Population Ecology, Residents' Attitudes, Hunter Success, Economic Impact, Modeling Management Options and Retention Time of Telazol of West Virginia Black Bears

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Abstract

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Christopher W. Ryan

The West Virginia Black Bear Research Project (WVBBRP) was initiated in 1972 to investigate population parameters, growth rates, home ranges, and habitat uses of a declining American black bear (*Ursus americanus*) population. As with other black bear projects in North America, the WVBBRP demonstrated that black bears enter dens in a predictable order and hunting season dates were adjusted accordingly to allow for population growth while maintaining hunting seasons. The West Virginia Division of Natural Resources (WVDNR) continued to monitor the black bear population and increased monitoring efforts and sample sizes in the 1990's as the black bear population increased in size and expanded its range. As part of the WVBBRP, we investigated black bear population ecology. Our objectives were to estimate reproductive rates, estimate survival and cause-specific mortality rates, examine effects of special hunting seasons and food conditions on survival, estimate population growth rates, examine population growth sensitivity to differing demographic parameters. Moreover, we examined the most cost effective method to monitor black bear reproduction, survival, and population trends. We trapped > 1,600 black bears and handled them > 4,000 times on 2 study areas and observed 300 new born litters of cubs during den visits from 1972–2007.

Reproductive parameter estimates were similar for numerous methods and should provide managers with more cost efficient ways of gathering data. Population demographics were different between oak (*Quercus* spp.)-hickory (*Carya* spp.) forest and mixed-mesophytic forest associations. Extreme mast failures influenced the number of black bears surviving to 1 year. Survival estimates of black bears were influenced by hunting season structures and food conditions. Special black bear hunting seasons conducted by the WVDNR reduced female survival and apparently stabilized the population in southern West Virginia. Black bear population dynamics differed within West Virginia and even within study areas depending on capture locations of females. Population dynamics and growth rates were affected by early hunting seasons and protection from hunting through private sanctuaries of large ($\geq$ 544 ha) tracts of land. Where we observed adequate hunting pressure, the 2-year running average of the black bear harvest was highly correlated to population estimates and provided managers with an index to population size when it was not feasible to gather specific demographic data. The 2-year running average of observational data from white-tailed deer (*Odocoileus virginianus*) hunters was correlated to statewide black bear population estimates but nuisance complaints were not correlated to population estimates. Adult female survival was the single parameter that had the largest individual impact on population growth rates, but it is difficult for managers to reduce survival of this age class without decreasing survival in other age classes. Juvenile and subadult female survival rates had little impact on λ when considered separately but had an additional influence when there were decreasing adult female survival rates. Therefore, we modeled varying parameter estimates to mimic special hunting seasons. On our northern study area where $\lambda = 1.091$ decreasing female survival estimates by 0.08 should stabilize the population. In areas where black bears are at or above their cultural carrying capacity managers should focus on controlling adult female survival rates but should also monitor subadult and

juvenile rates. States or provinces with hunting seasons should gather adequate hunter survey data to determine hunting pressure and determine if harvests are correlated to populations to provide accurate indices for managers. Long-term data sets provided the most accurate methods to examine parameter effects on population dynamics of black bears, but other indices may provide insight into population estimates or growth rates if economics preclude the gathering of more expensive parameter specific demographic data.

Although understanding the population dynamics of an individual species is critical, biologists must also consider public opinion when setting hunting seasons. Wildlife agencies have altered proposed regulations or have had seasons entirely stopped because of public opposition, necessitating a proactive approach to wildlife management based on a scientific understanding of public opinion rather than reactive decision-making in response to public resistance. In November–December 2006, we conducted a telephone survey of 1,206 West Virginia residents to determine their opinions and attitudes toward black bear populations and hunting seasons and to help strengthen the state's black bear management strategies. Although the majority of West Virginians, nearly 3 of 4 respondents in this study, indicated they know at least something about black bears in West Virginia, there were significant regional differences in the public's assessment of their knowledge of the species. Although most respondents thought the black bear population size was "about right," again, there were regional differences among respondents. In general, most respondents supported black bear hunting if the population was carefully monitored, if they knew the population was stable, or both; however, a number of regional and sociodemographic characteristics appeared to influence public opinion on black bear hunting and hunting seasons in the state, and support for specific seasons varied considerably according to hunting method. Interestingly, our study found that, even among hunters, public opposition exceeded support for the current, year-round training season of black bear hunting dogs without harvesting animals in the state. Although it is important for wildlife managers to consider human dimensions and public opinion data in conjunction with biological data when making management decisions, we demonstrate that it also is important for managers to consider regional and sociodemographic differences with respect to attitudes and opinions when making management decisions and population objectives.

In addition to demographic data about wildlife populations and public opinion, hunter participation and success rates are vital for managers developing management programs and to evaluate current regulations and special seasons. We conducted a systematic random mail survey of hunters that purchased a black bear stamp in West Virginia in 2006 to determine effects of hunting seasons and the economic impact of black bear hunting. Thirty-seven percent of respondents stated that they specifically targeted black bears while hunting; whereas, 63% stated that they hunted black bears concurrently while hunting white-tailed deer. Fifty percent of respondents primarily hunted with archery equipment, 26% used guns without dogs, and 24% used dogs to pursue black bears with success rates of 5.2%, 6.3%, and 19.2%, respectively. Twelve percent of hunters using archery equipment, 25% of gun hunters primarily hunting without dogs, and 41% of hunters primarily using dogs indicated they had participated at least once in the previous 5 special black bear hunting seasons. Hunters using dogs passed up more legal opportunities to harvest black bears than hunters using archery equipment or gun hunting without dogs. However, estimated harvests were similar because of the larger number of hunters that did not use dogs. The total economic impact of black bear hunting in West Virginia was $51,847,605. Managers should continue to evaluate the effectiveness of hunting seasons and make adjustments accordingly to reach management objectives.

Managers are often faced with the challenging task of developing a management plan from a number of practical options. We developed a management plan for American black bears using a rank-exponent technique to determine where to most effectively implement different harvest strategies. We identified and ranked 6 factors believed important to the successful implementation of different harvest strategies available for black bears in West Virginia. Each factor was ranked from 1 to 6, normalized, and used to compute a final score for each management unit using a rank-exponent technique. Although we used the ranking technique to develop a management plan for black bears, it is applicable to other hunted and non-hunted species.

The ability for managers to immobilize black bears for research projects and in nuisance situations is critical for a management agency. Telazol® (Fort Dodge Animal Health, Fort Dodge, IA) is an effective immobilization drug for black bears but concern exists regarding retention time of this drug in tissues relative to human consumption of bears. Therefore, we evaluated retention time of Telazol in captured American black bears immobilized with Telazol and held in captivity for 3 days, 7 days, 14 days, or 21 days. We detected Telazol in muscle and liver of one bear on day 7, in serum from 2 bears on day 7, and in urine of one bear each on day 3 and day 14. Our findings suggest Telazol is metabolized and eliminated quickly from the bear's system and should allow managers additional flexibility in mark-recapture studies and nuisance situations.

The data collected, analyzed, and tested in this dissertation will allow biologists to better understand black bear population dynamics in the Appalachian Mountains. Moreover, the cumulative effect of considering black bear demographics, public opinion, hunter success, management options, and having the ability to immobilize animals at additional times should benefit not only black bears, hunters, and the WVDNR, but all residents of West Virginia.

Dedication

I dedicate this dissertation to my lovely wife, Beth. This was a long road completing my Ph.D. while continuing to work full time and there is no possible way that I could have finished this project without her love and support. There were many nights, weekends, and overtime that I worked on this project that took time away from her but she was always understanding and supportive. I also dedicate this dissertation to my parents, Bill and Carolyn Ryan. There would have been no possible way that I would have taken all of my classes and worked at the same time if I didn't have them. So many days I went to the office for 16 hours to only come to their house to eat and sleep. Without them I wouldn't have physically had the time to do everything but somehow it all got done.

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Black Bear Population Ecology in West Virginia

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ABSTRACT The West Virginia Black Bear Research Project (WVBBRP) was initiated in 1972 to investigate population parameters, growth rates, home ranges, and habitat uses of a declining American black bear (*Ursus americanus*) population. As with other black bear projects in North America, the WVBBRP demonstrated that black bears enter dens in a predictable order and hunting season dates were adjusted accordingly to allow for population growth while maintaining hunting seasons. The West Virginia Division of Natural Resources (WVDNR) continued to monitor the black bear population and increased monitoring efforts and sample sizes in the 1990's as the black bear population increased in size and expanded its range. As part

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of the WVBBRP, we investigated black bear population ecology. Our objectives were to estimate reproductive rates, survival and cause-specific mortality rates, and population growth rates. We also examined the effects of special hunting seasons and food conditions on black bear survival and the sensitivity of population growth to differing demographic parameters. Moreover, we examined the most cost effective method to monitor black bear reproduction, survival, and population trends. We trapped > 1,600 black bears and handled them > 4,000 times on 2 study areas and observed 300 new born litters of cubs during den visits from 1972–2007.

Reproductive parameter estimates were similar for numerous methods and should provide managers with more cost efficient ways of gathering data. Population demographics were different between oak (*Quercus* spp.)-hickory (*Carya* spp.) forest and mixed-mesophytic forest associations. Extreme mast failures influenced the number of black bears surviving to 1 year. Survival estimates of black bears were influenced by hunting season structures and food conditions. Special black bear hunting seasons conducted by the WVDNR reduced female survival and λ (population growth rate) < 1.0 in southern West Virginia. Black bear population dynamics differed within West Virginia and even within study areas depending on capture locations of females. Population dynamics and growth rates were affected by early hunting seasons and protection from hunting through private sanctuaries of large (≥ 544 ha) tracts of land. Where we observed adequate hunting pressure, the 2-year running average of the black bear harvest was highly correlated to population estimates and provided managers with an index to population size when it was not feasible to gather specific demographic data. The 2-year running average of observational data from white-tailed deer (*Odocoileus virginianus*) bowhunters was correlated to statewide black bear population estimates, but nuisance complaints were not correlated to population estimates. Adult female survival was the parameter that had

the largest individual impact on population growth rates, but it is difficult for managers to reduce survival of this age class without decreasing survival in other age classes. Juvenile and subadult female survival rates had little impact on λ when considered separately but had an additional influence when there were decreasing adult female survival rates. Therefore, we modeled varying parameter estimates to mimic special hunting seasons by adjusting survival of all 3 age classes at once. On our northern study area where λ = 1.091 decreasing female survival estimates by 0.08 should stabilize the population. In areas where black bears are at or above their cultural carrying capacity managers should focus on controlling adult female survival rates but should also monitor subadult and juvenile rates. States or provinces with hunting seasons should gather adequate hunter survey data to determine hunting pressure and determine if harvests are correlated to populations to provide accurate indices for managers. Long-term data sets provided the most accurate methods to examine parameter effects on population dynamics of black bears, but other indices may provide insight into population estimates or growth rates if economics preclude the gathering of more expensive parameter specific demographic data.

KEY WORDS American black bear, Appalachian Mountains, growth rate, hunting, lambda, mast, oak, population dynamics, *Quercus*, reproduction, survival, source-sink, *Ursus americanus*, West Virginia

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INTRODUCTION

American black bear (*Ursus americanus*; hereafter, black bear) populations have increased dramatically across the eastern United States in the last 3 decades and many state agencies and universities monitor their abundance or demographic parameters (Pelton and van Manen 1996, Bridges 2005, Dobey et al. 2005, Garshelis and Hristienko 2006, Carr and Burguess 2008, Spiker 2008, Ternent 2008, Vashon and Cross 2008). However, the longevity and low reproductive potential of black bears as well as the high economic cost of gathering data make it difficult to efficiently monitor populations for an extended period of time. Examining variation in annual survival is more difficult for large carnivores than smaller and more abundant animals because of sample size restrictions (Brongo et al. 2005). In addition, analysis of short-term data sets may result in differing inferences than those based on longer term (> 20 years) data sets (Pelton and van Manen 1996). For analyses to accurately reflect population dynamics in a given area, data must be gathered over a wide range of environmental conditions and through multiple generations of black bears. Moreover, the inability to gather multiple sources of data (e.g., known fate, tagged, age reconstruction, den visits, reproductive tracts, etc.) for an extended period of time has made it difficult for agencies or universities to evaluate and compare estimates.

Information from hunted black bear populations is essential to ensure proper management and gain public trust. Several states (e.g., Colorado, Maine, Maryland, Oregon, New Jersey) have had their seasons closed or modified by public referenda or challenged through the political process (Boulay et al. 1999, Spiker 2008, Vashon and Cross 2008). Residents of various states also have questioned the practice of black bear hunting methods (Beck et al. 1995, Teel et al. 2002, Ryan et al. 2009). West Virginia residents support black bear hunting when they know the West Virginia Division of Natural Resources (WVDNR) monitors the population (Ryan et al. 2009). Examining long-term black bear data sets not only will provide agencies with necessary demographic data to manage populations but also will demonstrate to the public that the agency is proactively monitoring/managing the population.

Black bears have one of the lowest reproductive rates of mammals in North America because of delayed sexual maturity, small litter sizes, and a prolonged birth interval (Pelton 1982, Eiler et al. 1989, Miller 1990); thus small changes in reproduction may dramatically alter population levels (Craighead et al. 1974). Age (Alt 1982, Ryan and Vaughan 1997, Klezendorf 2002), physical condition (Samson and Hout 1995), fall mast availability (Elowe and Dodge 1989, Pelton 1989, McLaughlin et al. 1994), and alternative food sources (McDonald and Fuller 2001) may affect reproduction in black bears. Habitat quality, number of breeding females, and age structure are responsible in part for the number of cubs produced in any given year. Beecham (1980) and Rogers (1977) hypothesized that cub recruitment is density-independent, with most females producing at or near maximum potential, whereas LeCount (1987) stated that density dependent social regulation was a factor in cub survival in Arizona**.**

Food sources, and specifically oak mast, are the driving force behind black bear population dynamics in the Appalachian Mountains (Vaughan 2002). Availability of food in fall may synchronize reproduction in black bears and impact population structure (McLaughlin et al. 1994). Reproductive failures may occur after a hard mast failure but typically dampen over time relative to population size in the Appalachian Mountains (Bridges 2005). Changes in reproduction or population age structure impact black bear harvest rates and other indices that agencies monitor. Without long-term data sets, it would be impossible for researchers to effectively identify these relationships. In addition, mast conditions alone can impact harvest, non-hunting mortalities, and other black bear indices (Noyce and Garshelis 1997, Ryan et al. 2004, Ryan et al. 2007). Potential for mast production varies among habitat types (Stausbaugh and Core 1978) and has localized effects on black bear population dynamics (McLaughlin et al. 1994). Understanding how mast conditions affect reproduction and survival may allow agencies to develop a more cost-efficient method of tracking black bear populations through time.

Hunting is the major cause of mortality in adult black bears (Carney 1985, Kasworm and Thier 1994, Wooding and Hardisky 1994, Ryan 1997, Klenzendorf 2002, Bridges 2005). Adult male black bear survival rates are typically lower than female survival rates and lower in hunted areas than in non-hunted areas because of how agencies structure hunting seasons in relation to denning chronology and male's larger home ranges (Carney 1985, Kolenosky 1986, Hellgren 1988, Kasbohm 1994, Kasworm and Thier 1994, Bridges 2005). However, fertility rates of female black bears are not affected by the number of males in the population (Schenk and Kovas 1995) and are often more of a concern to hunters or managers in areas where adult males are the primary nuisance offenders. Thus, adult male black bear survival is of less importance to researchers but remains of particular interest to primary stakeholders.

Adult female survival has the greatest impact on black bear population dynamics and is the primary factor that managers can control (Bridges 2005). Adult female survival increased in many areas of eastern North America after agencies adjusted hunting seasons to open later because of the earlier denning chronology of female black bears (Johnson and Pelton 1980, O'Pezio et al. 1983, Schooley et al. 1994). Many agencies reported increasing black bear nuisance complaints, harvests, property damage and other indices after adjusting or closing hunting seasons (Carr and Burguess 2008, Ryan 2008, Spiker 2008, Ternent 2008). However, most agencies lack reliable female survival or population growth-rate estimates to make accurate management recommendations, or they are unable to modify hunting seasons to stabilize populations because of political influence. In West Virginia, hunting season dates and legal methods were modified in 1979 to increase female survival and population size.

Mortality rates of subadult black bears in both hunted and non-hunted populations are higher than adults (Elowe and Dodge 1989, Bridges 2005, Lee and Vaughan 2005). Yearling black bears have the highest mortality rate of any age class, and yearling males are the most vulnerable to human-induced mortalities (Carney 1985, Lee and Vaughan 2005). Yearling and 2-year-old male black bears often dominate harvest figures in heavily hunted populations and may account for > 50% of the harvest (Ryan 2009*a*). Although typically unimportant to black bear population dynamics, large fluctuations or declines in these age classes may result in lower harvests and hunter satisfaction.

Small sanctuaries (< 6,000 ha) may serve as refugia that protect adult female black bears and produce subadult black bears for recreational hunting, thus serving as a source population (Beringer et al. 1998). In heavily hunted areas, small refugia may be essential to the viability of black bear populations (Beringer et al. 1998). Male black bears disperse from their natal areas as yearlings or 2-year-old bears, whereas many females tend to stay in their natal areas or disperse shorter distances than males (Schwartz and Franzmann 1992, Lee and Vaughan 2003). These dispersing males are more vulnerable to hunting in close proximity to sanctuaries although subadult females also may be harvested near refugia (Beringer et al. 1998). In addition to hunting pressure, dispersal directly affects survival of young black bears through increased risk of mortality from vehicle collisions or cannibalism by larger black bears (Schwartz and Franzmann 1992). Source-sink population dynamics in black bears also may exist outside of traditional sanctuaries and may be observed where there is differential survival or reproductive rates among subpopulations (Beckmann and Lackey 2008). Understanding how small sanctuaries, whether on public or private land, contribute to black bear population dynamics may be crucial in successful management of black bears throughout the Appalachian Mountains.

Population growth rates of black bears were difficult for researchers or managers to estimate previously because the majority of studies were limited in duration (<10 years) and restricted by small samples sizes that contributed to large statistical standard errors. However, a few researchers were able to effectively model populations (Lindzey and Meslow 1977, Yodzis and Kolenosky 1986, Hellgren and Vaughan 1989, Clark and Smith 1994, Kasbohm et al. 1996, Klenzendorf 2002). Recently completed long-term studies and greater computer modeling capabilities have enabled researchers to produce reliable population growth estimates from a number of different methods for North American bears (*Ursus spp*.), and to model the effects of changing demographic parameters (Bridges 2005, Brongo et al. 2005, Clark and Eastridge 2006, Schwartz et al. 2006, Taylor et al. 2006*a*). Adult female survival typically has the largest impact on population growth rates of bears and is the primary factor that managers may manipulate to achieve desired population levels. However, adjusting hunting seasons to target adult female black bears also may subject juveniles or subadults to different harvest levels, which may compromise models. Relatively few studies have modeled fluctuating harvest (survival) rates of black bears to predict impacts on population growth rates (Klenzendorf 2002, Bridges 2005). Long-term datasets are crucial to understanding the effects of hunting seasons and varying survival rates on population demographics because they contain adequate data to model differing parameters.

WVDNR biologists began the West Virginia Black Bear Research Project (WVBBRP) on the northern study area in 1972 by tagging and equipping black bears with radio transmitters and have since continued to maintain a sample of radioed female black bears. Earlier studies in West Virginia (Pursley 1974, Miller 1975, Brown 1980, Kraus et. al 1988, Weaver 2004) provided some background information, but did not give specific information on reproductive rates, cub survival, dispersal, non-hunting mortalities, effects of early hunting seasons, mast conditions, or denning ecology of black bears. In the 1990's, the WVDNR intensified its efforts to collect demographic data and general biological information on black bear in southern West Virginia and started the southern study area. This large-scale project was further expanded in 2004 to increase the sample size of marked black bears on the northern study area.

Recent studies (Godfrey 1996, Higgins 1997, Ryan 1997, Klenzendorf 2002, Brongo et al. 2005, Bridges 2005) of hunted populations in Virginia and North Carolina provided demographic characteristics of black bears in the Appalachians. However, differences in black bear hunting methods, including a year-round dog training season in West Virginia, habitat types, reproductive potential, survival estimates, land ownership patterns, and season structure make it difficult to use data on a regional basis. In addition, there is limited published literature on costs associated with collecting and analyzing data necessary to monitor populations. Agencies must be able to estimate their cost and manhours to make effective recommendations on the future monitoring of black bear populations in addition to knowing how different indices relate to one another.

