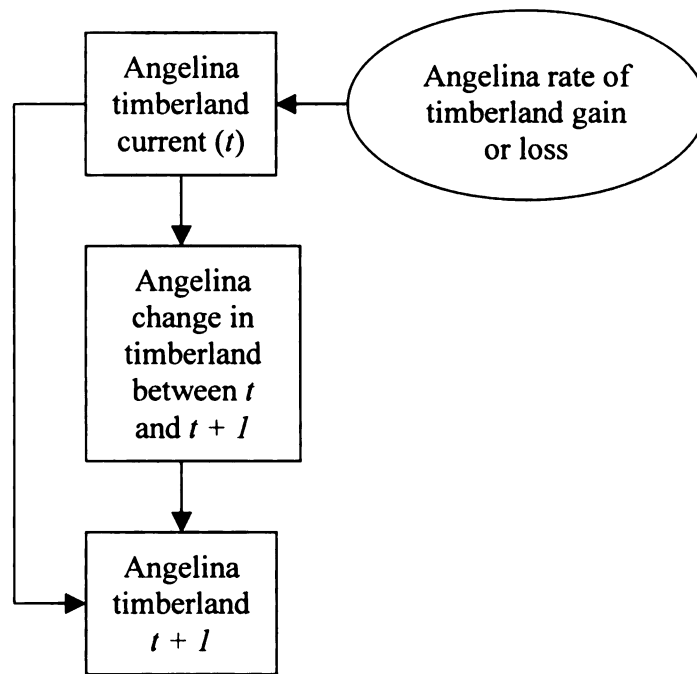


Figure 7.4. Example model structure of the timberland component. “Angelina timber current” indicated the area of timberland within Angelina County at time t . “Angelina rate of timberland gain or loss” acted as criteria to designate whether timberland was gained or lost at each time interval as determined by random number generation. “Angelina change in timberland area between t and $t + 1$ ” quantified the total amount of timberland gained or lost in Angelina County for each time interval. The total amount of timberland gained or lost in time t was then added to “Angelina timberland current” to calculate “Angelina timberland $t + 1$.” This model structure was repeated for each county within the study area.

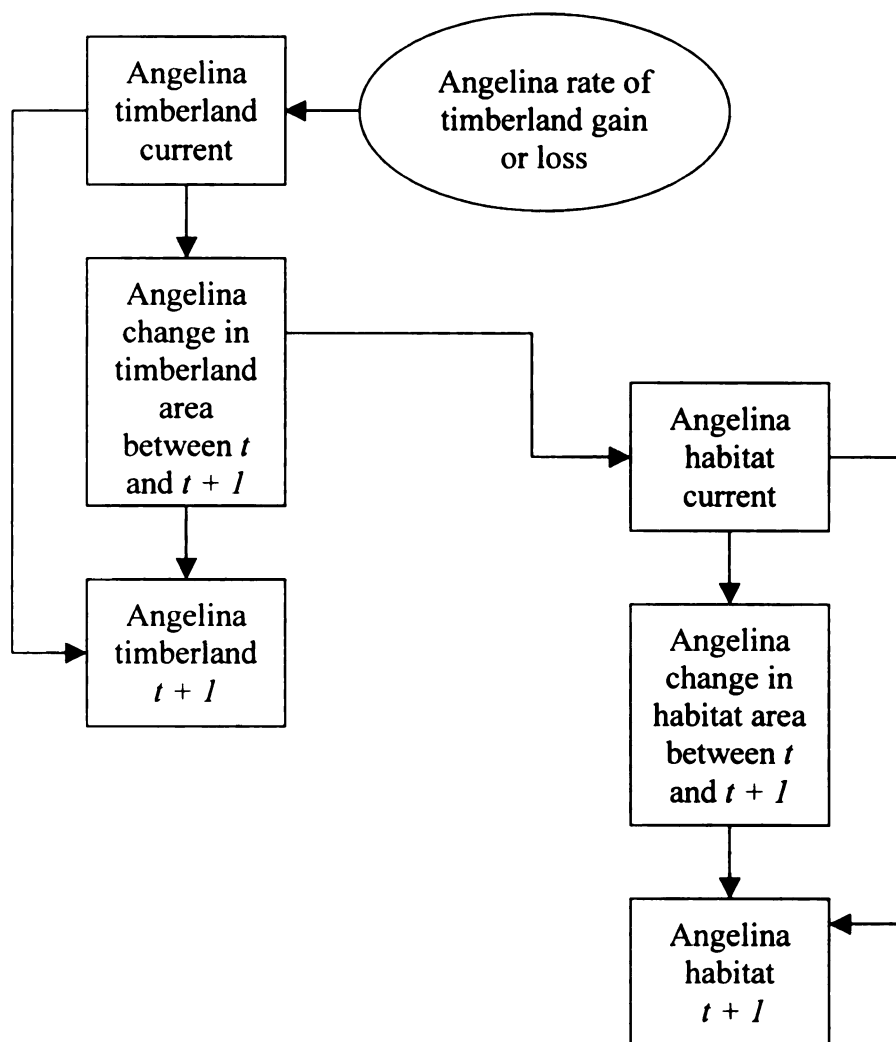


Figure 7.5. Example model structure of the habitat component. “Angelina habitat current” indicated the area of total habitat within Angelina County at time t . “Angelina change in habitat area between $t + 1$ ” quantified the total amount of habitat gained or lost in Angelina County for each time interval. The total amount of habitat gained or lost in time t was then added to “Angelina habitat current” to calculate “Angelina habitat $t + 1$.” This model structure was repeated for each county within the study area.

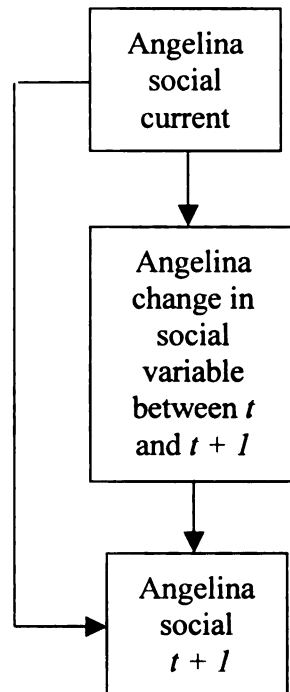


Figure 7.6. Example model structure of the social component. “Angelina social current” indicated the current value of age and gender social variables used in the model at time t . “Angelina change in social variable” acted as criteria to designate change in the social variable at each time interval as determined by random number generation. “Angelina change in social variable area for t and $t + 1$ ” quantified the total change in each social variable in Angelina County for each time interval. The total amount of change in each social variable in time t was then added to “Angelina social current” to calculate “Angelina social $t + 1$.” This model structure was repeated for each county within the study area.