OBJECTIVES

Black bear populations in the eastern United States, and specifically West Virginia, have continued to increase despite growing harvests. An escalating number of nuisance complaints from the public concerning black bears have put a financial strain on state agencies that attempt to manage populations with limited budgets. Further compounding the problem is human encroachment into wildlife habitat and how private land may act as refugia when access for hunting is limited or reduced. As our part of the WVBBRP, we investigated black bear population ecology on the basis of a long-term dataset. Our objective was to identify the requirements to stabilize ($\lambda = 1.0$) the black bear population in West Virginia under various management scenarios and to determine the most cost-efficient method for a state agency to monitor the population. Accordingly, we tested hypotheses related to reproductive factors and compared estimates derived from multiple methods (e.g. den visits, reproductive tracts, and age determination). We also tested hypotheses related to the effects of different hunting seasons, food conditions, capture locations, and capture type on black bear survival. Moreover, we compared differences in survival estimates gathered from multiple methods (e.g., known fate, tagged data, direct harvest, and age determination). Using these data, we modeled the requirements to stabilize the black bear population in West Virginia and investigated how private land refugia confound management issues. Many studies have investigated black bear population dynamics but few have examined how multiple methods of data collection are related, modeled how real world changes in black bear survival affect population dynamics, or considered costs associated with monitoring.

STUDY AREA

West Virginia is divided into 3 physiographic provinces: the Western Hill Section, the Allegheny Mountain and Upland Section, and the Eastern Ridge and Valley Section (Strausbaugh and Core 1978). The Western Hill Section is characterized as a central hardwood forest with vegetation communities ranging from oak (*Quercus* spp.)-hickory (*Carya* spp.) on drier sites to flood plain communities along the Ohio River. Sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*) dominate the Allegheny Mountain and

Upland Section; however, oak and black cherry (*Prunus serotina*) may dominate lower elevations and drier sites, and are very important to wildlife (Pack et al. 1999). The Eastern Ridge and Valley Section is predominately a composition of oak-hickory-pine (*Pinus* spp.). Elevation ranges from 73-1,524 m (Strausbaugh and Core 1978). The WVBBRP's southern study area was in the Western Hill Section; whereas, the northern study site was in the Allegheny Mountain and Upland Section (Figure 1).

METHODS

Historical Data

WVDNR personnel, led by the original black bear project leader Joe Rieffenberger, began collecting data in the early 1970's. Their study was in the higher elevation mountain counties in West Virginia because at that time it was the only location with a black bear population. Historically, these data were used to calculate direct harvest estimates and straight Lincoln-Peterson indexes; however, long-term analysis was never performed or published. In addition to the tagged bear database, den visits each spring provided counts of cubs or yearlings. Reproductive tracts also were collected from hunter-harvested bears and road kills beginning in the late 1980's. Approximately 30 to 60 reproductive tracts collected each year provided useful data (complete tract and tooth provided).

We began data collection in a new, separate region, the southern study area, in June 1999. However, some black bears were marked beginning in 1996. Nuisance black bear complaints were increasing in the southern study area and we designed the project to examine population dynamics of black bears in this area. WVDNR marked animals in the traditional mountain study area from 1972–2007; however, we intensified efforts in 2004 to increase sample sizes.

Harvest information.–Although black bear hunters are required to purchase a black bear damage stamp the stamp is not season specific (archery or firearm). Successful hunters checked their black bears at mandatory check stations and voluntary tooth submission was used for age determination (Willey 1973). We compared harvest data to Downing (Downing 1980, Davis et al. 2007) reconstruction population estimates for 5 counties with the longest data set from 1987–2002 using a Pearson's correlation.

Nuisance information.–WVDNR personnel recorded the number of nuisance black bear complaints from 1997–2008. They were instructed to record the type of complaint (e.g. seen, property damage, bird seed, etc.), date and county, and these data were entered into a database. We used a Pearson's correlation to examine the possible relation among nuisance complaints, mast indices, and population estimates. We used statewide population estimates from 1997–2004 for comparisons between population size and nuisance complaints.

Observational surveys.–The WVDNR, in cooperation with the West Virginia Bowhunters Association, conducts an annual survey of white-tailed deer (*Odocoileus virginianus*) hunters using archery equipment to determine observation rates of numerous species (Teets et al. 2007). We used a Pearson's correlation to examine relationships among observation rates of black bears, mast indices, and statewide black bear population estimates from 1995–2004. Moreover, as with harvest estimates, we averaged observational rates for 2 years and compared them to population estimates.

Project costs.–WVDNR personnel submitted work reports with the number of hours worked and mileage traveled on each project for the Federal Aid Wildlife Restoration Act. They also recorded effort spent collecting data on either the demographic data (e.g. trapping, conducting den work, survival monitoring, etc.) or for productivity analysis (e.g. collecting teeth from hunter harvested black bears, reproductive tracts, or game checking tags). We used WVDNR work reports from 2006 and 2007, and additional expenses for equipment, age analysis, etc. to determine an average cost of collecting each specific type of data.

Mast survey.– WVDNR, West Virginia Division of Forestry personnel, and volunteers measured mast conditions annually during August and reported mast indices for the state from 1972–2007 (Evans et al. 2007). The mast report indexes 9 hard mast species: American beech, walnut (*Juglans spp*.), hickory, white oak (*Q. alba*), chestnut oak (*Q. prinus*), black/red oak (*Q. velutina/Q. rubra*), yellow-poplar (*Liriodendron tulipifera*), scarlet oak (*Q. coccinea*), and scrub oak (*Q. ilicifolia*). In addition, 9 soft mast species were indexed: black cherry, grapes (*Vitis spp*.), hawthorn (*Crataegus spp*.), crabapple (*Pyrus spp*.), flowering dogwood (*Cornus florida*), blackberry (*Rubus spp.*), greenbrier (*Smilax spp*.), sassafras (*Sassafras albidum*), and apple (*Malus spp*., Evans et al. 2007). We used beech, black cherry, hickory, chestnut oak, red/black oak, scarlet oak, white oak, and scrub oak in our analysis because these mast species are used most frequently by black bears in West Virginia and are related to black bear harvest success (Ryan et al. 2004).

Surveyors were instructed to perform surveys in the same areas each year and conduct one survey at a high elevation site on or near the ridge line and one at a low elevation site closer to the corresponding water drainage. Survey information included location, county, date, elevation, and aspect (Evans et al. 2007). Each surveyor described available mast as abundant (above normal), common (normal), or scarce (below normal). A mast index was calculated for each mast species by adding the percentage of surveyors reporting mast as abundant and one-half of the percentage of the surveyors reporting mast as common (Evans et al 2007). Scarce was given a value of zero (Uhlig and Wilson 1952). Surveys were indexed by species and groups of species for each year (Evans et al. 2007).

Capture and Handling

We captured black bears on trap lines using culvert traps and modified Aldrich foot snares (Johnson and Pelton 1980) from June until the first Saturday in September. Trap lines consisting of 6–15 snares approximately 0.8 km apart were run for 10–14 days by WVDNR personnel. We used standard handling techniques and measurements for captured black bears (Johnson and Pelton 1980). We marked black bears with various colored ear tags before 1999. Beginning in 1999, we marked each black bear with a black, numbered ear tag in each ear and a corresponding numbered tattoo in the upper lip. We removed an upper premolar tooth for age determination on all captured black bears (Willey 1974). Nuisance black bears captured by WVDNR were marked with an orange ear tag in each ear and corresponding numbered tattoo in the upper lip.

Reproduction

We examined captured females for lactation, estrus, and presence of cubs at trap sites and equipped a minimum of 60 females (30 in each study area) with radio transmitters to determine reproductive rates. We considered adult females ($\geq$ 3 years) not showing signs of lactation available to reproduce, while juvenile females ($\leq$ 2 years) and adult females showing lactation were not considered available to reproduce (Godfrey 1996). For reproductive, survival and demographic analysis, we classified 1- and 2-year-old black bears as juveniles, 3- and 4-year olds as subadults, and black bears $\geq$ 5 years old as adults based on published information from the Appalachian Mountains (Bridges 2005) and our experience.

We determined female reproductive success during den checks on radio-collared females using standard techniques (Godfrey et al. 2000, Bridges 2004) or from cub observations shortly after black bears left the den. We visited each den in January, February, or March to determine the presence/absence of cubs or yearlings, cub sex ratios, and number of cubs per litter. Sample sizes differ between litter size and female reproductive success because cubs were heard at some dens but we were unable to safely handle the female (e.g. inaccessible tree den, mine breaks, etc.). We examined the influence of mast failure on reproductive success and differences in reproductive success between study areas and among age classes using a χ^2. We used SAS 9.1.3 (SAS 2004, Cary, North Carolina, USA) for all analyses and formatting for program MARK.

Age of primaripty was calculated using an unbiased estimator (Garshelis et al. 1998). We calculated interbirth interval by following female black bears for consecutive winters.

Beginning in the late 1980's, we collected female reproductive tracts from black bears that died from hunting or non-hunting causes from 1 September to 31 December and determined age by an upper premolar tooth (Willey 1974). We froze female reproductive tracts and placed them in a 10% buffered formalin solution one week before dissection. We recorded the number of corpora lutea, placental scars, and embryos for each reproductive tract (Kordek and Lindzey 1980, Tsubota et al 1990). We did not use incomplete reproductive tracts in data analysis for litter size. We examined differences between litter size from den visits and reproductive tracts among age classes with an ANOVA.

We used cohort and Downing population reconstruction methods to estimate population size (Pope 1972, Downing 1980, Davis et al. 2007). We estimated the number of black bears surviving to age one using the equation:

No. surviving cubs = (0.5 * ((0.75 * (No. 3-year old females + No. 4-year-old females)) + (0.97 * No. $\geq$ 5-year-old females)))

We tested for differences in litter size among age classes and between study areas using ANOVA and tukey's multiple comparison test. We used a t-test to examine differences between reproductive tracts and den visits and a χ^2 to examine mast influence. We used a Pearson's correlation to compare statewide male cohort estimates from Downing reconstruction with mast indices.

We examined evidence of reproductive synchrony (loss of entire litters) using AIC methods from 6 a priori models (Burnham and Anderson 2002). We examined the influence of mast conditions, 1-year lag of mast conditions, population size, and various combinations of these parameters. We report models within 5.00 $\Delta QAIC_c$ of the highest ranking model and $w_i \geq 0.10$. For complete models see Ryan 2009*b*.

Survival

We obtained survival and cause specific mortality rates of female black bears by tracking radio-equipped animals and recording their status as alive or dead. Each mortality signal was evaluated upon detection and the cause of death determined as: natural, illegal, wounding loss, vehicle collision, or unknown. We assigned mortality dates based on the last known date alive and date the mortality was detected (Pollock et al. 1989). We censored black bears that lost their signal at the last known date alive (Pollock et al. 1989). We determined annual direct harvest rates for male and female black bears. We assumed black bears to be available for harvest if we captured them that calendar year or they were located in the study area based on radio transmitter locations.

Known fate.–We used AIC model selection to examine parameters related to annual female black bear survival using the known fates model in Program MARK (White and Burnham 1999). Although the WVBBRP equipped some male black bears with radio transmitters during the course of the study, we excluded them from known fate analysis because of small annual sample sizes. Moreover, we were only concerned with annual survival rates because non-hunting mortality in black bears is very low (Bridges 2005). We selected explanatory parameters and developed a priori models based on published literature, our experience, and the framework of our hunting seasons.

We developed 11 a priori models for the northern study area females using the parameters of age classes, mast failures, and time. We analyzed survival data from 1991–2007 for female black bears on the northern study area because prior sample sizes were inadequate. We only used females trapped on research lines due to a small sample size of females trapped in nuisance situations on the northern study area.

On the southern study area we developed 13 a priori models using the parameters of age classes, hunting season structure, mast failures, time, and group (research, nuisance black bears translocated, and nuisance black bears not translocated) to examine annual female survival rates.

A global model was used to estimate $\hat{C}$ to correct for overdispersion ($QAIC_c$) in the data for each analysis (Burnham and Anderson 2002). We ranked models from lowest to highest $QAIC_{c.}$ We examined possible collar bias by comparing survival rates for all female age classes and groups for collared versus non-collared (tagged only) using the Burnham model in Program MARK (White and Burnham 1999). We used $QAIC_c$, w_i, and Δ_i, to rank and evaluate models (Burnham and Anderson 2002). We report models within 5.00 $\Delta QAIC_c$ of the highest ranking model and $w_i \geq 0.10$. We report sample sizes for parameters with point estimates and 95% confidence intervals. A complete list of a priori models and model selection results are provided in Ryan (2009*b*).

Tagged survival.–We estimated annual male and female black bear survival rates using the Burnham model in Program MARK (White and Burnham 1999). Differences among hunting season structure, mast conditions, study area, and age structure were examined.

We constructed 21 a priori models on the southern study area using the parameters of age class, hunting season structure, mast failure, time, and group (research, nuisance black bears translocated, and nuisance black bears not translocated) to examine annual survival rates of males. We developed 19 a priori models using the same parameters to examine annual survival rates of females.

On the northern study area, we developed 11 a priori models using parameters age class, mast condition, time, and group (research or nuisance black bears translocated) to examine annual male survival. We developed 7 a priori models using parameters age class, mast condition, and time to examine annual female survival.

We reported models within 5.00 $\Delta QAIC_c$ of the highest ranking model (Burnham and Anderson 2002) and a $w_i \geq 0.10$. A complete list of a priori models and model selection results are provided in Ryan (2009*b*).

Source-sink.– On the southern study area we examined differences in annual female survival using information-theoretic model selection (Burnham model in Program MARK; White and Burnham 1999). We assigned females to one of two groups: heavy or light hunting pressure based on their trap location. Areas with light hunting pressure were active surface or deep mines and provided very limited access to hunters. These areas were not posted “no hunting” or “no trespassing”; however, most areas had guard stations and active work areas that restricted access to hunters and the general public. Areas of heavy hunting pressure were not protected by guards and access was not restricted. Black bears were not confined to an area by any natural or manmade barrier. We developed 10 a priori models using the parameters of group, age, and hunting season structure to examine the possible relation between groups and survival.

Reconstruction survival.–We used Cohort and Downing population reconstruction to estimate annual survival rates separately for male and female black bears because of differential harvest rates (Pope 1972, Downing 1980, Bridges 2005, Davis et al. 2007). We collapsed age classes as 1, 2, 3, 4, and ≥ 5 years old to numerically compare population reconstruction estimates to survival estimates produced from a priori models produced in Program MARK (Davis et al. 2007). Although Davis et al. (2007) did not examine the accuracy or precision of combining age classes below the oldest collapsed age class, we combined age classes of 1- and 2-year olds, 3- and 4-year olds and ≥ 5-year olds for numerical comparison with a priori model estimates generated from Program MARK. We estimated statewide, northern study area, and southern study area survival from 1991–2007 for Downing reconstruction and 1991–2006 for cohort reconstruction (Pope 1972, Downing 1980). WVDNR first conducted a hunting season in 1988 on the southern study area and it took 3 hunting seasons to gather baseline age data. We estimated average survival by area, respective age classes, and gender from 1991–2002 for both Downing and cohort models because black bears in these age classes have had more time to be harvested and the population estimate is more accurate (Davis et al. 2007). For individual annual survival estimates see appendices in Ryan 2009*b*.

Direct harvest.–We calculated direct harvest survival estimates by dividing the number of black bears available for harvest by the reported tag returns from harvests, vehicle collisions, or animals killed for repeated nuisance activity. We considered an animal available for harvest if it was handled that calendar year or was equipped with a radio transmitter. We used individuals trapped on research trap lines and black bears trapped for nuisance behavior but not translocated.

We calculated estimates separately for northern females and males from 1991–2007 and for southern females and males from 1999–2007.

Cub survival.–We calculated minimum cub survival estimates on each study area by dividing the number of yearlings present in a den by the number of cubs present the previous year with the same female and excluded cub mortalities from whole litter loss (Clark and Eastridge 2006). We only included females where an accurate count of the number of cubs was made one year and of yearlings the next year. We censored total litter loss when there was suspected researcher bias in cub survival, especially early in the study. We did not include any litters where cubs were fostered and may have affected natural survival. We estimated expected litter survival using equations provided by Clark and Eastridge (2006).

Population Modeling

Program RISKMAN.–We used the Monte Carlo procedures in the population model RISKMAN (Program RISKMAN, version 1.9.003; Taylor et al. 2002, 2003, 2006*b*) to run stochastic population models for each study area to estimate λ, population size, evaluate different harvest rates, and black bear demographic effects on λ and population size. RISKMAN incorporates the bi-annual year reproductive cycle of black bears (Taylor et al. 1987*a*, *b*) and probability distributions of gender-specific survival with user defined age classes, cub survival, litter survival, and the probability of producing 1-, 2-, 3-, 4-, or 5-cub litters (Taylor et al. 2006*b*). We ran 1,000 stochastic simulations to estimate λ over a simulated 25-year period for each study area, different hunting season structure, and possible source-sink locations on the southern study area. We modeled process variation as 75% parameter uncertainty and 25% as annual variation (Howe et al. 2007) and used SE from all available demographic estimates.

We used reproductive data from den visits for the following estimates: probability of litter size and distribution across age classes; age of primiparity from unbiased estimation (Garshelis et al. 1998), litter survival (Clark and Eastridge 2006), and percent of females reproducing in the population (Godfrey 1996, Table 1). We used survival estimates from program MARK (White and Burnham 1999) based on the most heavily weighted model from the known fate or Burnham model for the respective gender or study area. However, the most heavily weighted estimates from Burnham model were used for juvenile and subadult females on the southern study area because of the small number of individuals equipped with radio transmitters and the large SE associated with those estimates in known fate models. Overall survival estimates were calculated as "individual survival" in RISKMAN and incorporated both hunting and non-hunting mortalities. We then set hunting and other mortalities to 0.0 because non-hunting mortality was so low and RISKMAN can incorporate all causes of mortality. Our survival analysis indicated that the early hunting season had a direct impact on black bear survival rates on the southern study area. Therefore, we ran the analysis separately with and without an early hunting season to determine its impact on population growth rate. Our survival models also indicated that there was a relation between where a female black bear was tagged on the southern study area and its survival.

We ran separate models using the survival rates from the Burnham model and whether a female was exposed to heavy or light hunting pressure. We calculated the total population growth rate on the southern study area by using the geometric mean of the lightly and heavily hunted areas. Depending on the study area, our data produced a minimum cub survival of 0.84–0.85; however, our data was only based on direct observation and not radio-collared data. We used the cub survival estimate of 0.87 from the neighboring state of Virginia (Bridges 2005).

His estimates were based on black bear cubs equipped with radio transmitters; therefore, they may be slightly higher and more accurate than our minimum cub estimates. We estimated the initial black bear population on each study area using Downing population reconstruction (Downing 1980, Davis et al. 2007) and used the 1999 estimate to provide the most accurate estimate. We inflated the female and male black bear population estimates by 15% and 11%, respectively because Downing population models underestimate black bear populations by these respective amounts (Davis et al. 2007). We used the same initial population size estimates for all analysis (hunting season structure or source-sink estimates) on the southern study area. After entering the population estimates into RISKMAN, we normalized the data and assumed a stable age distribution based on the classifications and survival rates specified.

Reconstruction analysis.–We used Downing (Downing 1980, Davis et al. 2007) and cohort population reconstruction to estimate geometric mean growth rate (λ) and population size for each study area and gender. The most appropriate way to summarize growth rates across years within a single iteration is by using a geometric mean because its cumulative effect is multiplicative across years and what happens in year 1 will affect calculations in following years (Taylor et al. 2006*b*). The slight modification of the geometric mean growth rate equation used in RISKMAN allowed numerical comparisons to be made across different methods (Taylor et al. 2006*b*). We estimated λ using population estimates from 1991–2003 for Downing and cohort reconstruction so that estimates would be more precise. In addition, we calculated the geometric mean growth rate for both Downing and cohort reconstruction from 1991–1999 so that all data would be incorporated in the model and to avoid violation of the assumptions of differential harvest rates on the southern study area (Davis et al. 2007). Population estimates were inflated by 15% and 11% for female and male black bears by study area for numerical comparison to simulation models from RISKMAN (Davis et al. 2007).

Sensitivity analysis.–On the northern study area, we decreased female survival and reproductive rates by 0.02 and 0.2 cubs per age class individually in program RISKMAN to examine different affects on λ. We did not conduct sensitivity analysis on the southern study area because the hunting season structure employed by the WVDNR appears to have stabilized the population at the current parameter estimates. In addition, it appears that the black bear population is experiencing source-sink population dynamics; thus evenly simulating decreases in survival may lead to erroneous conclusions by masking the differing survival rates within an area. Because program RISKMAN uses the proportion of the number of cubs to calculate litter size, we decreased the proportion of 1-, 2-, 3-, 4-, 5-cub litters to simulate 0.2 decreases in litter size. Because it is extremely difficult for managers to only harvest one respective age class during a hunting season and reproduction cannot be controlled, we simulated a constant decrease in female survival by 0.02 across age classes. We also simulated a decrease of .05 for adult females and .02 for subadults and juveniles to mimic an early hunting season where adult females may be more vulnerable to hunting than other age classes but their survival may also decrease. We ran 1,000 stochastic Monte Carlo simulations for each respective procedure until λ < 1.000.

RESULTS

Historical Data and Project Summary

Statewide black bear harvests increased from a low of 37 in 1982 to a record 2,069 in 2008 and exhibited strong exponential growth (R^2 = 0.9198; Figure 2). Hunters harvested 22,780 black bears from 1964–2008. Sex ratios of bears harvested in archery or firearm seasons held before

December were 61M: 39F and 67M: 33F for those harvested in the December firearm seasons. Harvest numbers on the northern study area increased from a low of 12 black bears in 1977 to a high of 327 in 2003 and 2008. On the southern study area, we observed an increase in black bear harvest from 7 in 1990 to 407 in 2003. The 6-year average from 2002–2007 was higher (F = 57.97, $P < 0.001$) on the southern study area with an early hunting season ($\bar{x}$ = 334) than without an early hunting season from 1996–2001 ($\bar{x}$ = 151).

The 2-year running average of black bear harvest was strongly related (r = 0.94) to population estimates (Figure 3). The number of nuisance black bear complaints to WVDNR offices ranged from 313–1,598 (Figure 4). Although some peaks in nuisance activity appeared to correspond to mast conditions, nuisance complaints were weakly related to total mast conditions (r = -0.358). Population estimates also did not explain the reason for the large number of nuisance complaints (r = -0.335). Observational rates of black bears from WVDNR bowhunter surveys (Teets et al. 2007) were positively related with population estimates (r = 0.692) and negatively related with total mast production (r = -0.694). However, there were large fluctuations (range 0.21–1.05 black bears observed per 100 hours) in observational rates that were likely caused by mast conditions. When averaged over 2 years, as was done for harvest rates, observation rates of bowhunters were more strongly related (r = 0.839) to population estimates.

Capture statistics.–We captured 1,016 (717M: 299F) black bears on the northern study area from 1972–2007 and 607 (372M:235 F) on the southern study area from 1996–2007 and handled them 2,777 and 1,297 times, respectively. On the northern study area, age of captured females averaged 4.44 years (SE = 0.24) and males averaged 3.35 years (SE = 0.11); on the southern study area females averaged 4.42 years (SE = 0.22) and males averaged 3.14 years (SE = 0.12).

Project costs.–WVDNR averaged spending an estimated $216,918 per year on wages, overhead, fringe benefits, mileage for vehicles and equipment collecting data on research trap lines, survival monitoring, and den work for survival and reproductive estimates. WVDNR averaged $33,271 in wages, overhead, fringe benefits, and mileage collecting teeth for age analysis, check station data and dissecting reproductive tracts.

Reproduction Analysis

Litter size.–The overall average litter size on both study areas was 2.65 (n= 300). The final data had 22 black bears of unknown age. Mean litter size did not differ ($P > 0.05$) between the southern ($\bar{x}$ = 2.85, n = 84, 95% CI = 2.68–3.02) and northern ($\bar{x}$ = 2.71, n = 153, 95% CI = 2.58–2.83) study areas for adult black bears or for subadult black bears on the southern ($\bar{x}$ = 2.1, n = 20, 95% CI = 1.80–2.39) and northern ($\bar{x}$ = 2.23, n = 21, 95% CI = 1.85–2.61) areas. However, adult females on each study area had larger litters than subadults ($P < 0.05$). We observed severe mast failures in 1988, 1997, and 2002 but they did not influence litter size ($P > 0.05$, Evans et al. 2007, Figure 5). Three-cub litters were most common on both the northern (46.5%, n = 85) and southern study areas (46.1%, n = 54), followed by 2-cub litters on northern (34.4%, n = 63) and southern (33.3%, n = 39), 4-cub litters on the northern (11.5%, n = 21) and southern (11.9%, n = 14), 1-cub litters on northern (7.1%, n = 13) and southern (6.8%, n = 8), and 5-cub liters on the northern (0.5%, n = 1) and southern study areas (1.7%, n = 2).

Mean litter size did not differ ($F = 1.22$, $P = 0.269$) between reproductive tracts collected from hunters ($\bar{x}$ = 2.58, 95% CI = 2.46–2.69) or cubs observed at den visits ($\bar{x}$ = 2.67, 95% CI = 2.57–2.76). Number of corpora lutea observed from reproductive tracts or cubs during den visits did not differ for adult black bears (*F* = 0.07, *P* = 0.792) or subadult black bears (*F* = 0.34, *P* = 0.561). Number of black bears surviving to age 1 was numerically similar for Downing population reconstruction ($\bar{x}$ = 2.24, 95% CI = 1.99–2.48) and average number of yearlings observed in den visits ($\bar{x}$ = 2.14, 95% CI = 2.01–2.14).

Success.–Black bears on the southern study area had a similar interbirth interval (1.93) to females on the northern study area (1.78, χ^2 = 0.554, *P* = 0.456). Mast failures in 1988, 1997, or 2002 did not reduce the interbirth interval on either study area; however, small sample sizes during those years made detecting a noticeable difference difficult.

Subadult female black bears on the southern study area ($\bar{x}$ = 82%, *n*= 28) successfully reproduced more often than the northern study area ($\bar{x}$= 57%, n = 47, χ^2 = 4.82, *P* = 0.028). However, female reproductive success was 97% for both the northern and southern study areas for adult females.

Primiparity.–Age of primiparity was lower on the southern study ($\bar{x}$ = 3.11) area than the northern study area ($\bar{x}$ = 3.93).

Reproductive synchrony.–We observed reproductive failure starting with the mast failure of 1992 that affected reproduction in 1993 and synchronized births but the synchrony dampened quickly over time (Figure 5). In addition, we observed large birth pulses on our northern study area following an extreme mast failure in 1997 followed by bumper mast crop in 1998. Mast conditions were negatively related to the number of male black bears in respective cohorts but did not explain the entire variability within the data. Hard mast conditions plus black cherry, provided the strongest correlation across years (r = -0.327). However, we observed numerous competing models explaining the variability of the data but there was no one model that would explain the majority of the data (Table 2). Therefore, we conclude that if reproductive synchrony does exist in West Virginia, it likely does not play a large role in the population dynamics of black bears and dampens quickly over time at the current population levels.

Survival Analysis

Known fate survival.–The data set for northern females consisted of 162 individuals. The global model had an estimated $\hat{C}$ = 1.23 with the residuals being slightly negatively distributed. The negative residuals were associated with collar censor or failure (e.g. dropped transmitters). Model 2 (w_i = 0.495, Table 3) indicated that survival was a function of age classes. Adult annual survival was highest ($\bar{x}$ = 0.91, 95% CI = 0.88–0.94), followed by subadult ($\bar{x}$ = 0.78, 95% CI = 0.59–0.89), and juveniles ($\bar{x}$ = 0.77, 95% CI = 0.44–0.93).

Model 3 (w_i = 0.201) provided evidence that mast conditions influenced female survival on the northern study area. Adult annual survival was highest ($\bar{x}$ = 0.91, 95% CI = 0.88–0.94), followed by subadults ($\bar{x}$ = 0.78, 95% CI = 0.59–0.89), and juveniles ($\bar{x}$ = 0.77, 95% CI = 0.44–0.93). Annual survival for all age classes was higher during mast failures ($\bar{x}$ = 0.93, 95% CI = 0.93, 0.81–0.98). Model 8 (w_i = 0.181) indicated survival was constant among age classes and years ($\bar{x}$ = 0.90, 95% CI = 0.87–.093).

The data set for southern females consisted of 109 individuals. The global model had an estimated $\hat{C}$ = 1.03 with the residuals being only slightly negatively distributed. The negative residuals were associated with collar censor or failure (e.g. dropped transmitters). Model 3 (w_i = 0.508, Table 4) indicated that survival was a function of three age classes and hunting season structure (Figure 6). Without an early hunting season subadults had the highest survival ($\bar{x}$ = 1.00, 95% CI = 0.00–1.00), followed by adults ($\bar{x}$ = 0.89, 95% CI = 0.78–0.94), and juveniles ($\bar{x}$ = 0.45, 95% CI = 0.00–1.00). With an early hunting season subadults had the highest survival ($\bar{x}$ = 0.97, 95% CI = 0.80–1.00), followed by juveniles ($\bar{x}$ = 0.79, 95% CI = 0.50–0.93), and adults ($\bar{x}$ = 0.78, 95% CI = 0.71–0.83).

Model 8 (w_i = 0.139) indicated survival was a function of hunting season structure. Survival without an early hunting season ($\bar{x}$ = 0.89, 95% CI = 0.78–0.95) was higher than with an early hunting season ($\bar{x}$ = 0.80, 95% CI = 0.75–0.85).

Model 5 (w_i = 0.112) indicated that survival was a function of 3 age classes, hunting season structure, and mast conditions. Juveniles and subadults with an early hunting season and without a mast failure, subadults without an early hunting season but with a mast failure, and adults without an early hunting season but with a mast failure had the highest survival ($\bar{x}$ = 1.00, 95% CI = 0.00–1.00). Adults without an early hunting season or mast failure ($\bar{x}$ = 0.88, 95% CI = 0.76–0.94) had higher survival than with an early season with ($\bar{x}$ = 0.78, 95% CI = 0.53–0.92) or without ($\bar{x}$ = 0.78, 95% CI = 0.71–0.83) a mast failure.

Tagged survival.–The data set for northern female ear-tagged database consisted of 208 individuals. The global model had an estimated Ĉ of 1.03 with the residuals being normally distributed with exception of a few outliers. Model 2 (w_i = 0.700, Table 5) revealed that survival was a best explained by considering different 3 age classes separately. Subadults had the highest survival ($\bar{x}$ = 0.86, 95% CI =- 0.77–0.91) followed by adults ($\bar{x}$ = 0.85, 95% CI = 0.80–0.89), and juveniles ($\bar{x}$ = 0.62, 95% CI = 0.52–0.71).

Model 3 (w_i = 0.300) indicated that survival was a function of 5 age classes and that some variability could be explained by separating each age class below 5 years. Three-year olds had the highest survival ($\bar{x}$ = 0.92, 95% CI = 0.74–0.98), followed by adults ($\bar{x}$ = 0.86, 95% CI = 0.80–0.90), 4-year olds ($\bar{x}$ = 0.82, 95% CI = 0.69–0.90), 2-year olds ($\bar{x}$ = 0.66, 95% CI = 0.51–0.78), and yearlings ($\bar{x}$ = 0.58, 95% CI = 0.44–0.71).

The data set for the southern female ear-tagged database consisted of 235 individuals. The global model had an estimated $\hat{C}$ of 1.03 with the residuals being normally distributed with exception of a few outliers. Model 2 (w_i = 0.321) demonstrated that survival was a function of 3 age classes and reporting, recapture, and fidelity were a function of research, nuisance black bears translocated, and nuisance black bears not translocated (Table 6). Adults had the highest survival ($\bar{x}$ = 0.76, 95% CI = 0.70–0.82), followed by juveniles ($\bar{x}$ = 0.75, 95% CI = 0.57–0.87), and subadults ($\bar{x}$ = 0.73, 95% CI = 0.58–0.84).

Model 13 (w_i = 0.311) indicated that survival, reporting, recapture, and fidelity were a function of research, nuisance bears translocated, and nuisance bears not translocated. Black bears captured in research settings had the highest survival ($\bar{x}$ = 0.77, 95% CI = 0.68–0.84), followed by nuisance black bears not translocated ($\bar{x}$ = 0.74, 95% CI = 0.61–0.84), and nuisance black bears translocated ($\bar{x}$ = 0.73, 95% CI = 0.31–0.94).

Model 6 (w_i = 0.292) indicated survival was a function of 3 age classes and hunting season structure and that reporting, recapture, and fidelity were a function of research, nuisance black bears translocated, and nuisance black bears not translocated. Adults without an early hunting season had the highest survival ($\bar{x}$ = 0.86, 95% CI = 0.74–0.93), followed by juveniles without an early hunting season ($\bar{x}$ = 0.84, 95% CI = 0.53–0.96), subadults without an early hunting season ($\bar{x}$ = 0.76, 95% CI = 0.53–0.96), adults with an early hunting season ($\bar{x}$ = 0.72, 95% CI = 0.64–0.79), subadults with an early hunting season ($\bar{x}$ = 0.68, 95% CI = 0.52–0.80), and juveniles ($\bar{x}$ = 0.67, 95% CI = 0.47–0.82).

The data set for the northern male ear–tagged database consisted of 540 individuals. The global model had an estimated $\hat{C}$ = 1.19 and the residuals were primarily normally distributed. Model 5 (w_i = 0.674, Table 7) demonstrated that survival was a function of 3 age classes and reporting, recapture and fidelity were a function of research or nuisance black bears. Adults had the highest survival ($\bar{x}$ = 0.63, 95% CI = 0.53–0.72), followed by subadults ($\bar{x}$ = 0.45, 95% CI = 0.36–0.55) and juveniles ($\bar{x}$ = 0.29, 95% CI = 0.22–0.38).

Model 9 (w_i = 0.213) indicated that survival was a function of 5 age classes and reporting, recapture, and fidelity were a function of research or nuisance black bears. Although not the strongest model, model 9 indicated that some variation may be explained by separating age classes into 5 groups instead of 3. Adult survival was highest ($\bar{x}$ = 0.63, 95% CI = 0.53–0.72), followed by 4-year olds ($\bar{x}$ = 0.53, 95% CI = 0.38–0.67), 3-year olds ($\bar{x}$ = 0.40, 95% CI = 0.29–0.52), yearlings ($\bar{x}$ = 0.31, 95% CI = 0.20–0.45) and 2-year olds ($\bar{x}$ = 0.28, 95% CI = 0.19–0.39).

Model 4 (w_i = 0.106) indicated that survival was a function of 3 age classes and if the black bear was captured in a research or nuisance situation. Reporting, recapture and fidelity were a function of research or nuisance black bears. Survival was highest for adult research black bears ($\bar{x}$ = 0.65, 95% CI = 0.55–0.75), followed by subadult research ($\bar{x}$ = 0.46, 95% CI = 0.36–0.56), adult nuisance ($\bar{x}$ = 0.41, 95% CI = 0.16–0.72), juvenile nuisance ($\bar{x}$ = 0.40, 95% CI = 0.11–0.78), subadult nuisance ($\bar{x}$ = 0.38, 95% CI = 0.18–0.63), and juvenile research ($\bar{x}$ = 0.29, 95% CI = 0.21–0.37).

The data set for the southern males consisted of 372 individuals. The global model had an estimated $\hat{C}$ = 1.34 with the residuals being normally distributed. Model 5 (w_i = 0.871, Table 8) demonstrated survival was a function of 3 age classes and hunting season structure and reporting, recapture, and fidelity were a function of research, nuisance bears translocated, and nuisance bears not translocated. Survival was highest for adults without an early hunting season ($\bar{x}$ = 0.79, 95% CI = 0.63–0.89), followed by subadults without an early hunting season ($\bar{x}$ =

0.78, 95% CI = 0.55–0.91), subadults with an early hunting season ($\bar{x}$ = 0.65, 95% CI = 0.52–0.75), adults with an early hunting season ($\bar{x}$= 0.50, 95% CI = 0.38–0.62), juveniles with an early hunting season ($\bar{x}$ = 0.47, 95% CI = 0.33–0.62), and juveniles without an early hunting season ($\bar{x}$ = 0.41, 95% CI = 0.26–0.59).

Source–sink survival.–The dataset from the southern study area examining differing female survival rates with different amounts of hunting pressure consisted of 230 individuals. The global model had an estimated $\hat{C}$ = 1.34 and the residuals were normally distributed. Model 5 had the highest support (w_i = 0.750) and indicated that survival was a function of 3 age classes and hunting pressure and reporting, recapture, and fidelity were a function of hunting pressure. Juveniles with light hunting pressure had the greatest survival ($\bar{x}$ = 1.00, 95% CI = 1.00–1.00), followed by subadults with light hunting pressure ($\bar{x}$ = 0.88, 95% CI = 0.63–0.97), adults with light hunting pressure ($\bar{x}$ = 0.86, 95% CI = 0.75–0.93), juveniles with heavy hunting pressure ($\bar{x}$ = 0.53, 95% CI = 0.35–0.70), subadults with heavy hunting pressure ($\bar{x}$ = 0.66, 95% CI = 0.48–0.80), and adults with heavy hunting pressure ($\bar{x}$ = 0.72, 95% CI = 0.63–0.80).

Model 3 also received support (w_i = 0.150) and indicated that survival was a function of 5 age classes and hunting pressure and reporting, recapture, and fidelity were a function of hunting pressure. As in some other models, some data could be explained by considering 5 age classes instead of only 3 groups. One, two, and 4-year olds with light hunting pressure had the highest survival ($\bar{x}$ = 1.00, 95% CI = 1.00–1.00), followed by adults with light hunting pressure ($\bar{x}$ = 0.86, 95% CI = 0.75–0.93), 3-year olds with light hunting pressure ($\bar{x}$ = 0.77, 95% CI = 0.43–0.94), adults with heavy hunting pressure ($\bar{x}$ = 0.72, 95% CI = 0.64–0.80), 3-year olds with heavy hunting pressure ($\bar{x}$ = 0.69, 95% CI = 0.45–0.86), 2-year olds with heavy hunting pressure ($\bar{x}$ = 0.65, 95% CI = 0.39–0.85), 4-year olds with heavy hunting pressure ($\bar{x}$ = 0.62, 95% CI = 0.40–0.81), and yearlings with heavy hunting pressure ($\bar{x}$ = 0.40, 95% CI = 0.20–0.65).

Reconstruction survival.–Statewide female survival estimates were numerically similar for adults ($\bar{x}$ = 0.82), subadults ($\bar{x}$ = 0.82), and juveniles ($\bar{x}$ = 0.82) using Downing population reconstruction methods and collapsing age classes into 3 groups from 1991–2002 (Figure 7). Survival was fairly constant across age classes with only 2-year old females ($\bar{x}$ = 0.75) having lower survival than ≥ 5-years olds ($\bar{x}$ = 0.82), 3-year olds (($\bar{x}$ = 0.82), 4-year olds ($\bar{x}$ = 0.82), or yearlings ($\bar{x}$ = 0.82). Survival estimates using cohort analysis were very similar across age classes or for collapsing age classes (range 0.75–0.80).

Adult males had the highest statewide survival ($\bar{x}$ = 0.75) using Downing population reconstruction methods and collapsing age classes into 3 groups from 1991–2002, followed by subadults ($\bar{x}$ = 0.66), and juveniles ($\bar{x}$ = 0.63, Figure 8). Two-year old males had the lowest survival ($\bar{x}$ = 0.58), followed by yearlings ($\bar{x}$ = 0.65), 3-year olds (0.65), 4-year olds ($\bar{x}$ = 0.66), and ≥ 5-year olds ($\bar{x}$ = 0.75). Survival estimates produced using cohort analysis were highest for ≥ 5-year olds ($\bar{x}$ = 0.73), followed by 4-year olds ($\bar{x}$ = 0.66), yearlings ($\bar{x}$ = 0.65), 3-year olds ($\bar{x}$ = 0.65), and 2-year olds ($\bar{x}$ = 0.58).

Adult females on the northern study area had the highest survival ($\bar{x}$ =0.80) using Downing population reconstruction methods and collapsing age classes into 3 groups from 1991–2002, followed by subadults ($\bar{x}$ = 0.75), and juveniles ($\bar{x}$ = 0.74). Two-year old females had the lowest survival ($\bar{x}$ = 0.67) on the northern study area, followed by 3-year olds ($\bar{x}$ = 0.73), 4-year olds ($\bar{x}$ = 0.76), yearlings ($\bar{x}$ = 0.79), and ≥ 5-year olds ($\bar{x}$ = 0.80) when using 5 age classes. Two-year olds also had the lowest survival ($\bar{x}$ = 0.66) using cohort analysis, followed by 3-year olds ($\bar{x}$ = 0.72), ≥ 5-year olds ($\bar{x}$ = 0.75), 4-year olds ($\bar{x}$ = 0.76), and yearlings ($\bar{x}$ = 0.79). When collapsing age classes into 3 groups, adults had the highest survival ($\bar{x}$ = 0.75), followed by subadults ($\bar{x}$= 0.74), and juveniles ($\bar{x}$ = 0.73) using cohort analysis.