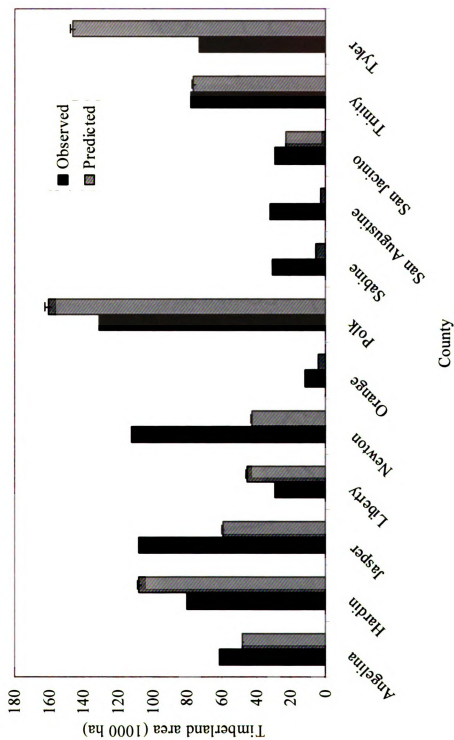


Figure 7.7. Observed versus predicted ($\pm$ SE) estimates of timberland area across all counties of the study area.

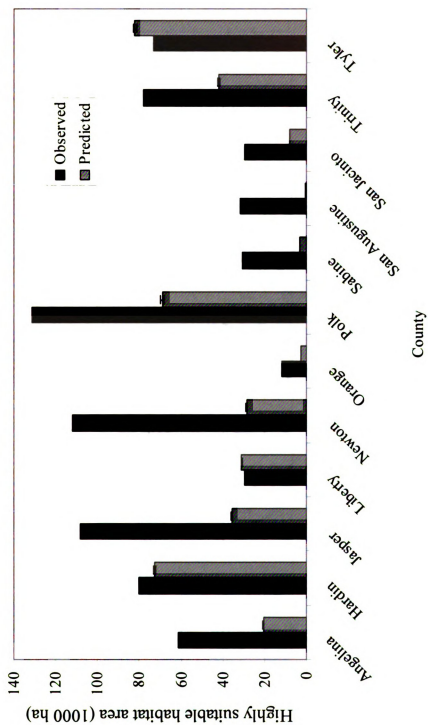


Figure 7.8. Observed versus predicted ($\pm$ SE) estimates of highly suitable habitat area across all counties of the study area.

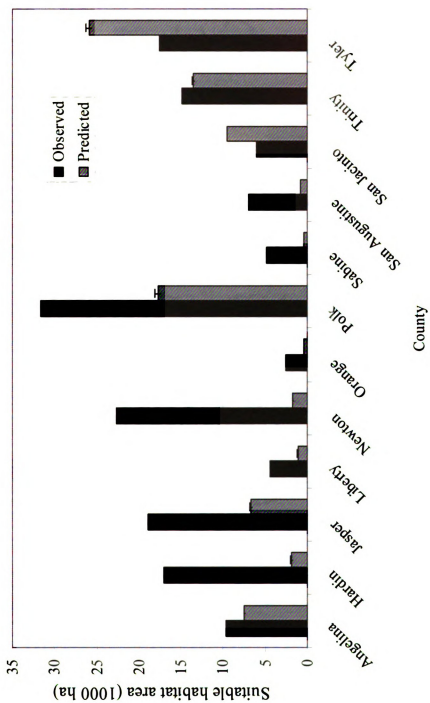


Figure 7.9. Observed versus predicted ($\pm$ SE) estimates of suitable habitat area across all counties of the study area.

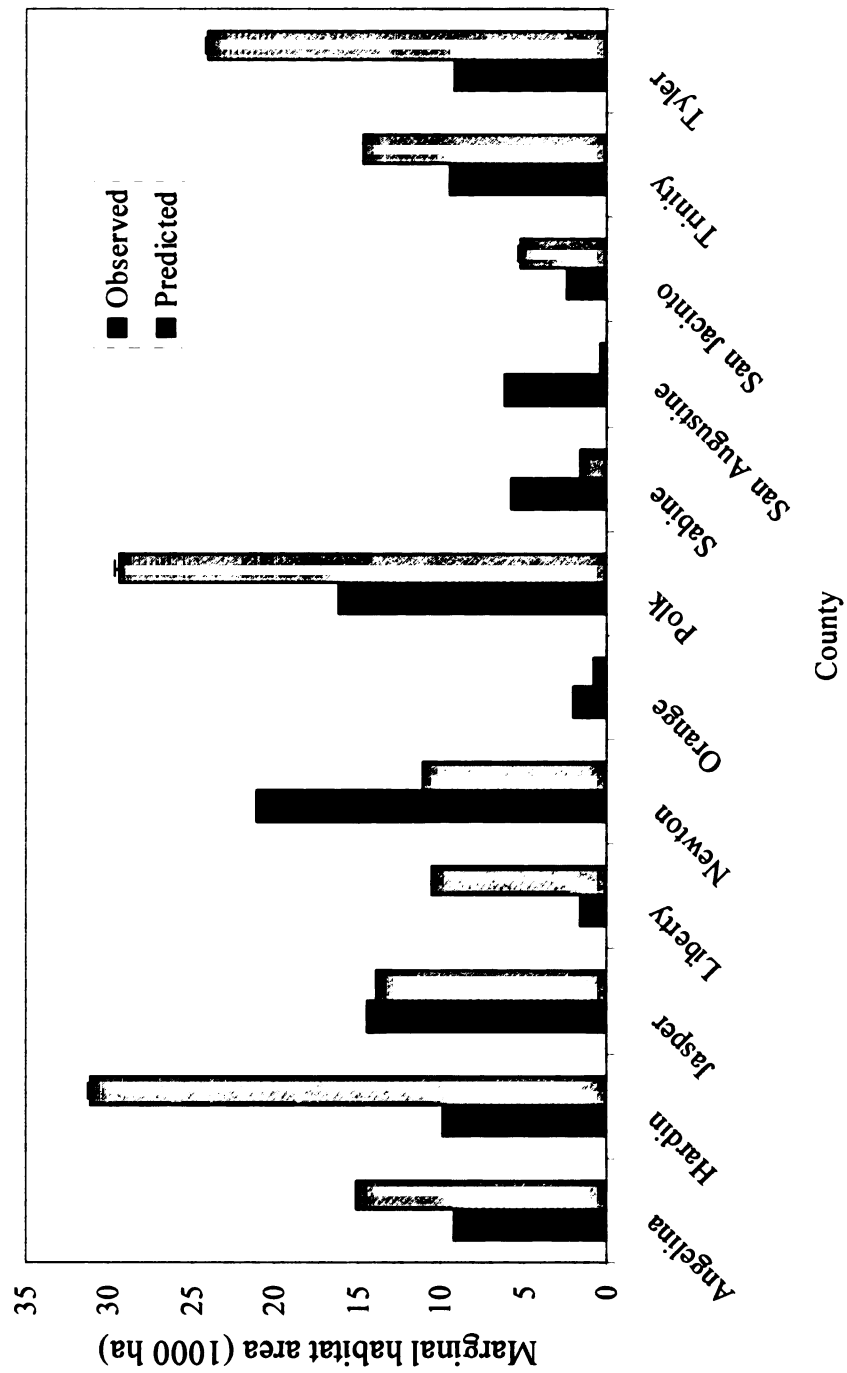


Figure 7.10. Observed versus predicted ($\pm$ SE) estimates of marginal habitat area across all counties of the study area.

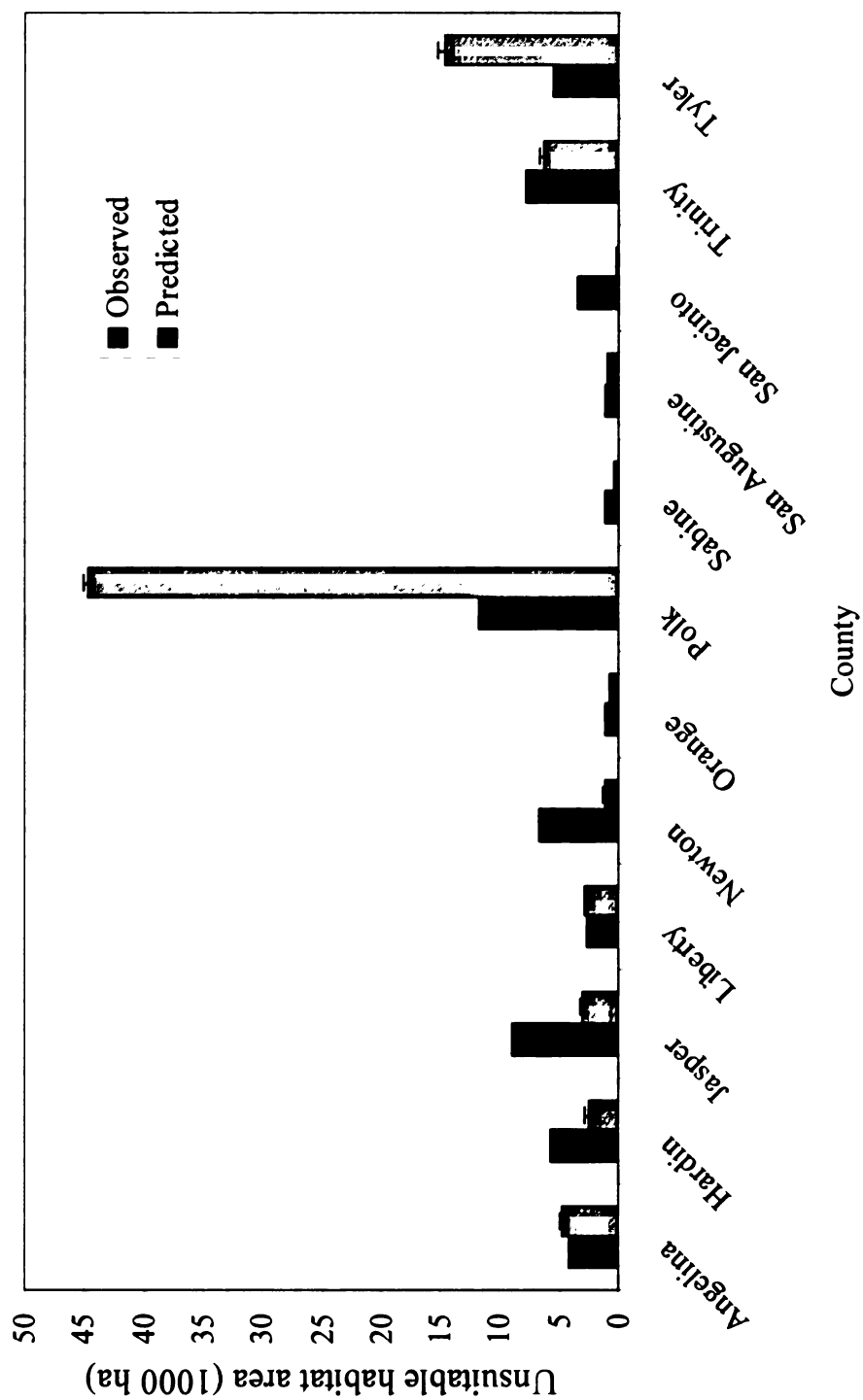


Figure 7.11. Observed versus predicted ($\pm$ SE) estimates of unsuitable habitat area across all counties of the study area.

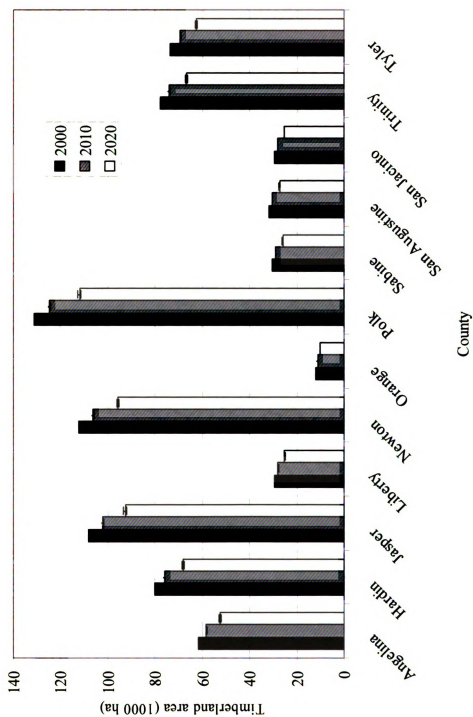


Figure 7.12. Present (2000) and projected (mean $\pm$ SE) timberland area across counties of the study area in 2010 and 2020.

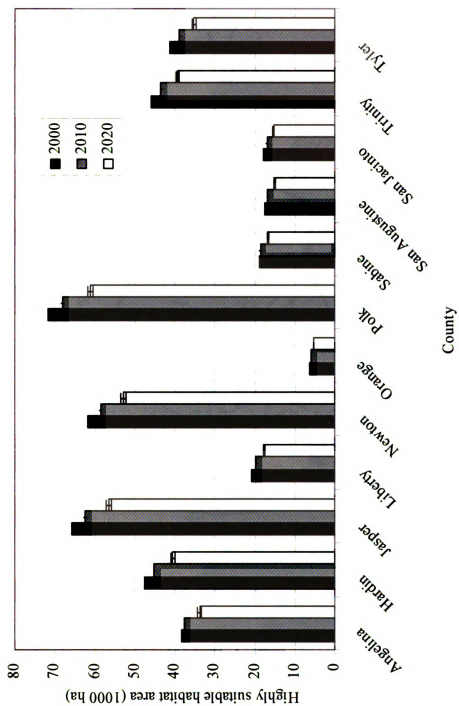


Figure 7.13. Present (2000) and projected (mean $\pm$ SE) highly suitable habitat area across counties of the study area in 2010 and 2020.