Adult males on the northern study area had the highest survival ($\bar{x}$ = 0.69) using Downing population reconstruction methods and collapsing age classes into 3 groups from 1991–2002, followed by subadults ($\bar{x}$ = 0.62), and juveniles ($\bar{x}$ = 0.60). Males ≥ 5-years had the highest survival ($\bar{x}$ = 0.69), followed by 3-year olds ($\bar{x}$ = 0.64), yearlings ($\bar{x}$ = 0.64), 4-year olds ($\bar{x}$ = 0.61), and 2-year olds ($\bar{x}$ = 0.53) when using 5 age classes. Adults had the highest survival ($\bar{x}$ = 0.72) using cohort analysis and collapsing age classes into 3 groups, followed by subadults ($\bar{x}$ = 0.62), and juveniles ($\bar{x}$ = 0.59). Two-year olds had the lowest survival ($\bar{x}$ = 0.52) using 5 age classes and cohort analysis, followed by 3-year olds ($\bar{x}$ = 0.62), 4-year olds ($\bar{x}$ = 0.62), yearlings ($\bar{x}$ = 0.63), and ≥ 5-year olds ($\bar{x}$ = 0.72).

Adult females on the southern study area had the highest survival ($\bar{x}$ = 0.85) using Downing population reconstruction methods and collapsing age classes into 3 groups from 1991–2002, followed by subadults ($\bar{x}$ = 0.84), and juveniles ($\bar{x}$ = 0.84). Yearlings females ($\bar{x}$ = 0.86) had the highest survival followed by ≥ 5-years old ($\bar{x}$ = 0.85), 3-year olds ($\bar{x}$ = 0.85), 2-year olds ($\bar{x}$ = 0.81), and 4-year olds ($\bar{x}$ = 0.74) using Downing population reconstruction and collapsing groups into 5 age classes. Subadults had the highest survival ($\bar{x}$ = 0.85) using cohort analysis, followed by juveniles ($\bar{x}$ = 0.83) and adults ($\bar{x}$ = 0.82) when collapsing age classes into 3 classes. Three-year olds had the highest survival ($\bar{x}$ = 0.88) using cohort analysis and 5 age classes, followed by yearlings ($\bar{x}$ = 0.84), 4-year olds ($\bar{x}$ = 0.83), ≥ 5-years old ($\bar{x}$ = 0.82), and 2-year olds ($\bar{x}$ = 0.81).

Adult males had the highest survival ($\bar{x}$ = 0.81) on the southern study area, followed by subadults ($\bar{x}$ = 0.75), and juveniles ($\bar{x}$ = 0.68) using Downing population reconstruction methods and collapsing age classes into 3 groups from 1991–2002. Males ≥ 5-years old and 4-year olds had the highest survival ($\bar{x}$ = 0.81), followed by 3-year olds ($\bar{x}$ = 0.72), 2-year olds ($\bar{x}$ = 0.69), and yearlings ($\bar{x}$ = 0.66) when using Downing population reconstruction and collapsing age classes into 5 groups. Adults had the highest survival ($\bar{x}$ = 0.80), followed by subadults ($\bar{x}$ = 0.77), and juveniles ($\bar{x}$ = 0.66) when using cohort analysis and collapsing age classes into 3 groups. Yearlings had the lowest survival ($\bar{x}$ = 0.64), followed by 2-year olds ($\bar{x}$ = 0.67), 3-year olds ($\bar{x}$ = 0.73), 4-year olds ($\bar{x}$ = 0.80) and ≥ 5-year olds ($\bar{x}$ = 0.80) when using cohort analysis and 5 age classes.

Direct harvest.–Survival estimates from direct tag returns were higher for females ($\bar{x}$ = 0.88, range 0.79–1.00) than males ($\bar{x}$ = 0.66, range 0.41–0.88) on the northern study area. Survival estimates for females ($\bar{x}$ = 0.83, range 0.71–0.96) on the southern study area were also higher than males ($\bar{x}$ = 0.66, range 0.25–0.94) from direct tag returns.

Cub survival.–Minimum cub survival was similar on the northern ($\bar{x}$ = 0.86, n = 57) and southern study areas ($\bar{x}$ = 0.84, n = 32) for females followed in consecutive years. Litter survival was the same on the northern (0.98) and the southern study areas (0.98).

Population Modeling

RISKMAN.–The geometric mean growth rate from stochastic models on the northern study area was λ = 1.091 (SE = 0.001) with an estimated population of 15,727 (SE = 376) individuals after 25 years (Figure 9). At a harvest rate of 20% across all age classes, hunters would harvest an estimated 3,145 black bears within the northern study area in 25 years.

Black bears on the southern study area exhibited a mean λ = 1.093 (SE = 0.002) before the implementation of an early hunting season. If the WVDNR had not started an early season there would have been an estimated 15,214 (SE = 436) animals within 25 years (Figure 12).

After the WVDNR implemented an early season $\lambda = 0.957$ (SE = 0.001), which should have reduced the population to an estimated 503 (SE = 12) individuals within 25 years; however, all other indices (e.g., harvest, capture rates, nuisance complaints, etc.) have not indicated a dramatic population reduction following 7 years of an early hunting season. Further examination of the data show that female black bears have higher survival rates in more protected areas of light hunting pressure and serve as source population with an estimated $\lambda = 1.223$ (SE = 0.001), whereas the black bear population in areas more accessible to hunters with heavy hunting pressure had an estimated $\lambda = 0.856$ (SE = 0.002, Figures 10 and 11). Without black bears dispersing from the source population, the heavily hunted population would be reduced to an estimated 45 (SE = 2) black bears in 25 years. However, assuming an initial equal population distribution $\lambda = 1.023$ for both the heavily and lightly hunted areas combined and would be much more indicative of the other indices used by the WVDNR.

Reconstruction analysis.–Downing population models estimated $\lambda = 1.006$ from 1991–2003 and $\lambda = 1.015$ from 1991–1999 for females on the northern study area when collapsing age structure to 5 years with an estimated population size of 514 individuals in 2003. We estimated $\lambda = 0.989$ and 1.009 using cohort analysis from 1991–2003 and 1991–1999, respectively for females on the northern study area with a population of 358 individuals.

Males black bears on the northern study area had an estimated $\lambda = 1.028$ and 1.047 from 1991–2003 and 1991–1999, respectively using Downing reconstruction with a population estimate of 696 individuals in 2003. Cohort analysis estimated $\lambda = 1.016$ and 1.039 from 1991–2003 and 1991–1999, respectively with an estimated 512 male black bears on the northern study area in 2003.

We estimated λ = 1.117 and λ = 1.134 for female black bears on the southern study area from 1991–2003 and 1991–1999, respectively with a population estimate of 856 individuals. Cohort analysis estimated λ = 1.077 and 1.096 for 1991–2003 and 1991–1999, respectively with an estimated population of 567 female black bears in 2003.

Male black bears on the southern study area exhibited an estimated λ = 1.139 and λ = 1.145 for 1991–2003 and 1991–1999, respectively using Downing reconstruction. We estimated the male black bear population in 2003 at 417 individuals using cohort reconstruction analysis with an estimated of λ = 1.127 and λ = 1.122 for 1991–2003 and 1991–1999, respectively.

We estimated the statewide female black bear population at 3,436 individuals in 2003 with an estimated λ = 1.067 from 1991–2003 and λ = 1.082 from 1991–1999 using Downing reconstruction methods. We estimated λ = 1.039 and 1.064 from 1991–2003 and 1991–1999 using cohort analysis with an estimated 2,119 female black bears statewide in 2003.

Downing reconstruction methods estimated the statewide male black bear population at 3,648 individuals in 2003 with estimated λ = 1.077 and 1.089 from 1991–2003 and 1991–1999, respectively. The statewide male black bear λ = 1.064 and λ = 1.081 from 1991–2003 and 1991–1999 using cohort analysis with a population estimate of 2,957 individuals.

Sensitivity analysis.–Adult female survival was the single parameter that had the largest influence on λ. For managers to achieve λ = 1.000, adult female survival rates on the northern study area would need to decrease from 0.91 to 0.74 assuming all other parameters remained constant (Figure 13). Subadult and juvenile survival rates fluctuations had a very negligible impact on λ (Figures 14 and 15). When we modeled subadult or juvenile survival rates separately, they each would have to decrease to at least 0.50 to make λ < 1.000. Reproductive rates (litter size) had a very minor impact on λ if female survival rates remained at the current estimates and would need to be at least half of our estimates to achieve a stable population. We modeled decreases in adult female survival of 0.05, 0.10, and 0.15 with decreases in subadult and juvenile survival of 0.02, 0.04, and 0.06 to reflect modifications to hunting seasons. A reduction in survival rates of 0.05, 0.10, and 0.15 in adult females and 0.02, 0.04, and 0.06 in subadult and juveniles had estimated rates of $\lambda = 1.052$, $\lambda = 1.008$, and $\lambda = 0.965$ (Figure 16). We also modeled an equally distributed reduction in female survival across age classes. Female survival estimates would need to decrease 0.08 across all age classes to achieve $\lambda < 1.000$ (Figure 16).

DISCUSSION

Harvest data, nuisance kills, or sale of bear parts has not traditionally been an accurate reflection of population size or growth in many areas (Noyce and Garshelis 1997, Garshelis 2002, Garshelis and Hristienko 2006). Biologists may have the professional opinion that the black bear population in their area is increasing but there is no discernible trend in their data (Garshelis and Hristienko 2006). Our data indicates that in areas where there is adequate hunting pressure the 2-year running average of the harvest, which should remove mast influence, is correlated to population estimates and should provide biologists with an accurate index of population, assuming no major trends in harvest exist. In addition, the geometric mean of 2-year running average of the harvest more closely reflected the growth rates calculated from demographic data collected over a long-term study than reconstruction methods where possible bias existed. Harvest data in Minnesota was not related to black bear population size and was more heavily influenced by natural food abundance (Noyce and Garshelis 1997). Natural food abundance also affects black bear harvests in West Virginia (Ryan et al. 2004) and was weakly related to nuisance complaints but more heavily influenced observational rates of hunter surveys.

However, we suspect the differences in hunting season structure (no baiting in West Virginia) and using the 2-year running average allowed us to remove the primary influence of natural food abundance and should supply biologists with an index to the population. Where hunter effort is constant, an increase in harvest numbers may be related to an increase in population abundance (Miller 1990). In addition to harvest correlations, population estimates also were strongly correlated to the 2-year observational data from hunter surveys. These data, along with other indices should supply managers with adequate trend data concerning the population if no long-term, highly expensive research project is possible. However, biologists should be aware of the limitations (large shifts in hunting pressure) that may lead biologists to misclassify declining populations as stable (Miller 1990). For example, the WVDNR conducted a special hunting season in 2008 that resulted in a record harvest of 2,069 black bears, which was an increase from 1,802 individuals in 2007 and 1,703 in 2006. We are not suggesting that the population increased 46% in one year, but rather that the increase reflected a major regulation change that increased hunting pressure. Also, some management units in West Virginia have harvest levels of 0 even though there are known black bear populations there, but these management units have little or no hunting pressure because of very conservative hunting seasons. Using averages of harvest data in conjunction with averages of observational data, that are measured on a hunter effort basis and thus correct some of the assumptions of previous data, may enable biologists to make true representations of their black bear populations. Agencies that have adequate long-term demographic data to model female survival rates, and data that suggest hunting pressure remains fairly stable, may consider using average harvest levels as an index for the population. Moreover, they may also determine a stronger relation when incorporating mast conditions.

Reproduction Analysis

Reproductive parameters in black bears typically increase from north to south and west to east in North America (Bunnell and Tait 1981, Rogers 1987, Alt 1989, Kolenosky 1990, Schwartz and Franzmann 1991, McLaughlin et al. 1994, Bridges 2005). Habitat quality, severity of winters, variability of acorns, or a lack of diversity of food supplies that directly link to nutrition are likely the primary factor why female black bears at more northern latitudes are smaller in size and exhibit a lower reproductive potential than individuals at southern latitudes (Rogers 1987, Eiler et al. 1989, Stringham 1990, Vaughan 2002). Black bears are one of the few mammals that do not strictly follow Bergman's rule, which states that races of species in colder climates (higher latitudes and farther away from coast lines) should be larger than individuals in warmer climates. Adult female black bears in West Virginia exhibited similar reproductive parameters to other populations in the Appalachian region (Eiler et al. 1989, Bridges 2005, Unger 2007) but were more prolific than populations at extreme northern latitudes and colder climates (Rogers 1987, Kasworm and Their 1994, McLaughlin et al. 1994).

Older black bears produced larger litter than younger females during our study. This is typical of other black bear populations where subsequent litters are larger than an individual's first litter (Lindzey and Meslow 1980, Alt 1989, Noyce and Garshelis 1994, McDonald and Fuller 2001, Bridges 2005). However, because many studies do not separate litter size by age classes, or often only report first or subsequent litters, and age of primiparity varies greatly across the black bear's range, it is difficult to compare results from various geographic locations across years. In addition, it is difficult to compare studies because the length of the study may affect calculations. For example, average litter size calculations would have varied greatly if the length of our study would have been shorter. When examining average litter size across both study areas and between subadults and adult age classes only subadults on the southern study area would have had similar numbers before and after 2002. For example, the average litter size for adults on the southern study area was 3.04 during the initial years of the study instead of 2.85 over the entire duration. In addition, average litter sizes were smaller for both adults (2.5 compared to 2.8) and subadults (2.12 compared to 2.31) if we had only done a 5-year study since 2003. Although it is often not the researcher's fault for the inability to conduct longer term studies, shorter studies may not provide enough insight into the true population dynamics of black bears. For example, a study using 4–5 years of data on recolonizing black bear population in Kentucky, that borders southern West Virginia, had an estimated litter size of 3.1 cubs and is the largest reported litters sizes in the southeastern United States (Unger 2007). However, this estimate would have been nearly identical to our initial estimate for our southern study area if we had a 4–5 year study period. In Maryland, a study area that borders our northern study area reported a mean litter size of 3.08 for $n = 13$, which was much higher than our estimate across the political boundary (Mathews and Garner 1993). Population estimates would have been different using a 5- or 10-year study design instead of a 28-year data set in the Great Smoky Mountains National Park (Pelton and van Manen 1996). Pelton and van Manen (1996) recommended that the Wildlife Society prepare a position statement on the advantages of long-term studies and we concur with their recommendation. Authors or managers may easily fall victim to false comparisons or erroneous conclusions if they base management decisions on short-term data sets.

Age of primiparity and successful breeding of young females are 2 of the main reproductive parameters influenced by nutrition (Eiler et al. 1989, Stringham 1990). Age of primiparity of black bears on our southern study area was 3.1 whereas it was 3.9 on our northern study area and was consistent with Virginia where females produced at younger ages on more southern study areas (Bridges 2005). Reproductive performance differs between areas of high versus low acorn production even within the eastern United States (Vaughan 2002). Similar to Massachusetts (Eiler et al. 1989) but at a different elevation in West Virginia, black bears on our northern study area primarily feed on black cherry and beechnuts. Although our northern study site has an average elevation of 929 m, it ranges from 389–1,469 m thereby supplying a diversity of food sources. On our southern study area, as in most of the southern Appalachian Mountains, oak is the primary food source along with hickory and black cherry and is directly tied to reproduction in black bears (Eagle and Pelton 1983, Eiler et al. 1989, Pelton 1989, Inman and Pelton 2002, Vaughan 2002). Declining nutrition or weight is correlated to increasing age of primiparity in black bears and is related to food supplies (Stringham 1990, Noyce and Garshelis 1994). It is difficult to compare age of primiparity across studies because bias may exist in how researchers made calculations in earlier studies (Garshelis et al. 1998) but our data concurs with previous research that age of primiparity is likely a function of habitat type or nutritional status (Stringham 1990). Food production is more diversified in the Appalachians than more northern climates such as Minnesota with acorns being a primary food source (Noyce and Coy 1990, Powell and Seaman 1990, Vaughan 2002) and is likely the reason for the differences even between our study areas.

Black bears in the northern latitudes of New York and Maine have exhibited reproductive synchrony after mast failures of beechnuts (Free and McCaffrey 1972, McLaughlin et al. 1994). Reproductive synchrony occurs when an environmental condition, normally a hard mast failure, affects the reproduction in one year of every-other-year animals and thus makes the majority of individuals reproduce in the same year. Reproductive synchrony can produce large fluctuations in black bear harvests (Free and McCaffrey 1972), especially at low populations. In

Massachusetts, black bears with access to high quality food successfully reproduced but females with low carbohydrate fall diets failed to produce cubs (Elowe and Dodge 1989). However, gypsy moth (*Lymantria dispar*) defoliation of oak trees that produced a complete acorn failure in Shenandoah National Park, Virginia did not affect reproduction and alternative fall food sources may have been important to black bears (Kasbohm et al. 1996). In the Appalachian Mountains of Virginia, peaks in reproduction occurred in even numbered years from 1992−1996 until the mast failure of 1997, which shifted peaks in reproduction to odd numbered years (Bridges 2005). It has been demonstrated that population growth is negatively related to oak mast production 4 to 5 years prior and so hard mast failures may trigger reproductive synchrony in the southern Appalachians but it may not be evident until years later (Clark et al. 2005). During our study it was difficult to provide strong evidence of synchronous reproduction with radio equipped black bears because of the small sample sizes in the initial years of the study and a number of competing models. In addition, it was difficult to correlate mast conditions to reproductive parameters because of small annual sample sizes. We also had a high rate of successful reproduction among adult females, which did not agree with the neighboring state of Virginia that observed differences in the proportion of females with cubs at den visits (Bridges 2005). However, as sample sizes increased in the later years of our study we did not observe a reproductive failure for our radio-collared females even during a mast failure, but we did observe increases and decreases in cohorts that directly corresponded with mast failures or abundance. For example, the largest male cohort on record on our northern study area was in 1999 which directly followed an extreme mast failure in 1997 and abundant mast conditions on record in 1998 but these large birth pulses did not affect harvest as in other studies (Free and McCaffrey 1972) likely because of the higher black bear populations available to hunters. The mast conditions in the oak-hickory forests of the Appalachian Mountains, along with other environmental factors, also affected wild turkey (*Meleagris gallopav*o) and ruffed grouse (*Bonasa umbellus*) production in West Virginia and throughout the Appalachian Mountains (Devers et al. 2007). Further complicating a researcher's ability to detect black bear reproductive responses to mast conditions is the fact that only oak "failures" may affect recruitment (Costello et al. 2003). In New Mexico, neither recruitment nor natality varied when oak production was indexed as "good" to "poor" but extreme failures caused recruitment reduction by more than 70% 2 years after an oak failure (Costello et al. 2003). Even though there are extreme habitat differences between New Mexico and West Virginia, oak production may play a similar role in black bear population dynamics. During our study, reproduction was negatively correlated to mast conditions but appear to only be influenced during extreme failures as in New Mexico (Costello et al. 2003).

Anthropogenic food sources are likely to increase the reproductive parameters in black bears (Baldwin and Bender 2009). Complicating our ability to positively detect a strong relation between reproductive parameters and mast conditions is the unknown influence on supplemental food sources during bad mast years. During mast failures, some female black bears in Massachusetts traveled ≤ 50 km to feed on corn and their reproduction was affected by which food sources they ate (Elowe et al. 1989, McDonald and Fuller 2001). In West Virginia, it is illegal to bait or feed black bears but it is legal to feed all other wildlife and legal to bait white-tailed deer for hunting. Nearly half of surveyed West Virginia bowhunters reported feeding white-tailed deer and 29% said that they practice baiting during hunting season (Teets et al. 2007). Before prohibiting baiting on national forest and state owned land in 1999, hunters in Virginia placed a large amount of supplemental feed out for wildlife (Gray et al. 2004). These artificial food sources may help to mask the influence of mast conditions on black bear reproduction.

The financial cost of gathering data is always a challenge in wildlife research. We are unaware of published studies that compare multiple methods of collecting data while considering the amount of money to collect such data. We used the equation provided in the reproductive methods to compare the number of yearling bears observed in a den and the number calculated from Downing reconstruction methods. Although we were only able to calculate data on a statewide basis because of sample size restrictions of premolar teeth collected within a study area, we would encourage researchers to calculate these parameters in their respective jurisdictions. The neighboring states of Virginia, Maryland, and Pennsylvania have mandatory tooth submission (Sajecki 2008, Spiker 2008, Ternent 2008) and may benefit along with other agencies from collecting such data. These data are very accurate (Harshyne et al. 1998) and are much easier and more economical to collect than visiting enough black bear dens annually to draw meaningful conclusions. Ultimately it is the number of black bears, more specifically females, entering the population and not the number of cubs that are born and that survive to one year that will affect the population. Therefore, if researchers have accurate data about the number of black bears entering the population at one year of age, and then have accurate survival estimates from 1-year until female senescence, an adequate population model (minus the cub population) may be built that would supply useful information to managers. Although, most easily accessible historical population modeling programs start with initial reproductive estimates, modeling could accurately be done starting with the number of 1-year olds entering the population.

We observed the same number of corpora lutea from hunter harvested or black bears dying from vehicle collisions as we observed from newborn cubs at den visits. Reproductive tracts have supplied managers with indexes to reproductive parameters for years (Kordek and Lindzey 1980) but few researchers have compared them to cubs observed at den sites or the amount of time and money used to collect such data. The WVDNR averaged spending 7 times the amount of money to collect data from radio collar equipped black bears compared to reproductive tracts and teeth. Moreover, it only required the project leader one or two days a year to dissect the tracts while gaining essentially the same data with less effort and costs. In areas where managers are able to collect reproductive tracts they should be able to gather the same amount of information at a much reduced cost rather than visiting dens for baseline reproductive information. In addition, because black bears have relatively small litter sizes, a comparatively slow reproductive cycle, and a slow reproductive maturity (Pelton 1982) it is essential to gather data over an extended period of time because it is often difficult to get large annual sample sizes. Researchers may actually be able to increase sample sizes for reproductive data by spending time establishing contacts with hunters who may supply reproductive tracts at no extra effort to the agency. Managers should be able to use a variety of these and other methods (McDonald and Fuller 2001) in the absence of annual field collection data at den sites.

Survival Analysis

Long-term survival analysis, and more specifically known fate analysis, provides the most reliable method to correctly indentify parameters that may affect survival and ultimately the population. Many studies of large carnivores have been limited in the past to short durations or large SE and low precision that may affect stochastic modeling calculations (Beecham 1983, Clark and Smith 1994, Samson and Hout 1995, Ryan and Vaughan 2001, Murray 2006, Unger

2007). However, as more long-term data sets and easily accessible computer programs become available, researchers have been able to examine parameters that they would have been unable to examine only a decade ago (Bridges 2005, Schwartz et al. 2006, Taylor et al. 2006*a*). Managers or stakeholders are often concerned with the influence of mast conditions, hunting seasons, and numerous other factors which may affect survival rates and the associated population dynamics of black bears (McDonald et al. 1994, Noyce and Garshelis 1997, Ryan et al. 2004). These relationships may often only be established through long-term analysis of a priori models.

Hunting is the primary source of mortality for most black bear populations (Lindzey et al. 1983, Kolenosky 1986, Schwartz and Franzmann 1991, Beringer et al. 1998, Bridges 2005, Dobey et al. 2005). Hunting season structure had the largest influence on black bear survival rates in southern West Virginia. Early research (Lindzey et al. 1983, Kolenosky 1986) indicated the need for reduced or controlled hunting to allow for population growth and the majority of jurisdictions in eastern North America responded by having no hunting or very conservative seasons (Carr and Burguess 2008, Sajecki 2008, Spiker 2008, Ternent 2008) which are set to protect the majority of adult females from harvest. The WVDNR employed a very conservative hunting season on the WVBBRP's southern study site during the first 6 years of our study but modified the season to the most liberal hunting seasons in North America for the last 6 years. Hunters were allowed 4 different hunting seasons to pursue black bears on the southern study area during the last 6 years of our study: (1) a 5-week long season with archery equipment prior to any black bears entering their den; (2) a 1-week season gun season with or without the use of hounds in late October-early November before any individuals would enter their winter dens; (3) a 1-week gun season without the use of dogs that ran concurrently with antlered white-tailed gun seasons; (4) and the traditional 4-week season in December when a majority of pregnant females have entered their dens. We observed a decrease in adult female survival rates from 0.89 to 0.78 when the WVDNR modified hunting seasons on our southern study area but survival rates on the northern study area remained constant throughout our study period with the traditional conservative seasons and were similar to the neighboring state of Virginia with comparable hunting seasons (Bridges 2005). States in the Appalachian Mountains with reproductive parameters close to our estimates are likely to experience significant growth in the their black bear population if they continue to have conservative or no hunting seasons and high female survival rates.

Decreased food supplies drive black bears to enter their winter dens earlier than normal or may concentrate individuals around alternative food sources and may impact harvests and the vulnerability of certain age classes to harvest (Johnson and Pelton 1980, McDonald et al 1994, Schooley et al. 1994, Noyce and Garshelis 1997, Ryan et al. 2004). In West Virginia, black bear gun harvests are higher in years of abundant mast conditions; whereas, archery harvests are higher during mast failures (Ryan et al. 2004). In Minnesota, mean age of females killed, percent females in the harvest, and hunting success were related inversely to natural food abundance (Noyce and Garshelis 1997). We observed increased female survival rates during mast failures when the WVDNR did not have an early hunting season. However, we did not find evidence of differing adult female survival rates during a mast failure when the WVDNR had an early hunting season implemented. These results seem contradicting to Minnesota but there are major differences in the hunting season framework. In West Virginia it is illegal to bait or feed black bears but baiting is allowed in Minnesota. Therefore, it is difficult to compare the studies because although natural food conditions affect home ranges, movements, and denning chronology, the differences are likely masked by the baiting seasons practiced in Minnesota but not West Virginia (Garshelis and Pelton 1981, Samson and Huot 1998, Dobey et al. 2005). We conclude that the hunting season structure employed by the WVDNR on the southern study areas basically removed the influence of mast conditions and decreased female survival even during a mast failure.

Juvenile and subadult male black bears typically make up the majority of black bear harvests and may be the most important age group to key stakeholder groups (Kolenosky 1986, Bridges 2005). Juvenile and subadult male survival rates on our northern study area were 0.29 and 0.45, respectively and were indicative of heavy hunting pressure. The majority of male black bears may not reach adulthood because they are typically vulnerable to hunting and other causes of mortality because of their dispersing nature (Elowe and Dodge 1989, Lee and Vaughan 2003, Lee and Vaughan 2005). Although male survival may not necessarily be related to population growth it may be important for agencies to monitor these parameters if they are directly related to harvests, nuisance complaints, and other indices that managers may monitor. Male black bears are a key source of recreation for stakeholders and also cause the majority of nuisance complaints. Stakeholder support of an agencies' ability to manage black bears may be directly related to their property damage or encounters with nuisance offenders (Ryan et al. 2009) and a better understanding of male survival rates may lead to higher approval ratings for agencies.

Adult female survival estimates were lower using Downing reconstruction methods than estimates produced with the known fate model in program MARK on the northern study area but were only slightly lower on the southern study area. Survival estimates from juvenile and subadult females on the northern study area were numerically similar; however, Downing reconstruction produced higher survival estimates than the Burnham model for juveniles and subadult females on the southern study area. Survival estimates produced using cohort analysis were lower for all age classes and would provide erroneous models that may not reflect the population. Natural mortalities are not included in population reconstruction so abundances are underestimated (Davis et al. 2007) and thereby would underestimate survival rates. However, natural mortality was low in ours and other studies and harvest makes the majority of deaths in a hunted population (Beechman 1983, Kolenosky 1986, Schwartz and Franzmann, 1991, Bridges 2005). Managers may often account for these small differences of underestimation of survival parameters over the course of a long-term study but violation of multiple other assumptions may prove troublesome, especially when applied to small management units. Numerous state agencies (Maryland, Pennsylvania, Virginia, etc.) have mandatory tooth submissions for hunter harvested black bears (Sajecki 2008, Spiker 2008, Ternent 2008). The WVDNR does not require hunters to submit a tooth for age analysis and therefore it is impossible to determine if the sampled population is a true representation of the total population. However, the average age of females from Greenbrier County, West Virginia where the WVDNR collected 89% of hunter harvested teeth from 1991–2007 was 3.94; whereas, it was only 3.51 in the northern study area for the same time where the WVDNR collected 59% of the female teeth. Davis et al. (2007) stated that weighting towards older white-tailed deer in simulations underestimated the simulated population by 20.4%. Although survival estimates from the multiple methods were numerically similar they would likely have been even more accurate if the WVDNR had mandatory tooth submission.

The cost of obtaining survival estimates from equipping black bears with radio transmitters cost over $180,000 per year more than for estimating survival from reconstruction methods. Although our female survival estimates from the different methods did not exactly match, they were extremely close. In addition, we may have violated some key assumptions (accurate representation of the population) in the data collection of premolar teeth. While the WVDNR may be collecting an adequate sample size and representation of black bear data on a statewide basis to determine female survival rates, by enacting a mandatory tooth submission law, managers would have adequate data to make management unit level recommendations. According to Davis et al. (2007), and finite population correction theory of statistical methods, it may not be necessary to sample every individual and sub-sampling may produce the same standard deviations as complete samples at a lower cost. However, violating the assumption that every individual had equal sampling probability (random sample or sample was a true representation of the population) may lead to parameter estimates being over or under inflated (Davis et al. 2007). Assuming no mark (collar) bias, known survival rates should supply the most accurate data but these data are often difficult for agencies to obtain on limited budgets or when there is a shortage of personnel.

Population Modeling

Many jurisdictions have gone from protecting or conserving black bear populations (Miller 1990) into the challenging realm of how to control their populations while satisfying numerous stakeholders (Ryan et al. 2009). Complicating the matter is that some stakeholders desire to have the population increased, some decreased, while others may or may not support hunting (Bowman et al. 2001, Ryan et al. 2009). No matter what the agencies overall management objective, the first goal is to correctly understand the population growth rate. The population growth rate on our northern study was $\lambda = 1.091$ and demonstrated that the population would continue to increase unless modifications were made to reduce female survival. In the neighboring state of Virginia, Bridges (2005) estimated $\lambda = 1.13$ and stated that adult female survival would need to be lowered to 0.69 to stabilize the black bear population. Although the majority of residents residing in our northern study area wanted the population to remain the same more wanted it decreased rather than increased (Ryan et al. 2009). In 2008, the WVDNR set the management goal of slightly reducing the black bear population and modified hunting seasons in the northern study area in an effort to achieve these goals. The West Virginia Natural Resources Commission approved a 1-week gun season in September with or without dogs and West Virginia hunters harvested a record 2,069 black bears. Six hundred and seventy black bears were harvested during the early season with a sex ratio of 52M:48F. The WVDNR is still awaiting data from age analysis on harvested females to determine the true impact on the population; however, the season appears to have been successful at harvesting additional black bears. If state agencies in the eastern United States, and specifically the Appalachian Mountains have the goal of stabilizing black bear populations, then they need to evaluate new and innovative methods to harvest additional females. Moreover, states with newly established and expanding black bear populations (Kentucky, Maryland, Ohio) may benefit from the knowledge gained from other jurisdictions and modify their seasons to allow slower population growth than what has happened throughout other states (Pennsylvania, Virginia, West Virginia, etc) where populations grew exponentially in the last 3 decades. Modifying hunting seasons to target the female segment of the population is the most effective method to manage the population.

The WVDNR established the most liberal black bear hunting seasons in North America on our southern study area during the last 6 years of our study. We estimated the black bear population rate of growth at $\lambda = 1.093$ prior to the special hunting seasons and the population would have exploded to > 15,000 individuals if the WVDNR had not enacted the special hunting seasons that lowered female survival. However, with a special hunting season we estimated $\lambda =$

0.957 and that rate of growth would have reduced the population to less than half within 25 years, but other indices indicate that the population has remained fairly level since 2002.

Sanctuaries or areas protected from hunting may help to complicate management issues for bear managers because of possible source-sink population dynamics. North Carolina has sanctuaries that offer protection for female black bears and serve as a source population for the surrounding hunted areas (Beringer et al. 1998). Black bear populations in Okefenokee National Wildlife Refuge and northern Florida have served as a source population for hunting mortality in Georgia (Dobey et al. 2005). In the areas around the North Carolina sanctuaries, black bears, particularly young males, often disperse from their natal range and are more likely to be harvested by hunters (Beringer et al. 1998). Male black bears are known to disperse at least 80 km in the Appalachian Mountains (Lee and Vaughan 2003) and may come from females that live in areas protected from hunting (Beringer et al. 1998). In addition, during poor mast years black bears may move out of protected areas and increase their home ranges in search of food (Garshelis and Pelton 1981, Samson and Huot 1998, Dobey et al. 2005). Grizzly bears are also known to have differing λ depending on where they reside in the Greater Yellowstone Ecosystem (Schwartz et al 2006). Identifying these relationships has reshaped previous thoughts about how agencies should manage grizzly bears (Schwartz et al. 2006) and other bear species.

On our southern study area, black bears living on areas exposed to lighter hunting pressure through the protection of active mine sites had population growth at $\lambda = 1.223$; whereas, black bears living on areas more accessible to heavy hunting pressure exhibited $\lambda = 0.856$. The cumulative interaction of these 2 populations is likely the reason that managers have not experienced a large decline in the black bear population in our southern study area. Adult female black bears living on active mine sites may be serving as a source population for the more heavily hunted areas and have enabled the WVDNR to have the most liberal black bear seasons in North America without drastically reducing the overall population. Although the WVBBRP has never conducted a habitat suitability analysis of these active mine sites, from our experience they appear to be lower quality black bear habitat with mountain top removal sites, many roads, and a reduction of oak trees. Black bears use habitats within 240 m of roads less than expected (Clark et al. 1993) but we hypothesize that the black bears occupying these active mines sites have become accustomed to human food sources and are more tolerant of the vast road network because of the lack of hunting pressure. Black bears are also known to concentrate around anthropogenic food sources at dump locations (Payne 1978) and these large garbage bins are often common on the active mine site and may supply constant food sources. There are 122 tracts of land ≥ 404 ha, 117 which are private and total 379,230 ha spread throughout our southern study area and some are likely acting as a refuge during hunting seasons. Black bear populations at the White River National Wildlife Refuge had $\lambda > 1.000$ when animals were only translocated from their study area or killed from hunting around the refuge; however, $\lambda < 1.000$ when both translocation and hunting occurred (Clark and Eastridge 2006). If population reduction was the overall goal for managers in this area it is likely that they would have to remove some adult females from active mine sites to stabilize the population. Without removing some individuals from the protected population it is likely that the overall black bear population would remain constant even with the most current liberal hunting seasons in North America.

Although not part of our study, the WVBBRP equipped a sample of 23 adult females with GPS radio transmitters (Lotek, Newmarket, Ontario, Canada) in August 2007 to gather data on home ranges, activity patterns, movements, and vulnerability of hunting to better understand the relationship of black bears on or around these active mine sites compared to more heavily hunted areas. Data collection of this phase of the WVBBRP is not complete, but some initial data is demonstrating that adult females may spend the majority of their time around these active mine sites and some may be totally inaccessible to hunting during the various harvest seasons (Figure 18). Additional data also indicates that female black bears trapped on mine sites may not only be spending a large amount of their time around mine sites but also residential areas that may impact their vulnerability to hunting (Figure 19). Source–sink population dynamics may occur around residential areas where black bears may be more vulnerable to higher rates of mortality through vehicle collisions, nuisance complaints, etc. (Beckmann and Lackey 2008), but these residential areas, especially when adjacent to an active mine site, may offer even more protection for adult females. In New Hampshire, nuisance female black bears lived year-round in the communities where they were nuisance offenders (New Hampshire Game and Fish 2005). Nuisance black bear complaints have recently increased in many eastern states and are a primary concern for many agencies (Carr and Burguess 2008, Leigh and Chamberlain 2008, Spiker 2008, Ternent 2008). Adult females living around residential areas in our southern study area may also be serving as a source population that has little or no vulnerability to hunting as in New Hampshire (New Hampshire Fish and Game 2005). Managers and researchers will need to consider the entire population when attempting to managing black bears not just the areas that may be accessible to hunting.

Reconstruction methods underestimated λ on our northern study area but were numerically similar on our southern study area and were what we expected on a statewide basis. Downing reconstruction is quite robust in estimating λ for black bear populations that experience no trend in harvest rates or natural mortality (Davis et al. 2007). Although we generally did not experience a trend in harvest or survival rates over time, numerous factors inherently (mast conditions, early hunting seasons, etc.) influenced harvest and thus survival rates and may have impacted our reconstruction accuracy. However, small fluctuations in increased harvest rates do not impact the accuracy of λ (Davis et al. 2007). We may have violated 2 assumptions (although these were beyond our control) that could have impacted reconstruction accuracy, the mis-aging of samples and the large fluctuation in harvest trends from early hunting seasons. Davis et al. (2007) suggests analyzing data in different time periods if large fluctuations in the harvest rates are known to exist. However, this assumption may often prove difficult to follow because managers often adjust seasons to achieve the desired population effect. Reconstruction analysis provides managers with a useful tool to monitor λ, but violations of key assumptions may provide erroneous conclusions. It may be difficult on managers to apply data at a management unit level rather than across their entire jurisdiction if they do not have mandatory tooth submission. If the WVDNR or other jurisdictions desire to use reconstruction methods to monitor λ then they should make sure that they are sampling an accurate representation of the population. However, this may require total sampling because of the denning chronology of black bears related to hunting season. They should also make small changes in their hunting seasons to control the population rather than wait until a drastic population reduction change is needed.

Adult female survival normally has the largest impact on population growth rates of large carnivores. We agree that sensitivity analysis of demographic parameters of black bears in our northern study area demonstrated that adult female survival has the largest impact on population dynamics. While it is important for managers to know the parameters that have the largest influence on λ it is often impractical for them to implement strategies that only influence a particular age class because black bears are impossible to age through visual confirmation. In addition to modeling which parameter has the largest influence on λ, we also modeled various possible harvest scenarios under more liberal hunting seasons or increased mortality from non–hunting sources. Decreasing the total female survival by 0.07 should stabilize the population on our northern study area if that is the desired effect. Managers should also be aware that differing female survival rates across age classes will impact the population differently. For example, adjusting adult female survival rates at different intervals along with decreasing juvenile and subadult survival rates will impact the black bear population in their jurisdiction differently than just adjusting one age class. Some jurisdictions in the eastern United States (Massachusetts, Pennsylvania, West Virginia) have hunter success and harvest rates and by lengthening seasons or adjusting bag limits they may be able to adjust harvest levels to achieve management goals (Cardoza 2008, Ternent 2008, Ryan et al. 2009*b*). To make accurate management recommendations it is important for managers to understand the entire impact of varying female survival rates (through variations in hunting or non-hunting mortalities) across all age classes.

MANAGEMENT IMPLICATIONS

Indices to monitor black bear population have been suggested as early as the 1970's (Payne 1978), but it was often difficult to compare multiple methods or indices because long-term data sets were needed and because of insufficient sample sizes. Bait stations, hunter observational surveys, traditional mark-recapture studies, tetracycline mark-recapture studies, mark-resight studies, telemetry studies, reconstruction analysis, non-invasive genetic techniques, harvests, and nuisance complaints among other methods have been used to monitor black bear populations (Payne 1978, Hellgren and Vaughan 1989, Garshelis and Visser 1997, Miller et al. 1997, Akenson et al. 2001, Noyce et al. 2001, Klenzendorf 2002, Boersen et al. 2003, Diefenbach et al. 2004, Clark et al. 2005, Garshelis and Hristienko 2006, Garshelis and Noyce 2006, Gompper et al. 2006, Davis et al. 2007), but few were able to compare multiple methods or include costs of gathering data. The 2-year running average of the harvest and 2-year observational data was correlated to population estimates and may provide managers with adequate trend data to base management decisions. If managers are aware of the limitations and assumptions, they may be able to use averages of harvest data to provide quick estimates that are a reflection of the population and easy for stakeholders to understand in addition to being relatively economical to obtain. Downing reconstruction methods proved promising in areas where there was an adequate representation of tooth samples collected. However, because the WVDNR does not have mandatory tooth submission they may violate numerous assumptions and must spend additional money and manpower collecting data that may be easily collected at check stations or surveys. Agencies that have mandatory tooth submission from hunter harvested animals and adequate hunting pressure or can ensure an unbiased sample representation for Downing population reconstruction should be able to adequately reflect population trends and provide managers with another relatively cheap method to monitor the population. In hunted populations, we would advise agencies to conduct surveys to determine hunting pressure and to determine if various other indices may be correlated to their population estimates.