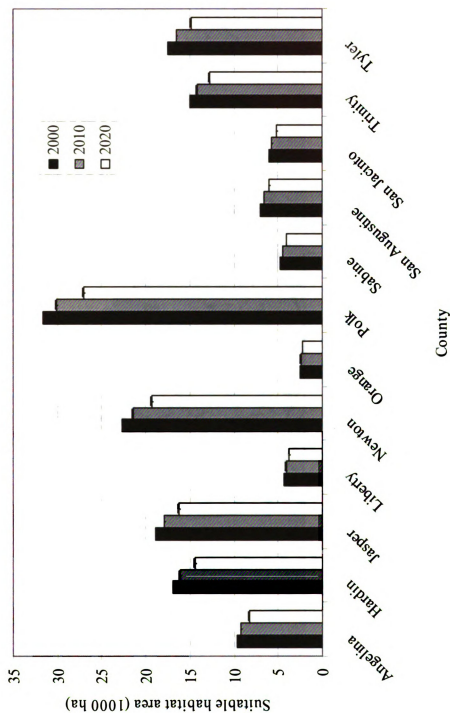


Figure 7.14. Present (2000) and projected (mean $\pm$ SE) suitable habitat area across counties of the study area in 2010 and 2020.

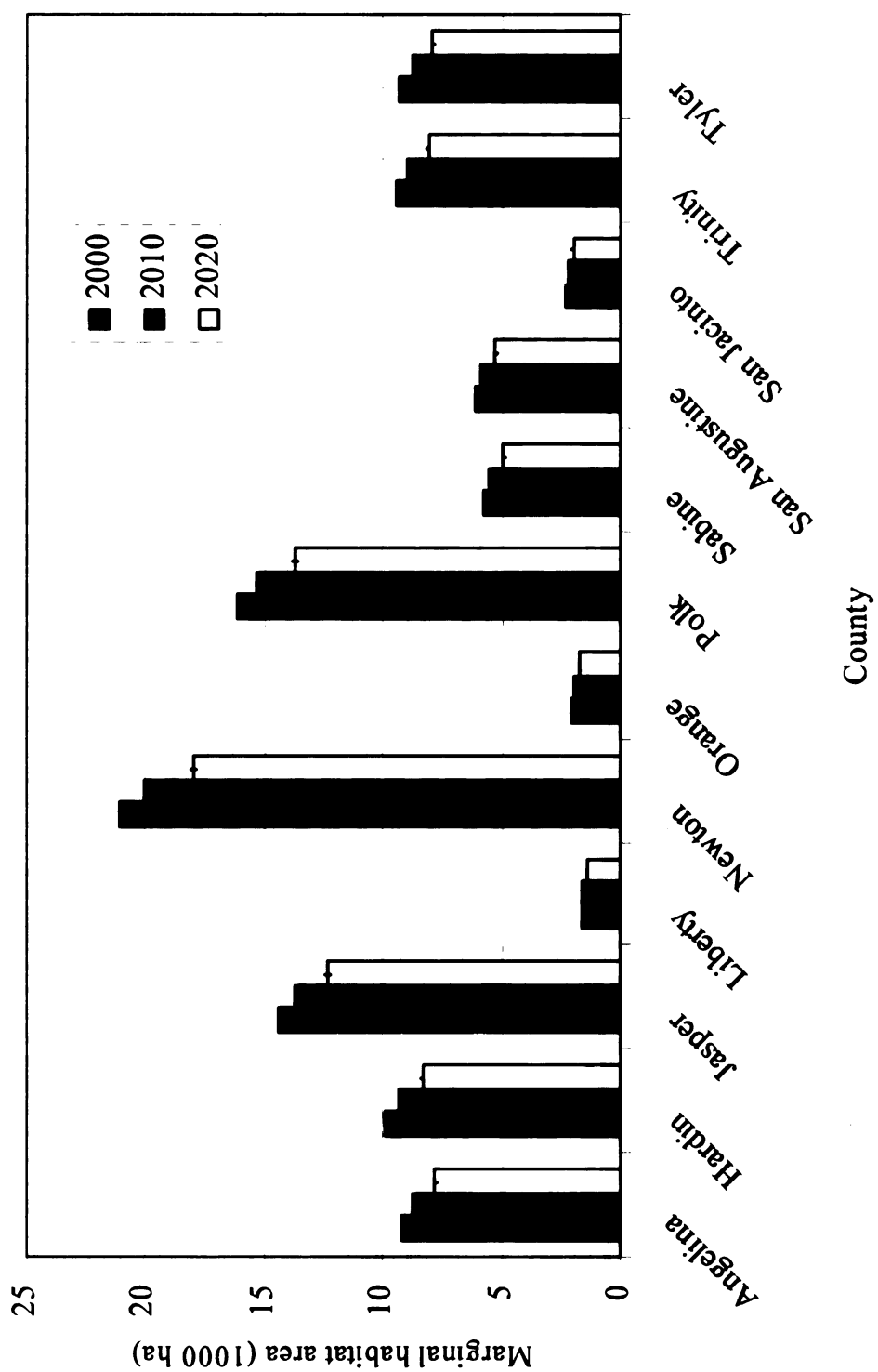


Figure 7.15. Present (2000) and projected (mean $\pm$ SE) marginal habitat area across counties of the study area in 2010 and 2020.

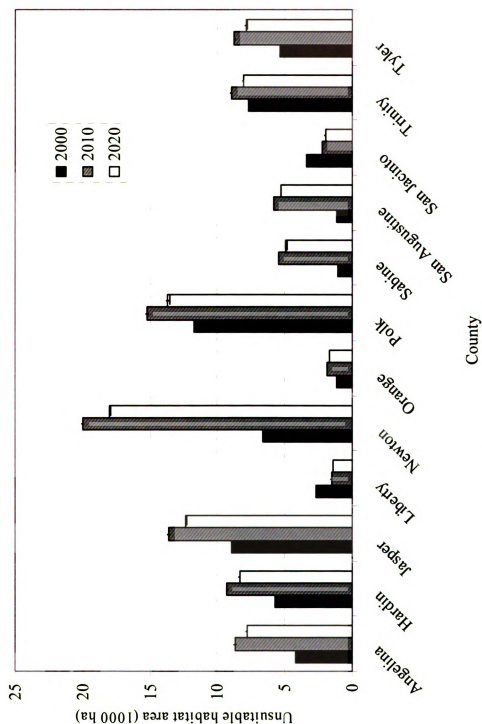


Figure 7.16. Present (2000) and projected (mean $\pm$ SE) unsuitable habitat area across counties of the study area in 2010 and 2020.

		Ecological feasibility		
		High	Medium	Low
Social feasibility	High		San Jacinto Tyler (17,851) (41,277)	Jasper Newton (65,918) (61,765)
	Medium	Sabine San Augustine (18,954) (17,601)	Angelina (38,437)	Liberty (20,799)
	Low	Hardin Trinity (47,639) (45,816)	Polk (71,593)	Orange (6,201)

Figure 7.17. Rank sum results for quantifying the difference in county rankings for ecological and social feasibility of a black bear reintroduction. A score of 1-4 on either the ecological or social feasibility resulted in a rank of “high,” 5-8 was a “medium,” and 9-12 was a “low.” Area of highly suitable habitat within timberland for each county is shown in parentheses.