Manipulation of harvests has long been a founding principle in wildlife management. Managers can adjust season dates, bag limits, quotas, and various other methods to achieve a desired harvest level (Miller 1990). Adult female survival is often cited as the driving force behind most large carnivore populations but controlling specific age structure survival rates are often difficult when hunters cannot distinguish between gender let alone age classes. We modeled varying demographic parameters in relation to λ and concur with previous studies that adult female survival is the single parameter controlling black bear populations in the

Appalachian Mountains. However, decreasing juvenile and subadult female survival rates are additive effects when a reduction in adult female survival has occurred through hunting seasons or natural mortality. Managers wishing to adjust black bear population levels to desired abundance should consider not only adult survival but also how individual age classes may respond to an adjustment in hunting seasons. Population modeling programs such as program RISKMAN that enable managers to model varying parameter effects on the population may assist managers with real world data situations.

Although not stated in many scientific papers, money is the driving force behind which projects an agency may or may not conduct or where administrators decide to focus their management or research efforts. The WVDNR averaged spending $216,836 per year on collecting demographic data but only $33,271 on check stations, reproductive tracts, and tooth collection with age analysis. We are not suggesting that long–term known fate and reproductive studies are not the most accurate or useful source of information to identify parameters that may affect black bear population dynamics. Rather, we are suggesting that agencies may use other sources of data to identify the parameters that may affect their black bear population and use data sources available to make informed management decisions if they are unable to conduct expensive, labor intensive long–term studies. Moreover, known fate and reproductive data are economically difficult to obtain for black bears and nearly all studies are confined to a small geographic area. These data are then used make management decisions at the jurisdictional level. Extrapolating data from small subsets may often lead to erroneous conclusions in wildlife research (Fuller 1991, Ostermann–Kelm et al. 2005) and applying data from small study areas may not be beneficial to the management of black bears in the Appalachian Mountains. As in Virginia, we identified differences in demographic parameters of black bears within our jurisdiction (Bridges 2005). Although researchers attempt to pick the most representative study area in a region so that SE may be small to provide accurate calculations, differences in habitats, hunting pressure, or other parameters may preclude managers from using data across an entire jurisdiction. Applying data from a small study area over a wide geographic range may be even more detrimental than gathering more economical data for the entire jurisdiction. For agencies on a limited budget we would suggest gathering as many types of data that may be correlated to their black bear population if they are unable to conduct large long–term studies across their entire jurisdiction.

SUMMARY

- We evaluated black bear population ecology on 2 study areas in the Appalachian Mountains from 1972–2007 and handled > 1,600 individuals > 4,000 times.
- The 2-year running average of black bear harvests were correlated to population size in areas of adequate hunting pressure. In addition, the 2-year running average of hunter observation of black bears was strongly correlated to estimated populations. Managers may be able to use this data as an index to populations in their jurisdiction if survey data indicates that there is adequate hunting pressure.
- Data from female reproductive tracts were similar to number of cubs observed during den visits. Managers should be able to accurately estimate reproductive parameters from reproductive tracts without making labor intensive trips to den sites if adequate samples sizes from teeth are not available.
- On a statewide basis, reproductive rates of black bears from den visits were similar to data collected from reconstruction analysis once the percent of each age class reproducing was estimated.

- Most survival models indicated that black bear survival could be grouped into one of 3 age classes: (1) Juveniles: 1- and 2-year olds; (2) Subadults: 3- and 4-year olds; (3) and Adults: ≥ 5-year olds.
- Adult female survival rates were affected by the hunting season structure and mast availability.
- Male survival was affected by hunting season structure and if the black bear was captured in a research or nuisance situation.
- With traditional hunting seasons observed throughout much of the eastern North America we observed $\lambda = 1.091$ for our northern population.
- We observed a decrease in λ with special hunting seasons targeting the harvest of additional females and nuisance black bears.
- Adult female survival had the largest effect on λ and was the primary parameter controlling population dynamics.
- Although juvenile and subadult female survival rates had little impact on λ, they were additive when combined with decreased adult female survival rates.
- We observed source-sink population dynamics on our southern study area because of limited access for hunters on private tracts of land. Estimated female survival rates were higher on these tracts of land leading to a source population for more heavily hunted areas.
- Managers need to consider not only the population dynamics of black bears when making management recommendations, but also how black bears may be distributed across landscapes and thus may or may not be vulnerable to harvest.

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Figure 1. Northern and southern black bear study areas in West Virginia, USA.

Figure 2. Black bear harvests in West Virginia, USA, 1972–2008.

Figure 3. Correlation between black bear population estimate from Downing population reconstruction and black bear harvests in Greenbrier, Nicholas, Pocahontas, Randolph, and Webster counties, West Virginia, USA, 1987–2002.

Figure 4. Number of nuisance black bear complaints received by the West Virginia Division of Natural Resources and total mast index, West Virginia, USA, 1997–2008.

Figure 5. Estimated male black bear cohort by year from Downing population analysis versus hard mast and black cherry conditions in West Virginia, USA, 1981–2004.

Figure 6. Black bear survival rates + SE with (♦) and without (■) early hunting seasons in southern West Virginia, USA, 1996–2007. Adult female estimates generated in with known fate model and subadult and juvenile survival rates with Burnham model in Program MARK.

Figure 7. Female black bear survival estimates from Downing population reconstruction in West Virginia, 1991–2002.

Figure 8. Male black bear survival estimates from Downing population reconstruction in West Virginia, 1991–2002.

Figure 9. Black bear total population (a) and growth rates (b) estimates in northern West Virginia, USA from 1,000 Monte Carlo simulations in program RISKMAN for 25 years.

Figure 10. Black bear total population (a) and growth rates (b) estimates in southern study area if the West Virginia Division of Natural Resources had not implemented an early hunting season in West Virginia, USA. Data calculated from 1,000 Monte Carlo simulations in program RISKMAN for 25 years.

Figure 11. Black bear total population (a) and growth rates (b) estimates in heavily hunted areas in southern West Virginia, USA from 1,000 Monte Carlo simulations in program RISKMAN for 25 years.

Figure 12. Black bear total population (a) and growth rates (b) estimates in lightly hunted areas in southern West Virginia, USA from 1,000 Monte Carlo simulations in program RISKMAN for 25 years.

Figure 13. Black bear population growth rates with varying levels of adult female survival rates in northern West Virginia, USA. Data was analyzed in program RISKMAN with 1,000 Monte Carlo simulations per procedure.

Figure 14. Black bear population growth rates with varying levels of subadult female survival rates in northern West Virginia, USA. Data was analyzed in program RISKMAN with 1,000 Monte Carlo simulations per procedure.

Figure 15. Black bear population growth rates with varying levels of juvenile female survival rates in northern West Virginia, USA. Data was analyzed in program RISKMAN with 1,000 Monte Carlo simulations per procedure.

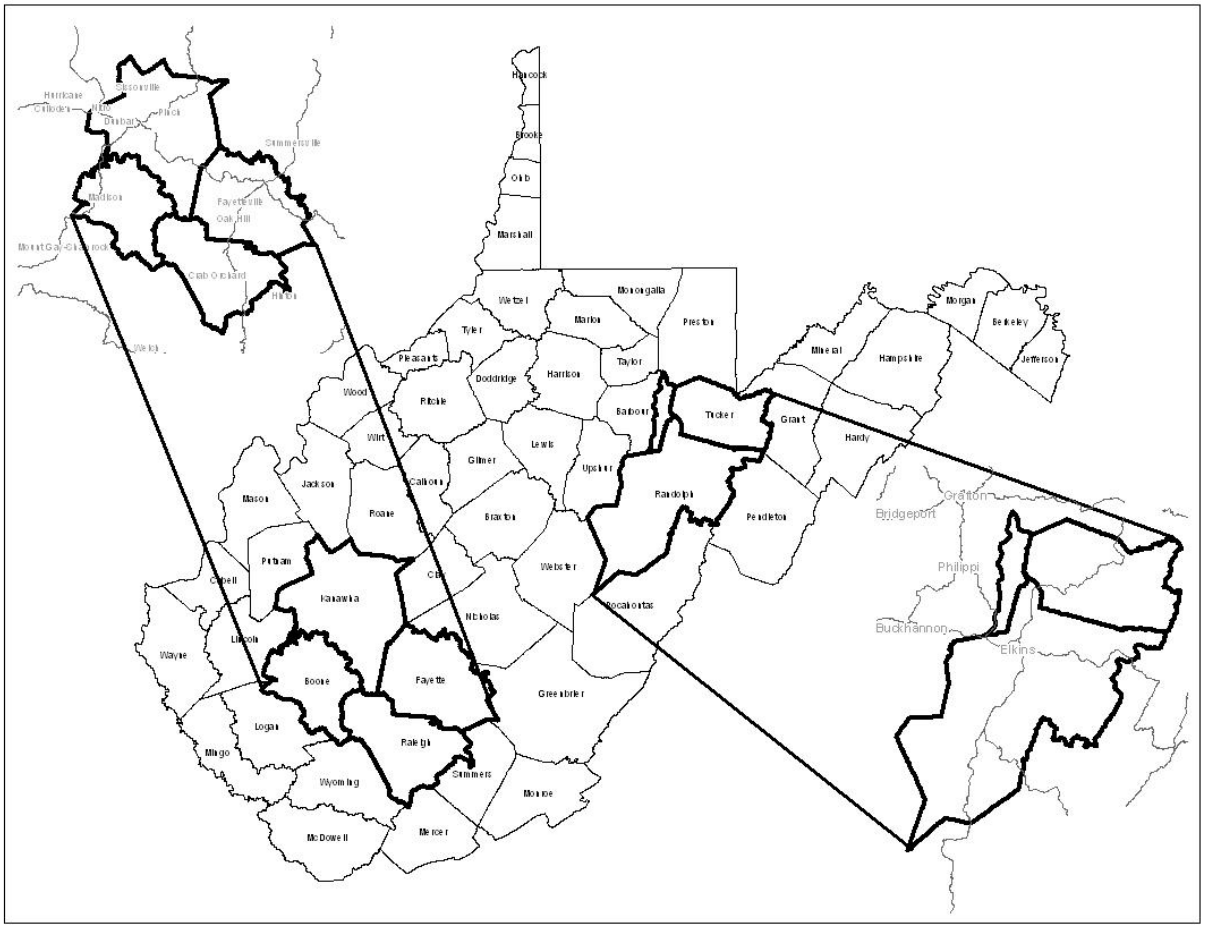
Figure 16. Black bear population growth rates with a respective reduction of adult, subadult, and juvenile survival rates: the initial estimate (Normal), 0.05, 0.02, and 0.02 (A), 0.10, 0.04, 0.04 (B), and 0.15, 0.06, 0.06 (C) in northern West Virginia, USA. Data was analyzed in program RISKMAN with 1,000 Monte Carol simulations per procedure.

Figure 17. Black bear population growth rates with a constant reduction in female survival rates of 0.02 intervals in northern West Virginia, USA with all other parameters constant. Data was analyzed in program RISKMAN with 1,000 Monte Carlo simulations per procedure.

Figure 18. Black bear total locations (a) and $\geq$ 90% of fixes (b) of 2 female black bears around an active mine from GPS collars (Lotek, Newmarket, Ontario, Canada) in Raleigh County, West Virginia, August 2007–March 2008.

Figure 19. Black bear locations from 2 females trapped on an active mine site in southern West Virginia. Data collected with GPS collars (Lotek, Newmarket, Ontario, Canada) in Kanawha County, West Virginia, August 2007–March 2008.

Figure 20. Black bear locations from 2 females trapped on an active mine site in southern West Virginia. Data collected with GPS collars (Lotek, Newmarket, Ontario, Canada) in Kanawha County, West Virginia, August 2007–March 2008.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Culloden
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Brooke
Ohio
Marshall
Wetzel
Monongalia
Marion
Preston
Tyler
Pleasants
Taylor
Doddridge
Harrison
Wood
Ritchie
Barbour
Tucker
Grant
Wirt
Lewis
Gilmer
Upshur
Calhoun
Jackson
Mason
Roane
Braxton
Randolph
Pendleton
Putnam
Cabell
Kanawha
Webster
Nicholas
Pocahontas
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Boone
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Greenbrier
Logan
Raleigh
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Summers
Wyoming
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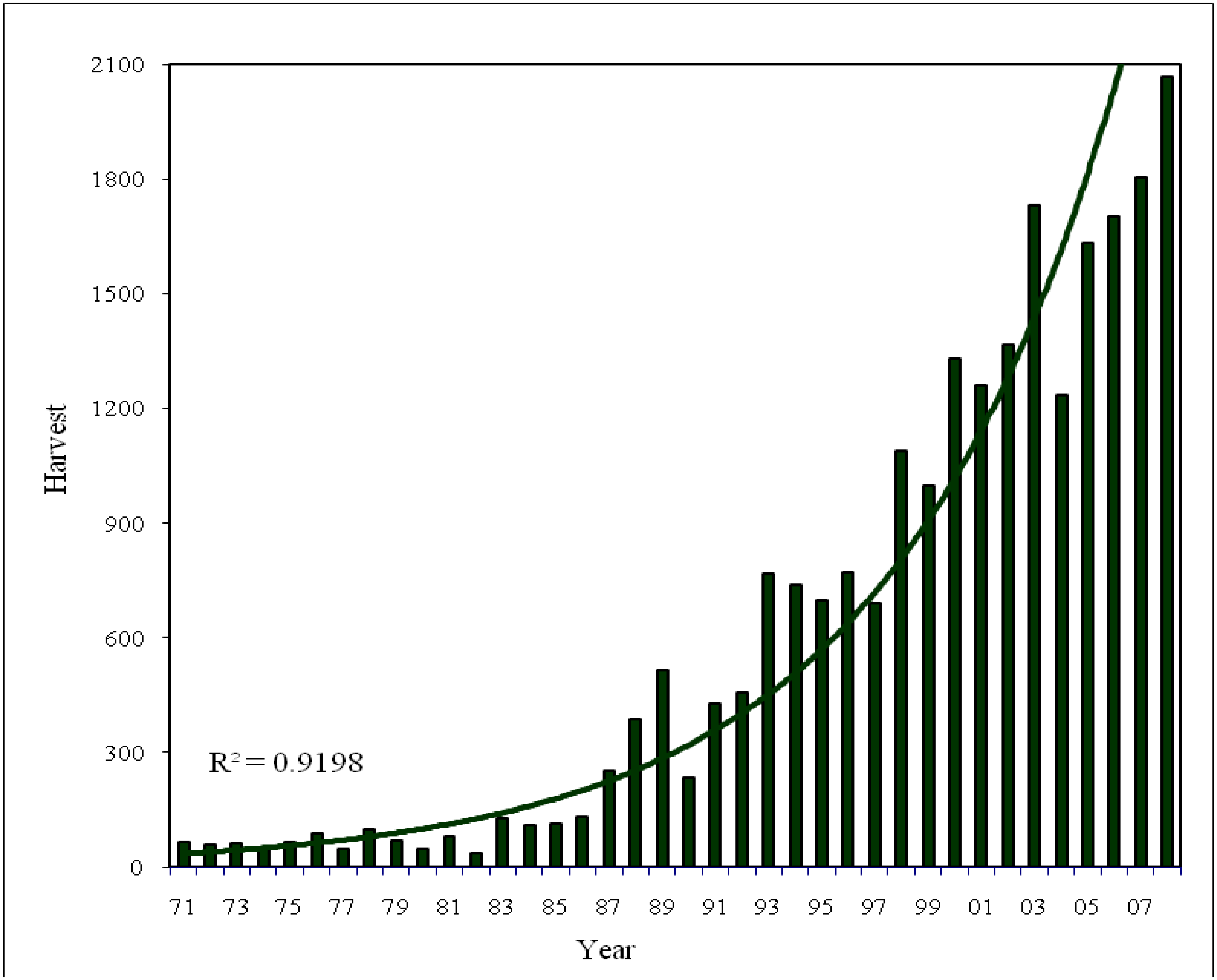
2100
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Harvest
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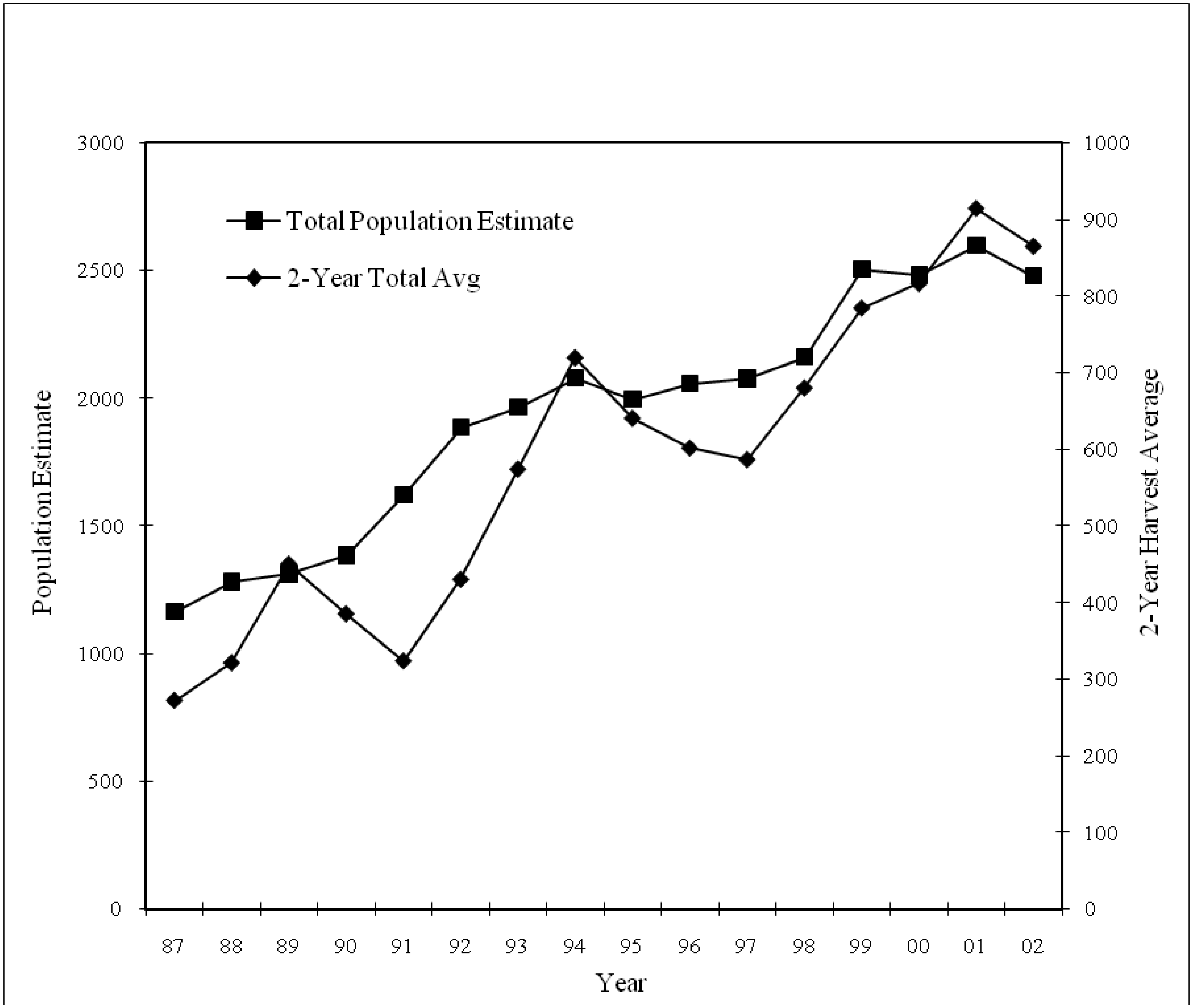
Total Population Estimate
2-Year Total Avg
Population Estimate
2-Year Harvest Average
Year
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2500
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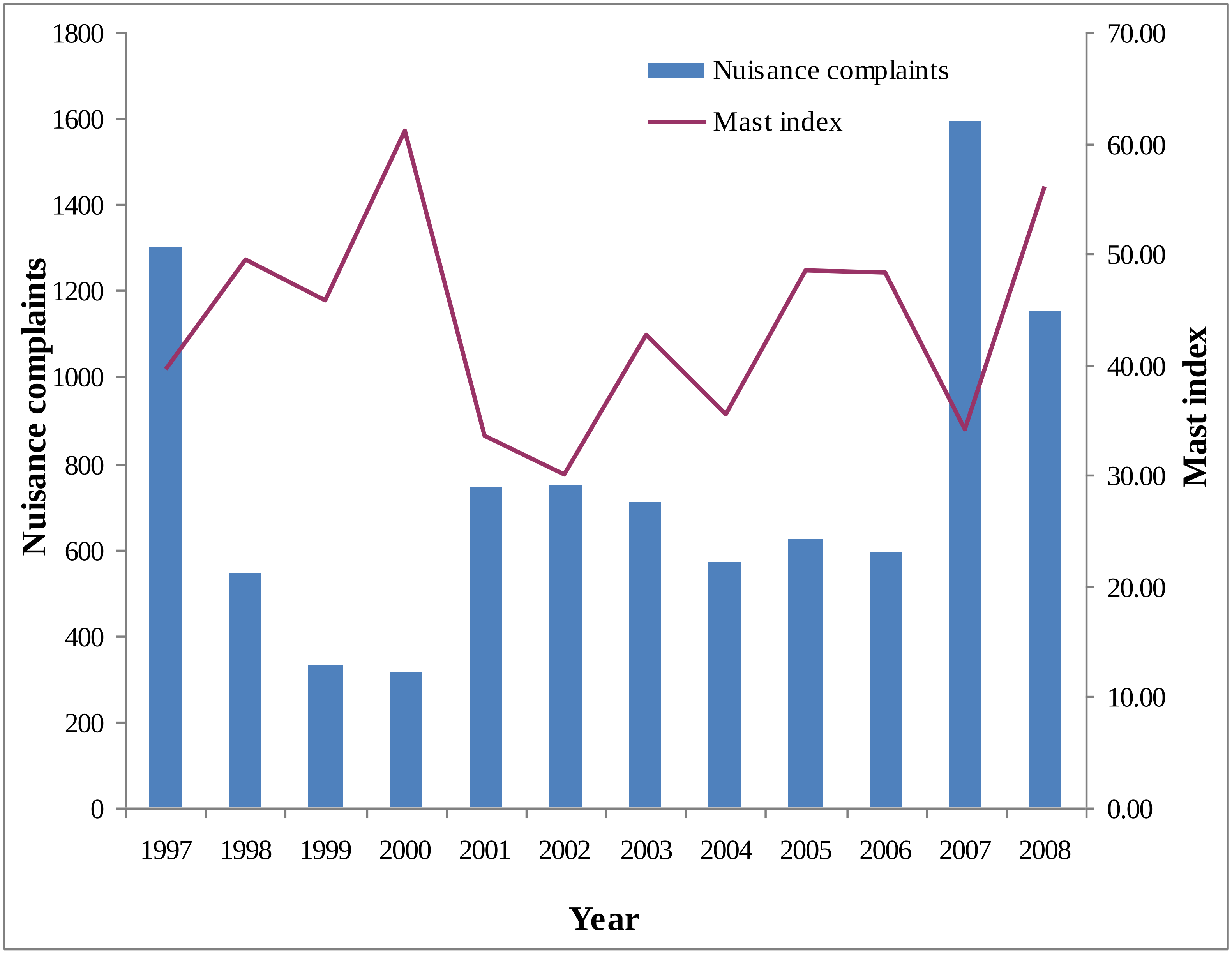

Nuisance complaints
Mast index
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1200
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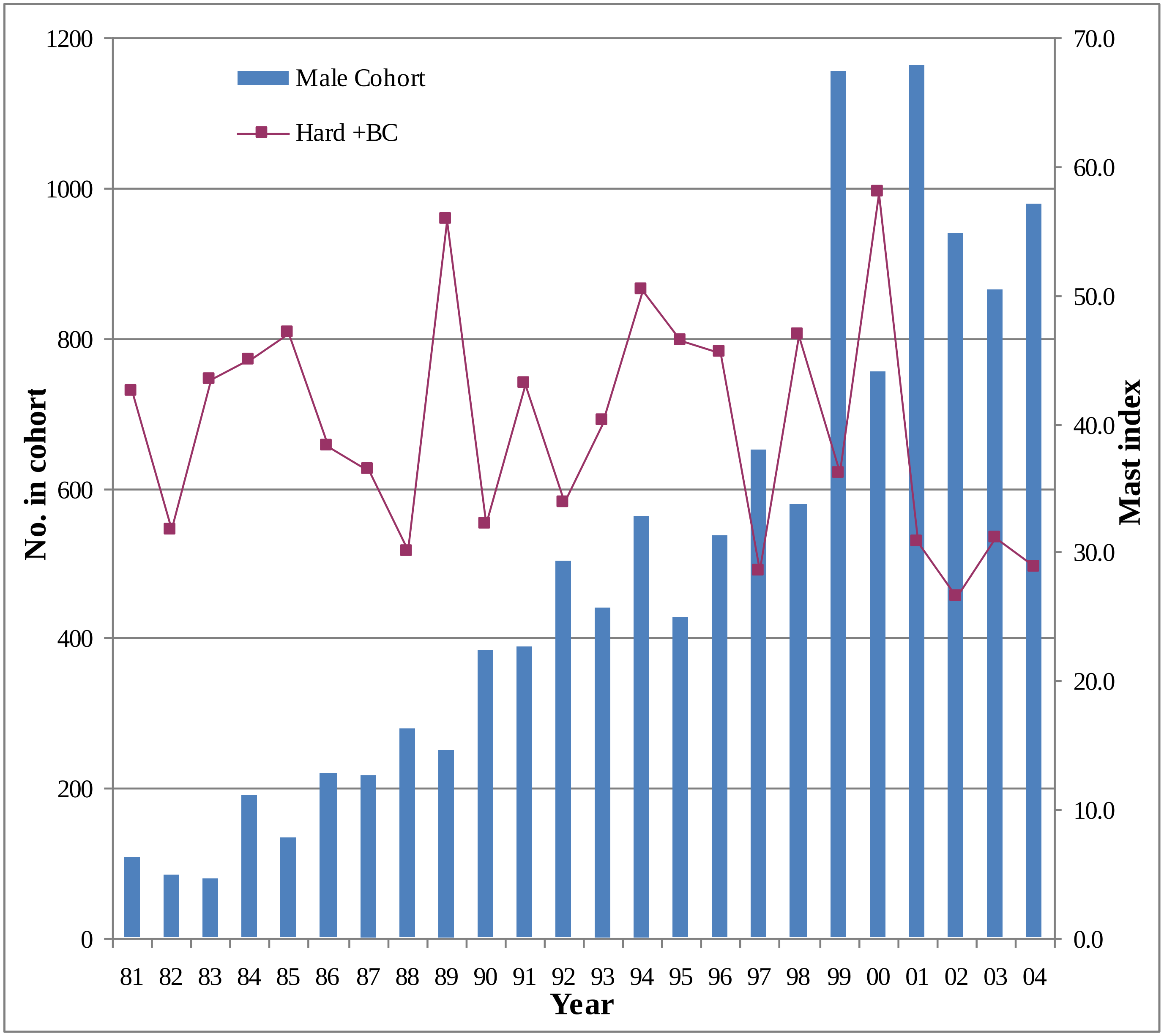
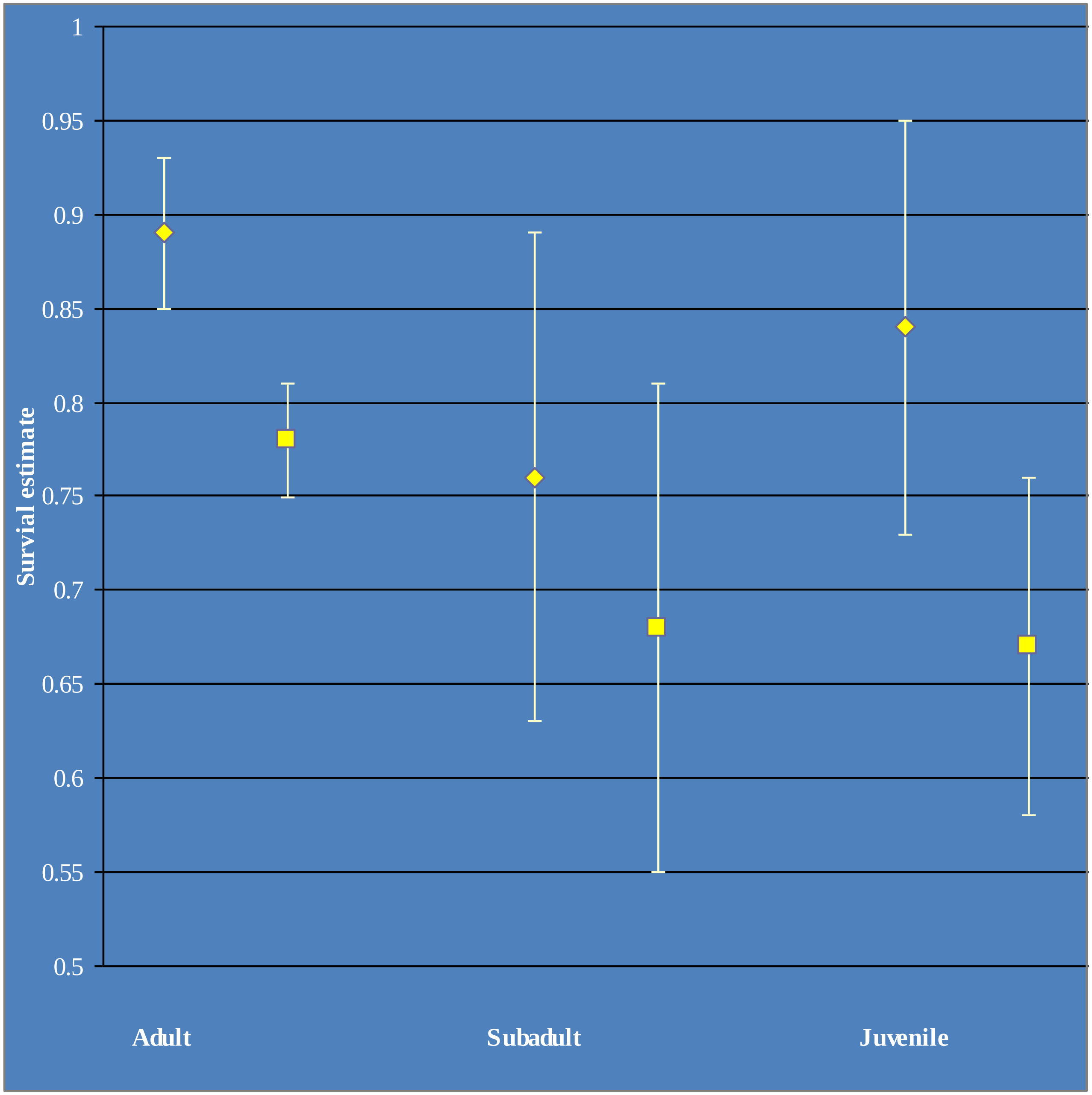
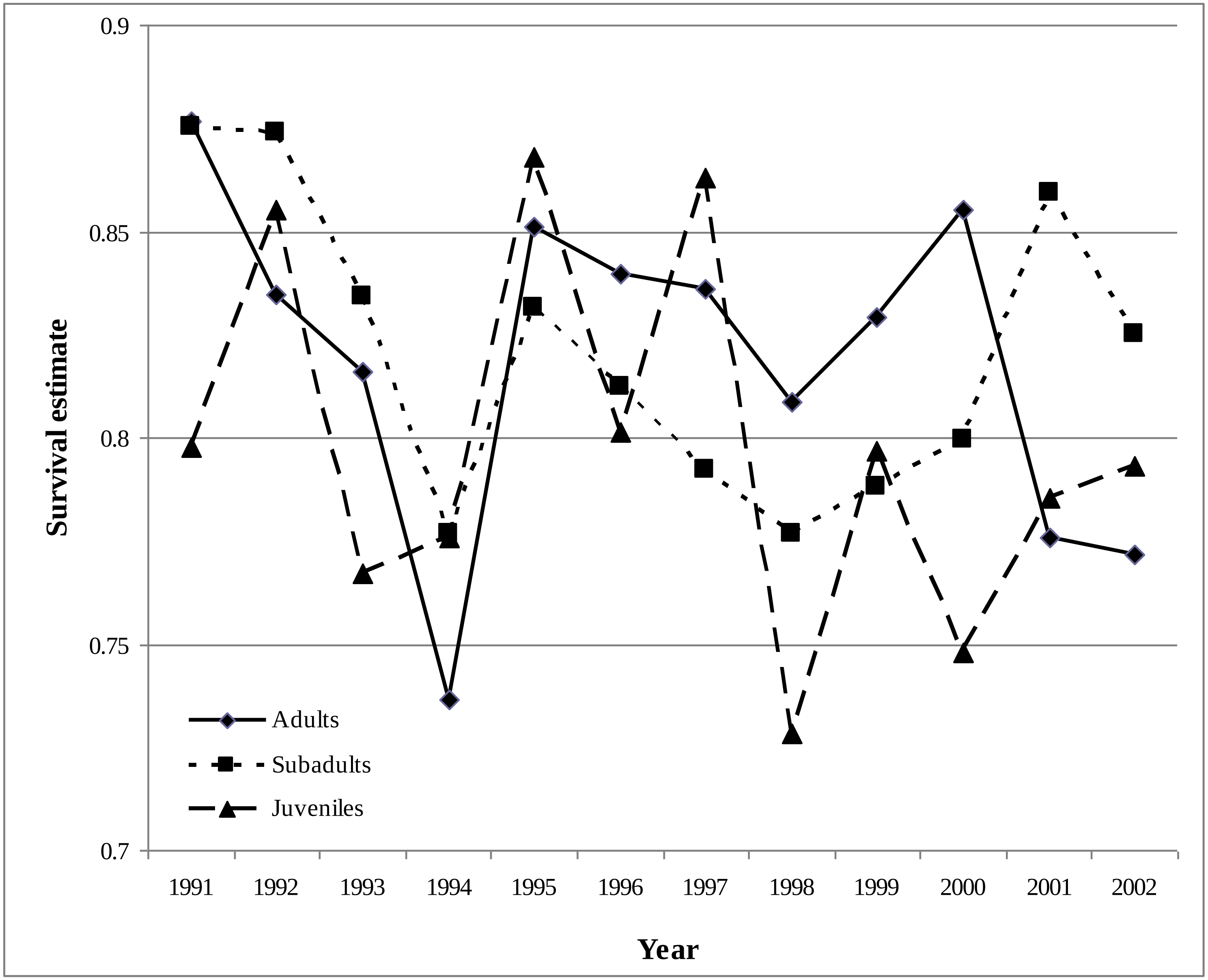
Nuisance complaints
Mast index



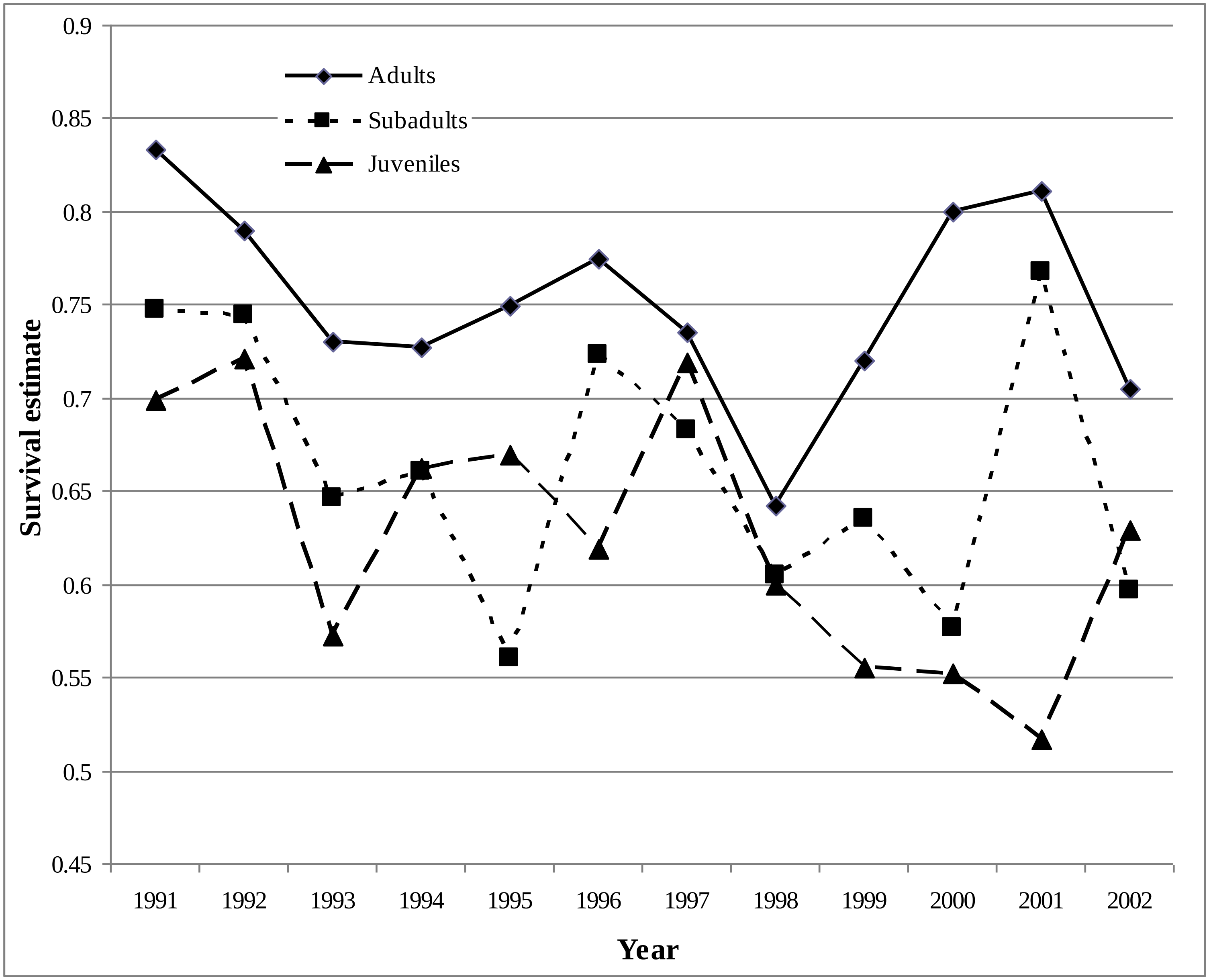
Male Cohort
Hard +BC
No. in cohort
Mast index
Year
0
200
400
600
800
1000
1200
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04



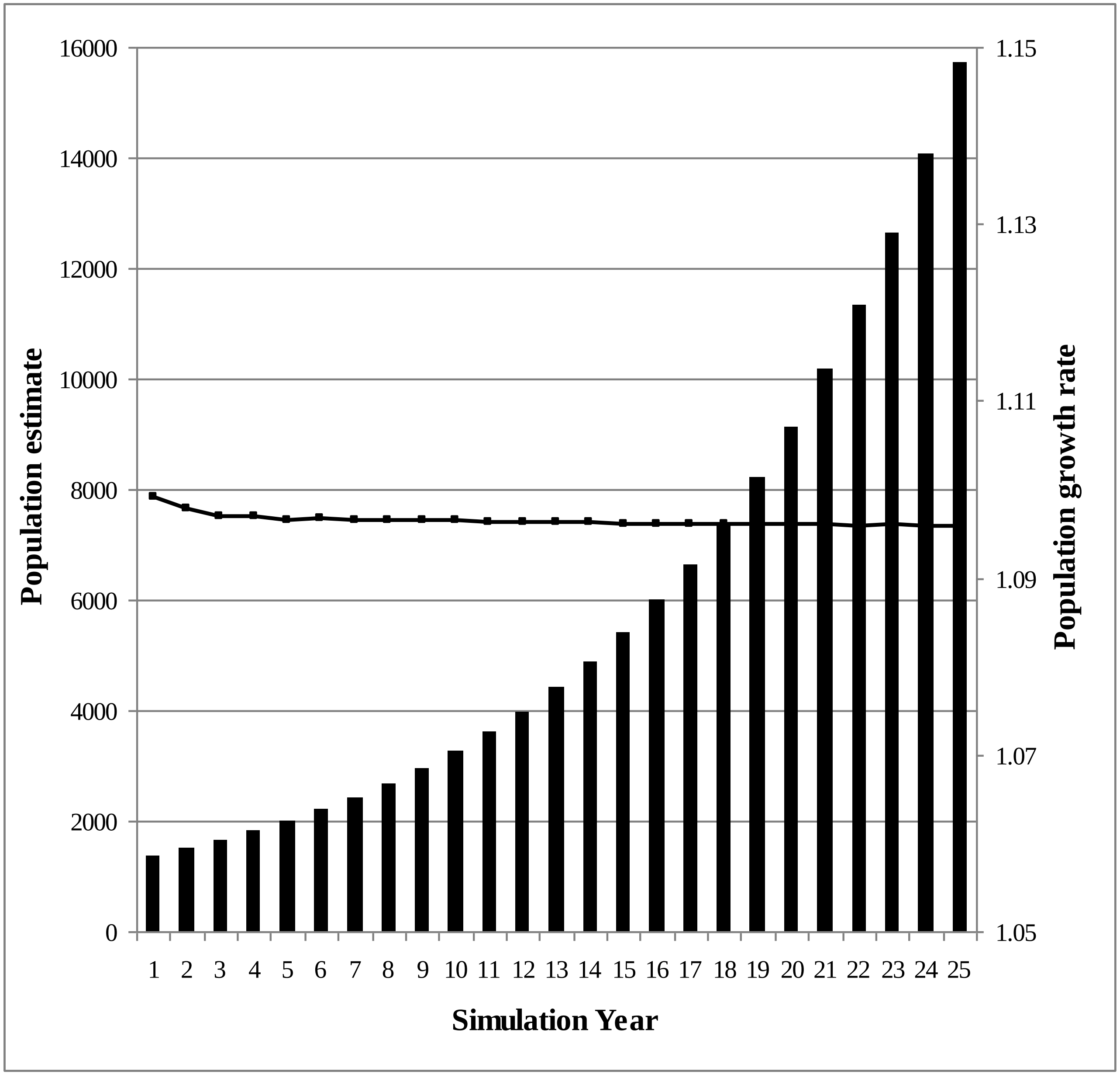
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
Survial estimate
Adult
Subadult
Juvenile