SUMMARY

Many researchers separately studied ecological and social factors that may affect potential wildlife reintroductions, but few have considered such factors simultaneously. As human activity continues to penetrate previously rural areas, wildlife management must focus on ways to meet the needs of wildlife while also considering socioeconomics. For this dissertation, my research goal was to determine the feasibility of a Louisiana black bear reintroduction in and around Big Thicket National Preserve (BTNP), Texas. Because of BTNP's small size and disjunct distribution, the preserve alone is not large enough to fully meet the needs of a viable bear population. Therefore, quantity and quality of bear habitat among nearby private timberlands and other public lands will be as important for a bear population recovery as habitat within the preserve. I explored six focal subjects: (1) ecological feasibility of a reintroduction, as determined by remotely sensed imagery (Chapter 2), (2) assessment of the importance of private timberlands for maintaining bear habitat over time (Chapter 3), (3) residents' attitudes toward bears and an increase in the black bear population size (Chapter 4), (4) preferred management strategy for a black bear recovery (Chapter 5), (5) spatial distribution of individual attitudes toward a black bear recovery (Chapter 6), and (6) development of a conceptual framework to integrate ecological and socioeconomic factors that may affect a reintroduction both at present and in the future.

Although previous studies have focused on bear habitat characteristics in particular locations within southeast Texas, no studies have adapted a landscape perspective to assess the area and distribution of bear habitat across the region. With an

estimated 1.3 million ha of highly suitable habitat, southeastern Texas contains enough habitat for a viable bear population. Large areas of highly suitable habitat are well connected, as suggested by negative correlations between habitat patch size and mean nearest neighbor distance between patches of highly suitable habitat. Habitat data were analyzed at both the 30m (raw scale of data) and 1-ha (more appropriate scale for studying bear ecology), and the most significant finding related to this was that remote areas of habitat (>1 km from human activity), located mostly within the eastern portion of the study area, were only visible using a 1-ha scale. This research suggests that there is enough habitat for a population of approximately 2,256 bears, but additional more-detailed land cover analysis within particular locations will be needed to improve accuracy of habitat analysis.

A majority of public land was classified as highly suitable. However, because of the relatively small area of public lands, the widespread presence of timberlands across the landscape will likely be an important factor in determining the maintenance of bear habitat over time. For the past 30 years, timberland area has been decreasing over time. This has important implications for bear recovery for the reasons that (1) the proportion of timberlands containing highly suitable habitat has increased over time as a result of increased attention to stand management for wildlife, and (2) >30% of land that has been consistently highly suitable for bears over the past 30 years was contained among timberlands. Louisiana-Pacific Corporation's (LP) divestment in 2002 will likely affect large areas of habitat between BTNP units, between BTNP and local national forests, and along the Texas-Louisiana border. Although no detailed data are yet available for assessing how LP's divestment will affect bear habitat, land is being sold to the highest

bidder, which does not bide well for maintaining bear habitat in an area that is attractive for suburban development and retirement communities.

As important as ecological feasibility of a reintroduction is social feasibility. Because southeastern Texas contains a large human population, it is essential to incorporate residents' attitudes toward and opinions about a bear reintroduction into bear planning and management. Considerable research has focused on socioeconomic and demographic factors that affect attitudes toward wildlife and conservation. A survey was completed here to determine whether particular socioeconomic factors affect residents' attitudes toward black bears and preferred management strategies for bear recovery. Males, younger respondents, respondents who were more knowledgeable about bears, and those who participate more frequently in passive-appreciative activities related to wildlife were more likely to have positive attitudes toward bears and support increasing the bear population. Concerns about problems that bears may cause (e.g., pilfering in garbage, perception that bears are a danger to people) was a significant predictor of whether a respondent preferred a passive (non-human assisted) or active (human-assisted) recovery strategy. Because a majority of respondents were male, and the survey sample was disproportionably white/Caucasian compared to actual local demographics, further collection of social data is necessary to assess attitudes of underrepresented groups, as well as attitudes of particular user groups such as beekeepers and hunters.

Spatial analysis of respondents' preferred management strategy resulted in two significant clusters. One cluster of respondents in proximity to Angelina National Forest (in San Augustine and Jasper Counties) indicated that they did not support a non-assisted bear recovery strategy. Specific reasons cited by these respondents included that they

(the respondents) thought that a non-assisted recovery would take too long, and that they wanted bears in the area now. Another cluster of respondents in Orange County indicated that they did not support a recovery strategy that sought to exclude bears from the area. Orange County is the most urbanized county within the study area, and even though respondents indicated that they did not want to exclude bears from the area, approximately 40% indicated that they were not sure exactly what management strategy they preferred. Because a strong spatial distribution of attitudes was not identified, public outreach will likely to be more of a challenge than if particular attitudes were neatly clustered across the landscape.

To integrate ecological and social data, a framework for a systems model was developed and used to assess ecological and social feasibility of a bear reintroduction across the study area. Based on results from this research, past trend of declining timberland area is likely to continue and may dictate overall changes in bear habitat over time. If large areas of timberland are lost, there is a good possibility that such areas will be replaced by residential, commercial, and industrial development. Ideally, the greatest ecological and social feasibility would both be found within the same counties, but this was not the case. Results from the systems model suggested that the greatest ecological feasibility for a reintroduction existed in Sabine, Trinity, and San Augustine Counties, but social feasibility was greatest in Jasper, Tyler, and Newton Counties. As a result, national forests, which also contain expanses of core habitat, may be better potential bear release sites than BTNP. Knowledge about black bears was the social variable for which changes in the variable's value most affected changes in model output. Therefore, efforts to increase residents' knowledge about bears may result in increased social feasibility

across the study area. The Texas Parks and Wildlife Department may use this information to customize public outreach and management based on the ecological and social feasibility within a particular county.

This dissertation is only the beginning of research aimed to determine whether bears can be reintroduced into southeast Texas. Because of the coarse-scale analysis used for both ecological and social components, finer detailed analysis is needed to verify habitat data, as well as further explore residents' attitudes and opinions about a bear reintroduction. The East Texas black bear management plan, which was released in 2005, suggests public outreach as the main focus for bear recovery efforts over the next 15 years. Major changes are proposed for the southeast Texas landscape that could be detrimental to bear recovery efforts. But by starting public outreach now, the Texas Parks and Wildlife Department may be able to create enough interest and support for bear recovery among citizen groups that bear management goals will be included in planning for local development of human infrastructure. Although it is unknown at this time whether and when bears will ever be released into southeast Texas, I have developed a systems model to integrate ecological and social data for evaluating ecological and socioeconomic feasibility of a species reintroduction, which may also be applied to other wildlife conservation-related endeavors.

Data collected from this dissertation are not exhausted, and I offer three ideas of future research. First, I will continue development of the systems model to incorporate changes in land use in areas that are not publicly owned or managed by private timber companies. Although expansion of human activity will be greatly affected by presence of timberlands, exploration of land use changes in other locations within the study area may

lend insight into how land cover has changed in areas that were occupied by timberlands in the past. Second, although detailed analysis of social variables that affect attitudes toward bears has been completed, I will seek to apply risk perception analysis to survey data. Several models for assessing acceptance capacity for wildlife have been developed, and it would be interesting to compare how survey data related to bear recovery can (or cannot) be incorporated into landscape analysis. Third, I will seek to explore how data and results from this research can be expanded into greater detail to contribute to the development of theory related to interdisciplinary research, improve policy and decision-making for wildlife management, and our understanding of the dynamics of human-dominated ecosystems.

APPENDIX

A. 1. SURVEY PRENOTICE

The prenotice was printed on Michigan State University Department of Fisheries and Wildlife letterhead

26 January 2004

«fname» «lname»

«address1»

«city_name», «state_prov_code» «zip_postal_code»

In a few days you will receive a request in the mail to fill out a questionnaire for an important research project being conducted by Michigan State University in cooperation with the Texas Parks and Wildlife Department.

I am writing in advance to encourage your participation in this questionnaire, and because I understand that many people like to know ahead of time that they will be contacted. This questionnaire is one part of a study to learn about opinions of East Texas residents regarding black bear sightings in your area. This is a very important study that will help researchers and natural resource managers manage bears with East Texas residents' diverse opinions and interests in mind.

If you have any questions about this project now or after you receive your questionnaire, please feel free to call me **toll free at 1-800-814-9289**. If you have questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact Peter Vasilenko, Chair of the University Committee on Research Involving Human Subjects (UCRIHS), 202 Olds Hall, Michigan State University, by phone: (517) 355-2180, fax: (517) 432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, MSU, East Lansing, MI 48824-1046.

It's only with the generous help of people like you that our research can be successful. Thank you in advance for your time and consideration.

Sincerely,

Anita Morzillo
Project Manager

P.S. As our way of saying thanks for your participation, we will be enclosing a small gift with your survey. Remember, your survey will arrive in a couple of days. We look forward to hearing from you!

A. 2. SURVEY MAILING #1 COVERLETTER

The coverletter was printed on Michigan State University Department of Fisheries and Wildlife letterhead

29 January 2004

«name»

«address»

«city», «state» «zip»-«four»

Recently, you should have received a notice about an upcoming survey about black bears in East Texas. I am now writing to ask for your help in a study of East Texas residents being conducted by Michigan State University in cooperation with the Texas Parks and Wildlife Department. This questionnaire is one part of a study to learn the opinions and desires of East Texas residents about black bear sightings in East Texas. This very important study will help researchers and natural resource managers manage bears with East Texas residents' diverse opinions and interests in mind.

We are contacting a random sample of East Texas residents to ask their opinions about wildlife, black bears, and black bear management. We are interested in the wide range of opinions that currently exist. There are no right or wrong answers. Your opinions are very important to us and will make a difference for bear management in East Texas.

Your responses will be kept completely confidential. The survey has identifying information for mailing purposes only. Your name and address will never be associated with your responses and your privacy will be protected to the maximum extent allowable by law. Your response to this survey and any of the questions is completely voluntary and it should take about 15 minutes to complete. You indicate your voluntary agreement to participate by completing and returning this survey. Please complete this questionnaire at your earliest convenience, seal it, and drop it in any mailbox (no envelope is needed). Return postage has been provided.

If you have any questions about this project, please feel free to call me **toll free at 1-800-814-9289**. If you have questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact Peter Vasilenko, Chair of the University Committee on Research Involving Human Subjects (UCRIHS), 202 Olds Hall, Michigan State University, by phone: (517) 355-2180, fax: (517) 432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, MSU, East Lansing, MI 48824-1046.

Thank you very much for helping with this important study.

Sincerely,

Anita Morzillo
Project Manager

P.S. This survey is intended for someone who is at least 18 years of age and a resident of East Texas. If the person to whom this is addressed does not fit this description, please give this survey to a person in your household who does. If no one in your household fits this description, please write on the survey that no one was eligible to complete it and send the survey back to me. Many thanks.

A. 3. SURVEY INSTRUMENT



ATTITUDES ABOUT BLACK BEARS IN EAST TEXAS

1. Which of the following statements **best** describes your current interest in and involvement with wildlife? (*Please check [✓] ONE statement*)

- ☐ I am interested in wildlife AND I actively take part in wildlife related activities
- ☐ I am interested in wildlife BUT I do not take part in many activities that are specifically related to wildlife
- ☐ I am NOT interested in wildlife AND I do not take part in many activities that are specifically related to wildlife
- ☐ I am NOT interested in wildlife BUT for various reasons I am involved in wildlife-related activities

2. Please indicate how often you, or members of your household, participate in each of the following activities for work or pleasure. (*Please circle ONE response for each activity*)

	Often	Sometimes	Never
Hike			
Jog/run outside			
Bike (trail/mountain or road)			
Camp (tent, trailer, RV)			
Motorboat/jetski/waterski			
Canoe/kayak			
Ride motorized all-terrain vehicles			
Read about wildlife			
Watch wildlife TV shows or movies			
Observe or study wildlife outdoors			
Hunt big game (e.g., deer)			
Hunt smaller animals (e.g., squirrel)			
Fish			
Work on a farm or ranch			
Work in the timber industry			
Work in the oil/gas industry			
Other activities (<i>please specify</i>)			

3. Are you a member of any organizations related to wildlife (e.g., Ducks Unlimited, Audubon Society)? (Please check [✓] ONE)

☐ Yes -- Please answer question 3a

☐ No -- Please go to question 4

3a. If yes, what organization(s)? _____

4. Where do you get most of your information about wildlife in Texas? (Please check [✓] ONE)

☐ Television

☐ Newspaper

☐ Magazines

☐ Internet

☐ Hunting/fishing regulation guide

☐ Wildlife professionals

☐ Family, friends, or co-workers

☐ Your own experiences

☐ Other (please specify) _____

5. Please indicate which, if any, of the following types of interactions with black bears you, or members of your household, have experienced in any location. (Please check [✓] all that apply)

☐ Watched black bears in the wild or in captivity (e.g., in a zoo)

☐ Read something or watched TV shows/movies about black bears

☐ Hunted black bear

☐ Had a personal encounter with a black bear

☐ Livestock had an encounter with a black bear

☐ Read or heard of a black bear being killed by authorities

☐ None of the experiences described above

☐ Other types of experiences (please specify below)

6. Have you ever seen a black bear in the wild? (Please check [☐] ONE)

[☐] Yes -- Please answer questions 6a and 6b

[☐] No -- Please go to question number 7

[☐] Unsure -- Please go to question number 7

6a. If yes, when and where? _____

6b. If yes, for each item below please indicate, on a scale of 1 to 5, your reaction to seeing a black bear. (Please circle ONE number per line)

Happy	5	4	3	2	1	Unhappy
Excited	5	4	3	2	1	Not excited
Curious	5	4	3	2	1	Not curious
Frightened	5	4	3	2	1	Not frightened

7. Prior to receiving this survey, were you aware that: (Please circle ONE response for each statement)

	Yes	No
Until the early 1900's, East Texas contained a large population of black bears		
The number of black bear sightings in East Texas has increased during the past decade		
Black bear populations are increasing in size in Arkansas, Louisiana, and Oklahoma		
Black bears in East Texas are protected by both federal and state legislation		
Black bears exist throughout most of the United States and North America		
Black bears are mainly vegetarians		

Please go on to the next page

8. Which of the following statements best reflects how you feel about black bears in East Texas? (Please check [✓] ONE)

- [] I would enjoy having black bears around AND I would not worry about problems they may cause
- [] I would enjoy having black bears around BUT I would worry about problems they may cause
- [] I would not enjoy having black bears around BUT I would not worry about problems that they may cause
- [] I would not enjoy having black bears around AND I would worry about problems they may cause
- [] I have no particular feelings about black bears regardless of problems caused or not caused by them

9. It is likely that people in East Texas have many different opinions about black bears. To what extent do you agree or disagree with each of the following statements? (Please circle ONE response for each statement)

	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
The presence of black bears is a sign of a healthy environment					
Black bears would reduce the size of wild hog populations					
Black bears in East Texas would increase my quality of life					
Black bears near my home would increase my quality of life					
Black bears have the right to exist wherever they may occur					
I would feel personally at risk if black bears exist in East Texas					
I am afraid of black bears					
Black bears commonly harm humans					
Wildlife experts know how to manage black bears					
Wildlife experts understand landowners' concerns about black bears					

10. To what extent do you agree or disagree with each of the following statements?
(Please circle ONE response for each statement).

	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
The black bear population in East Texas should be increased					
The black bear population in East Texas should be increased <u>only</u> if steps are taken to lessen the chances of human-bear conflicts					
The black bear population in East Texas should remain the same					
Black bears should <u>not</u> exist in East Texas					

11. Do you hunt? (Please check [✓] ONE)

[] Yes -- Please answer question 11a

[] No -- Please go to question 12

11a. Would you be interested in hunting for black bear in East Texas?
(Please check [✓] ONE)

[] Yes

[] No

[] Unsure

12. In general, do you believe black bears are a potential danger to humans? (Please check [✓] ONE and answer 12a)

[] Yes

[] No

[] Unsure

12a. Provide reasons for your answer. (Please be as specific as possible)

13. Do you believe black bears are a nuisance? (Please check [✓] ONE and answer 13a)

☐ Yes

☐ No

☐ Unsure

13a. Provide reasons for your answer (Please be as specific as possible)

14. Do you think black bear populations in East Texas should increase naturally (i.e., without assistance from a natural resource agency)? (Please check [✓] ONE and answer 14a)

☐ Yes

☐ No

☐ Unsure

14a. Provide reasons for your answer (Please be as specific as possible)

15. Do you think that natural resource agencies should assist in increasing the black bear population size in East Texas? (Please check [✓] ONE and answer 15a)

☐ Yes

☐ No

☐ Unsure

15a. Provide reasons for your answer (Please be as specific as possible)

16. Would you support the restocking of black bears into suitable habitats in East Texas by natural resource agencies? (Please check [✓] ONE)

☐ Yes

☐ No

☐ Unsure

17. Some people are concerned that recovery of black bears in East Texas may cause problems for people. In your opinion, which statement best describes how potential bear problems should be handled by natural resource agencies? (Please check [✓] ONE)

- ☐ Relocate the problem bear to a different area
- ☐ Use dogs to frighten bears until bears are no longer a problem
- ☐ Kill problem bears after a first offense
- ☐ Kill problem bears only after several offences
- ☐ Bears should not be disturbed
- ☐ Other (please specify) _____

18. Is each of the following more or less likely to happen to you compared to you having a negative encounter with a black bear? For example, if you believe that you are more likely to become a murder victim than experience a negative encounter with a bear, then circle more likely. (Please circle ONE response for each item)

<i>Example: Becoming a murder victim.</i>	More Likely	Less Likely	Unsure	I cannot determine this based on my personal experience
Getting into a car accident				
Getting into an accident if you ride a motorcycle				
Getting scratched by a cat				
Having an accident if you drive a tractor				
Getting into a commercial airline crash				
Dying as a result of cancer				
Getting bitten by a dog				
Getting struck by lightning				
Winning \$1 million in the lottery				

In order for us to better understand peoples' responses to the previous questions, we need to know a few things about your background. Please remember, your responses are completely confidential. Neither your name nor your address will be directly linked to your responses in any way.

19. For approximately how many years have you:

Lived in East Texas? _____ years

Lived at your current residence? _____ years

20. For approximately how many generations has your family lived in East Texas?

_____ generations

21. In what county do you live? _____ County

22. If you have lived in other locations, please indicate the states or countries that you have lived in (including other regions of Texas).

23. Do you own any land in East Texas? (*Please check [✓] ONE*)

[] Yes -- *Please answer questions 23a and 23b*

[] No -- *Please go to question 24*

23a. For how many years have you owned land in East Texas?

_____ years

23b. How many acres of land do you own? _____ acres

24. Which of the following land use activities presently take place on the land that you own or live on? (*Please check [✓] all that apply*)

[] Timber management [] Row crop agriculture (e.g., corn)

[] Livestock grazing [] Residential

[] Hunting [] Oil/natural gas extraction

[] Beekeeping [] All-terrain vehicle use

[] Commercial/industrial

[] Other (*please specify*) _____

25. Which of the following land use activities do you expect will take place in the future on the land that you own or live on. (Please check [☒] all that apply)

- | | |
|---|--|
| ☐ Timber management | ☐ Row crop agriculture (e.g., corn) |
| ☐ Livestock grazing | ☐ Residential |
| ☐ Hunting | ☐ Oil/natural gas extraction |
| ☐ Beekeeping | ☐ All-terrain vehicle use |
| ☐ Commercial/industrial | |
| ☐ Other (please specify) _____ | |
-

26. In what type of community do you currently live? (Please check [☒] ONE)

- ☐ Rural, Farm
- ☐ Rural, Non-farm
- ☐ Small town (<5,000 people)
- ☐ Large town (5,000-10,000 people)
- ☐ Suburb
- ☐ Small city (10,001-50,000 people)
- ☐ Large city (>50,000 people)

27. How many individuals are in your household? _____

How many individuals are less than 18 years old? _____

28. Do you have any pets? (Please check [☒] ONE)

- ☐ Yes
- ☐ No

29. Are you male or female?

- ☐ Male
- ☐ Female

30. In what year were you born? 19_____

31. What is the highest level of formal education that you have completed? (Please check [✓] ONE)

- ☐ Primary school (grade 8)
- ☐ High school graduate or equivalent (e.g., GED)
- ☐ Vocational or trade school
- ☐ Some college
- ☐ Associate's degree (2 year degree)
- ☐ College graduate (Bachelor's or 4 year degree)
- ☐ Graduate or professional degree

32. What is your race or ethnicity? (Please check [✓] all that apply)

- ☐ White/Caucasian
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Asian
- ☐ Native American
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Other (please specify) _____

33. What was your gross household income (before taxes) in 2003? (Please check [✓] ONE)

- ☐ Less than \$20,000
- ☐ \$20,000 to \$39,999
- ☐ \$40,000 to \$59,999
- ☐ \$60,000 to \$74,999
- ☐ \$75,000 or more

Please go on to the next page

34. For our future reference, by which means, if any, would you like to receive information about black bears in East Texas? (*Please check [☒] all that apply*)

☐ Pamphlet/brochure ☐ I am not interested

☐ Compact disk (CD)

☐ VCR tape

☐ Digital video disk (DVD)

☐ Public information session

☐ Internet

☐ E-mail

☐ Other (*please specify*) _____

Please use this space for any additional comments.

☐ *Check [☒] here if you would like us to send you a summary of survey results.*

☐ *Check [☒] here if you would like us to send you general information about black bears in East Texas.*

TO RETURN THIS SURVEY, SIMPLY SEAL IT AND DROP IT INTO ANY MAILBOX. RETURN POSTAGE IS PROVIDED.

THANK YOU FOR YOUR TIME AND ASSISTANCE!!

A. 4. REMINDER POSTCARD

12 February 2004



Recently you were mailed a questionnaire from Michigan State University, in cooperation with the Texas Parks and Wildlife Department, seeking your opinion about black bears.

If you have already completed and returned the survey, please accept our sincere thanks! If not, please do so today. Because of the small number of people contacted, it is very important that we receive your feedback.

If you did not receive the questionnaire, or it got misplaced, please call me **toll free at 1-800-814-9289** and we will get another questionnaire in the mail to you.

Sincerely,

Anita Morzillo
Project Manager

A. 5. SURVEY MAILING #2 COVERLETTER

The coverletter was printed on Michigan State University Department of Fisheries and Wildlife letterhead

26 February 2004

«name»

«address»

«city», «state» «zip»-«four»

A few weeks ago we sent you a questionnaire asking for your opinions about wildlife, black bears, and black bear management. So far, we have not received your response. If this letter and your completed survey have crossed in the mail, please disregard this letter and accept our sincere thanks for your participation in this study!

The comments of people who have already responded show that East Texas residents hold a wide variety of views about black bears. We know the results are going to be very useful to natural resource managers and researchers.

We are writing again because of the importance that your questionnaire has for helping to get accurate results. Although we sent questionnaires to people across several counties, it is only by hearing from nearly everyone to whom surveys are mailed that we can be sure that the results are truly representative of the opinions of East Texas residents. If you have not had a chance to fill out the survey questionnaire, we would appreciate your prompt attention.

Some people have told us that they have no interest in, knowledge of, or experience with black bears and they feel that their response is therefore not important. We want you to know that everyone's opinion is important for this survey. A few people have written to say that they should not have received the questionnaire because they are not a resident of East Texas or they are not at least 18 years of age. If either of these concerns applies to you, please give the survey to a person in your household who meets these criteria. If no one in your household is eligible, please indicate this on the survey and send it back to us. We would really appreciate it, and this way we can remove you from our mailing list.

Your name will never be associated with your responses in any way and your privacy will be protected to the maximum extent allowable by law. Your response to the survey and any of its questions is completely voluntary. The survey should only take about 15 minutes to complete. After you are finished completing the questionnaire, please seal it, and drop it in any mailbox (no envelope is needed). Return postage has been provided.

If you have any questions about this project, please feel free to call me **toll free at 1-800-814-9289**. If you have questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact Peter Vasilenko, Chair of the University Committee on Research Involving Human Subjects (UCRIHS), 202 Olds Hall, Michigan State University, by phone: (517) 355-2180, fax: (517) 432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, MSU, East Lansing, MI 48824-1046.

Sincerely,

Anita Morzillo
Project Manager

A. 6. NONRESPONSE FOLLOW-UP SURVEY

24 June 2004

Recently you were mailed a questionnaire seeking your opinion about black bear management in East Texas. Since our response rate to this survey was lower than we had hoped, we would like to ask you a few questions so we can understand the reasons for this non-response.

We are not asking you to fill out anything like the survey we sent you previously. Rather, we have attached a stamped, addressed postcard for you to fill out, detach, and drop in the mail. It should take no more than 5 minutes to fill out the postcard. We would sincerely appreciate you taking the time to return this to us as soon as possible because it will provide valuable information for our study.

As before, your response to this postcard is voluntary, but we would not be asking you for this information if we did not consider it important. You may be assured of complete confidentiality. The postcard has an identification number for mailing purposes only. Your name will never be linked to your responses.

Your cooperation is greatly appreciated. Thank you for taking the time to assist us with this study.

Sincerely,

Anita Morzillo
Project Manager

A. 6. (Cont'd.)

1. Was there a particular reason why you did not respond to our survey on Attitudes about Black Bears in East Texas?
(*Check all that apply*)
- | | |
|---|--|
| ☐ I do not like answering surveys | ☐ The survey looked too long and/or complicated |
| ☐ I do not have time to answer surveys | ☐ I am unhappy with the Texas Parks & Wildlife Department and/or its programs |
| ☐ I know very little about bears | ☐ I am not interested in the issues in the survey |
| ☐ I never received the survey | ☐ I would prefer being contacted by telephone |
| ☐ Another reason (please specify): _____ | |
2. In a typical year, do you participate in any of the following activities? (*Check all that apply*)
- | | | | | | |
|----------------------------------|----------------------------------|---|----------------------------------|---------------------------------|--|
| ☐ Hunting | ☐ Fishing | ☐ Wildlife viewing | ☐ Camping | ☐ Hiking | ☐ Ride motorized all-terrain vehicles |
|----------------------------------|----------------------------------|---|----------------------------------|---------------------------------|--|
3. Prior to receiving this survey, were you aware that: (*Please check one response for each statement*)
- | | | | |
|--|------------------------------|-----------------------------|---------------------------------|
| a. Until the early 1900's, East Texas contained a large population of black bears | ☐ Yes | ☐ No | ☐ Unsure |
| b. Black bears exist throughout most of the United States and North America | ☐ Yes | ☐ No | ☐ Unsure |
| c. The number of black bear sightings in East Texas has increased during the past decade | ☐ Yes | ☐ No | ☐ Unsure |
| d. Black bears are mainly vegetarians | ☐ Yes | ☐ No | ☐ Unsure |
4. Would you enjoy having black bears in East Texas? (*Check one*)
- | | | |
|------------------------------|-----------------------------|---------------------------------|
| ☐ Yes | ☐ No | ☐ Unsure |
|------------------------------|-----------------------------|---------------------------------|
5. In general, do you believe black bears are a potential danger to humans? (*Check one*)
- | | | |
|------------------------------|-----------------------------|---------------------------------|
| ☐ Yes | ☐ No | ☐ Unsure |
|------------------------------|-----------------------------|---------------------------------|
6. Would you support the restocking of black bears into suitable habitats in East Texas by natural resource agencies? (*Check one*)
- | | | |
|------------------------------|-----------------------------|---------------------------------|
| ☐ Yes | ☐ No | ☐ Unsure |
|------------------------------|-----------------------------|---------------------------------|
7. Do you have a college degree? ☐ Yes ☐ No
8. Are you male or female? ☐ Male ☐ Female
9. Were you born before 1950? ☐ Yes ☐ No



Thank you!

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