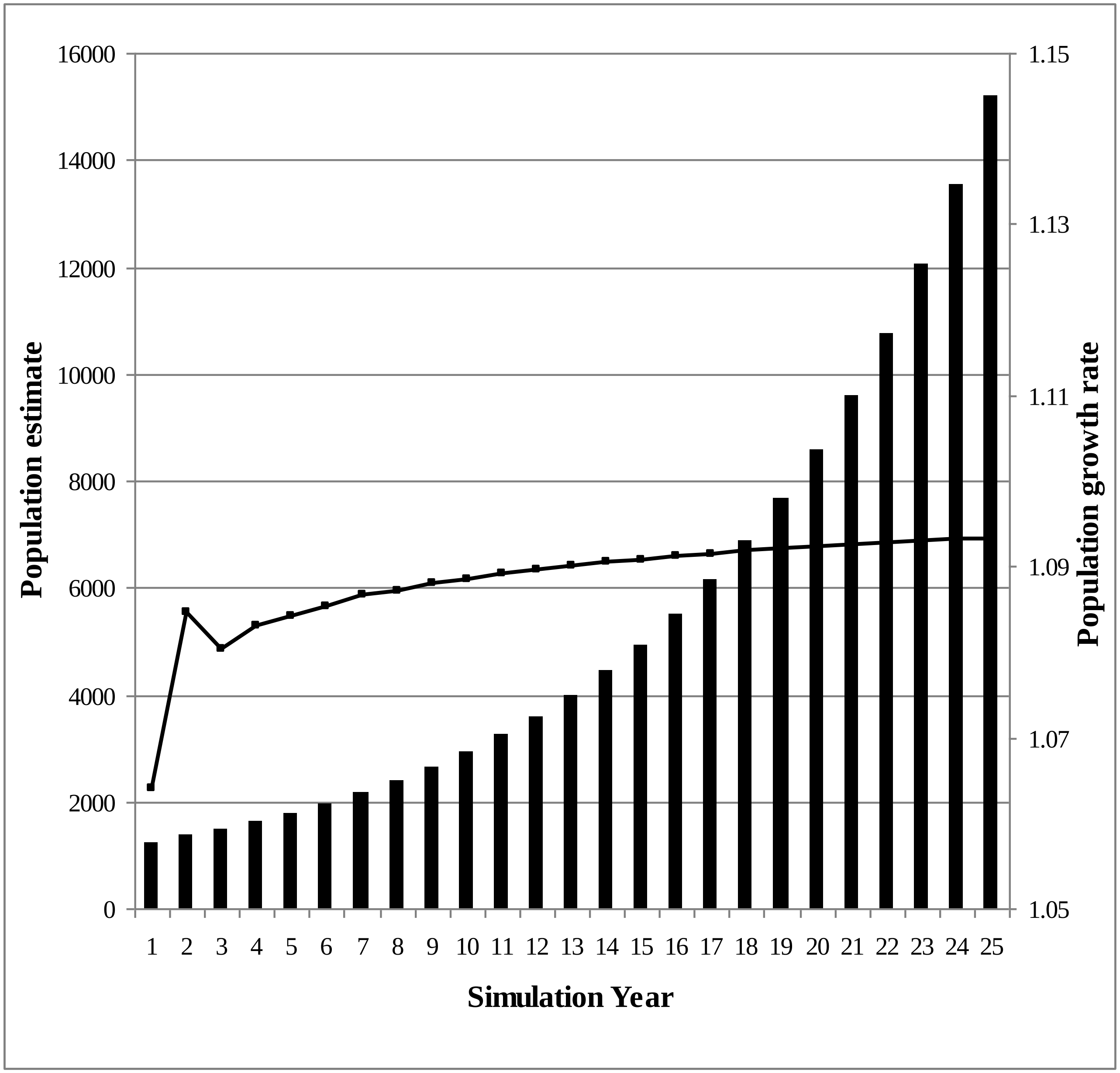
0.9
0.85
0.8
0.75
0.7
Survival estimate
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year
Adults
Subadults
Juveniles



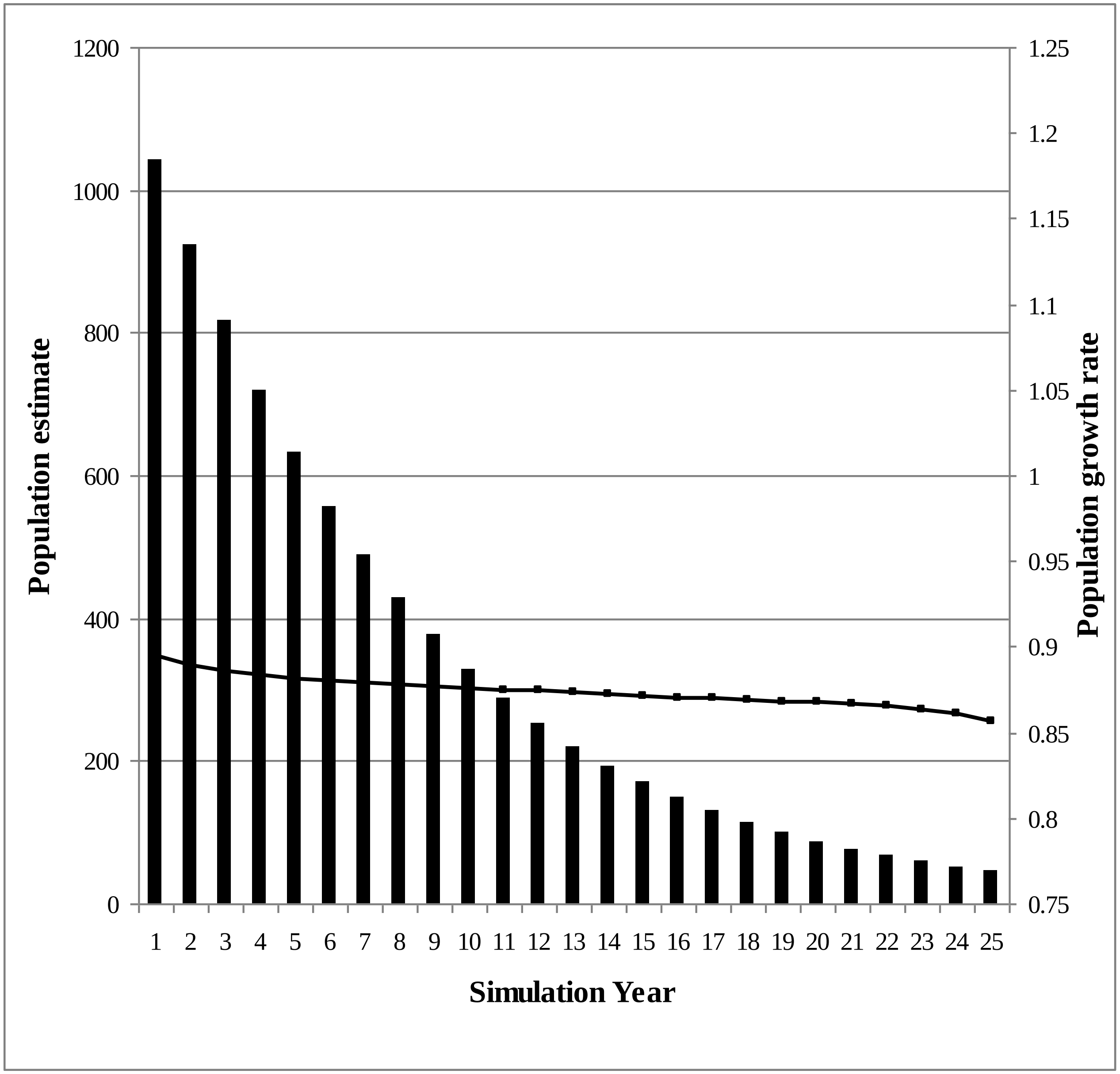
Adults
Subadults
Juveniles
Survival estimate
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year



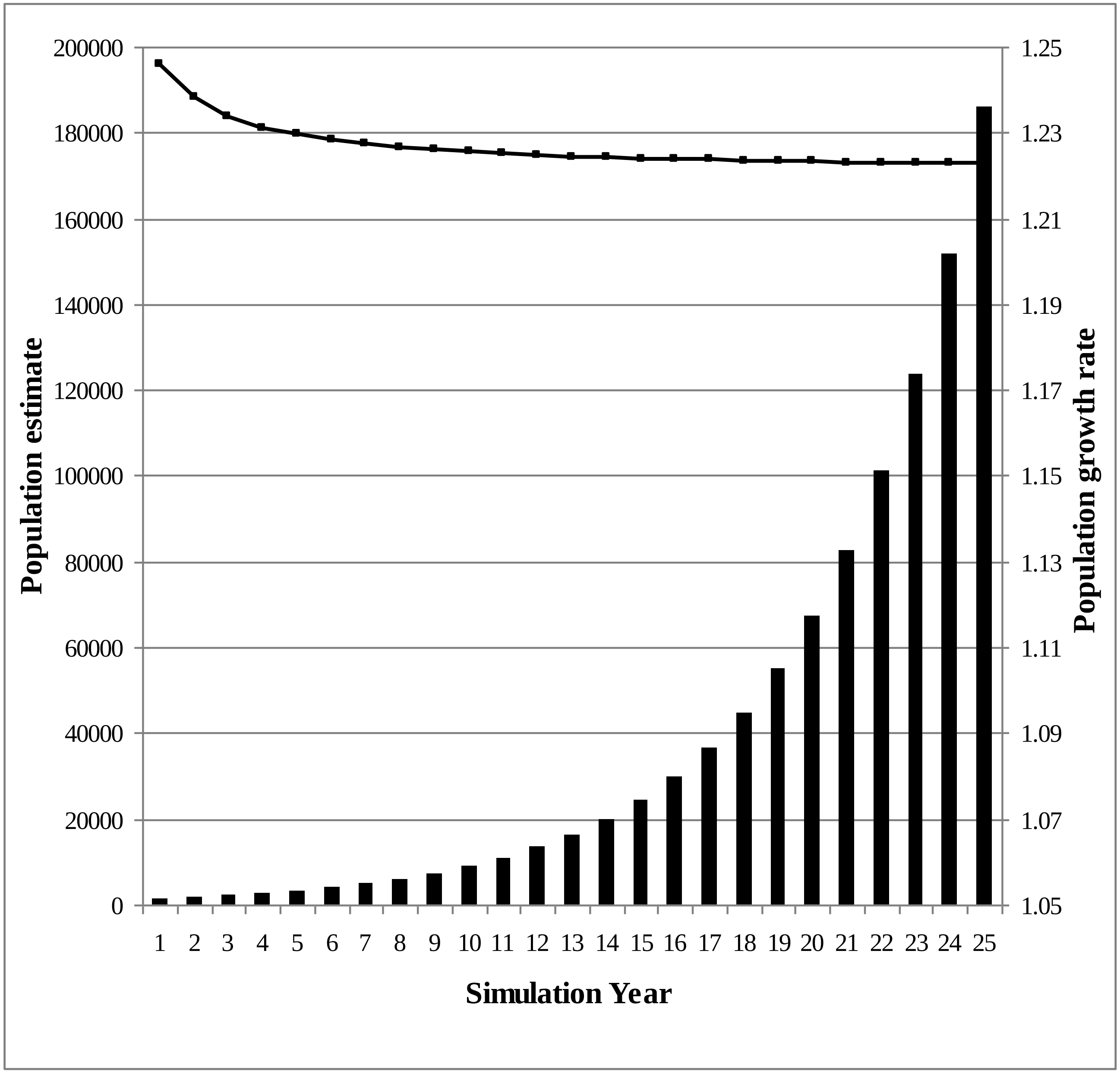
16000
14000
12000
10000
8000
6000
4000
2000
0
1.15
1.13
1.11
1.09
1.07
1.05
Population estimate
Population growth rate
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Simulation Year



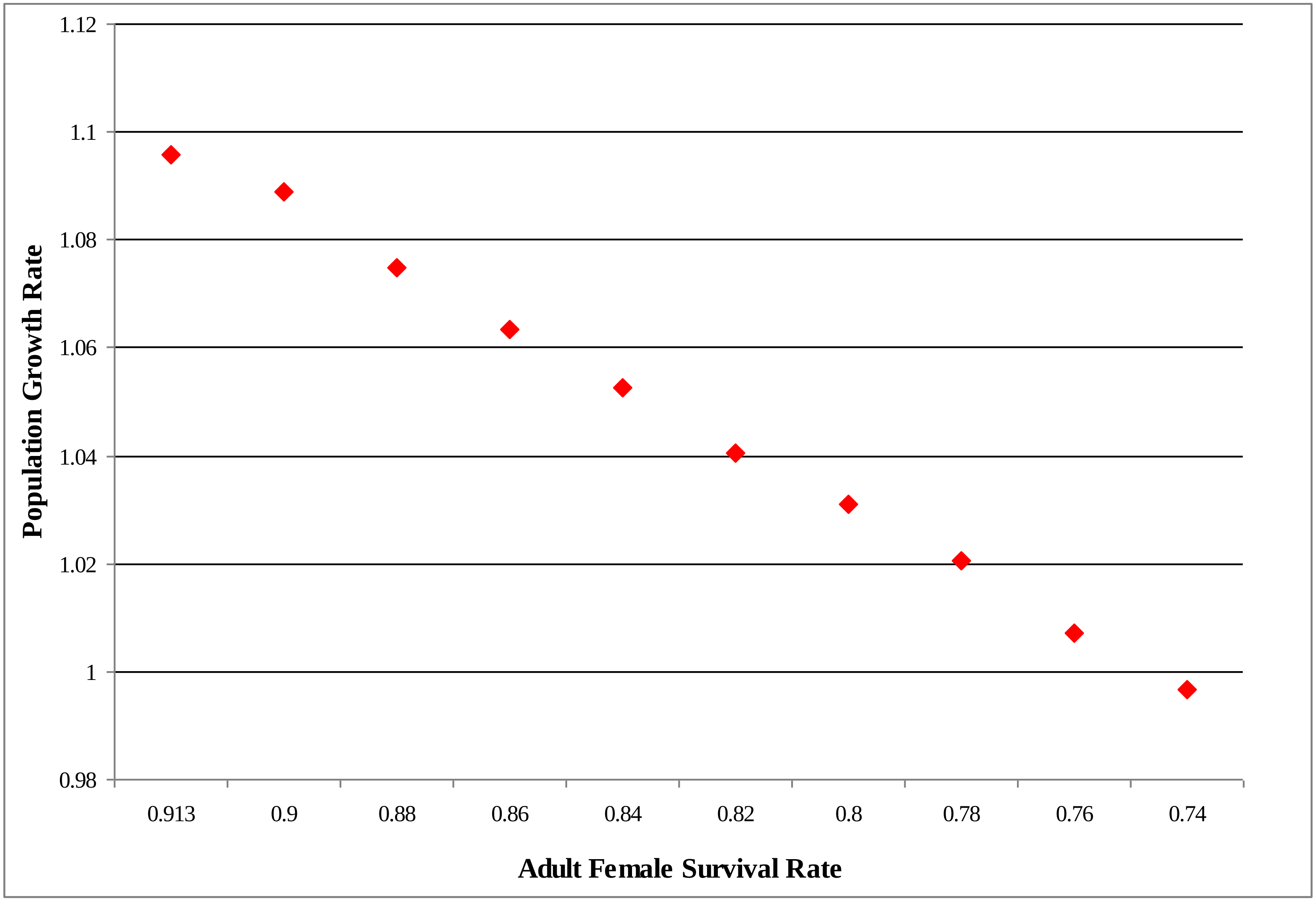
16000
14000
12000
10000
8000
6000
4000
2000
0
1.15
1.13
1.11
1.09
1.07
1.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Population estimate
Population growth rate
Simulation Year

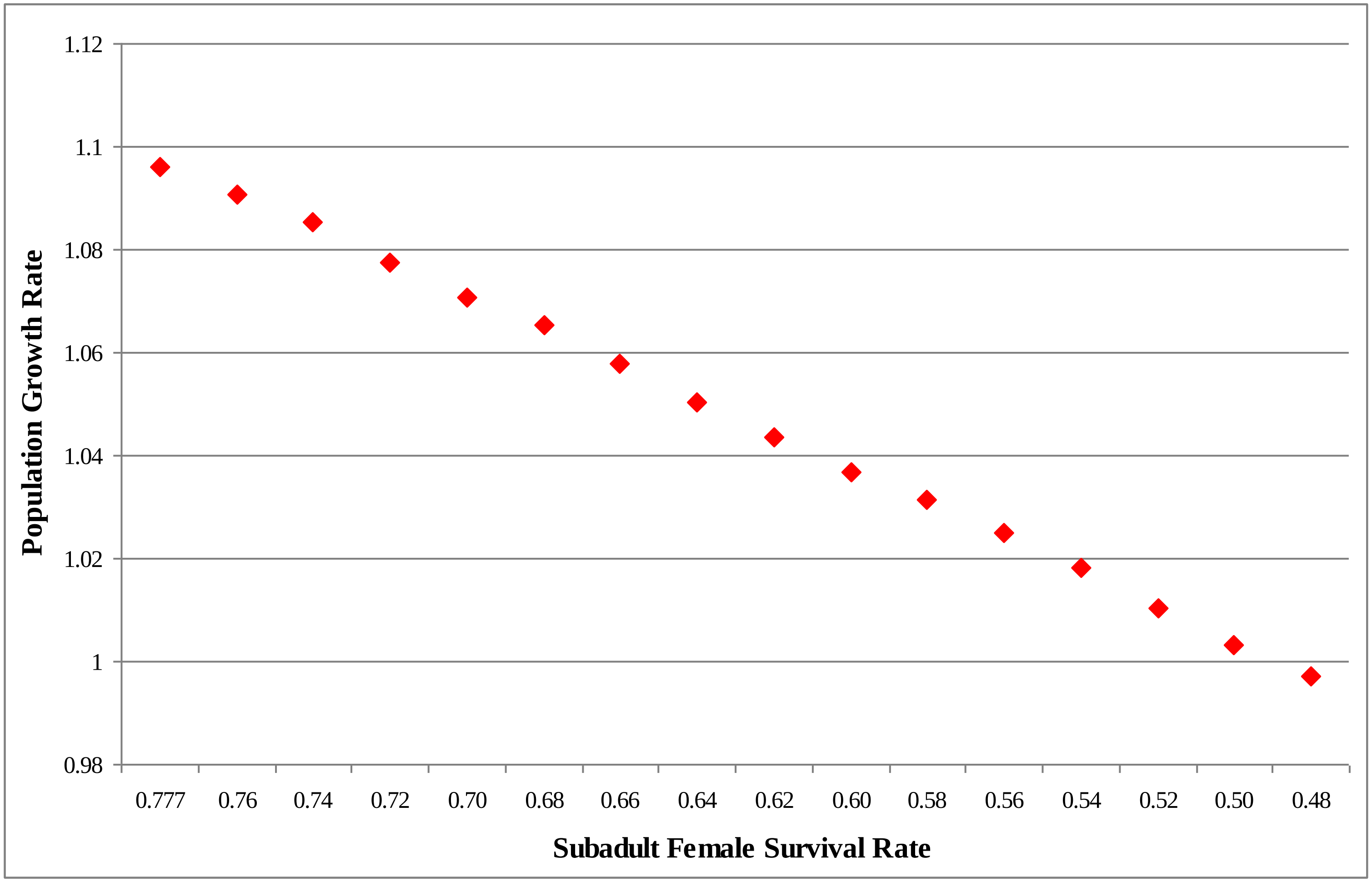


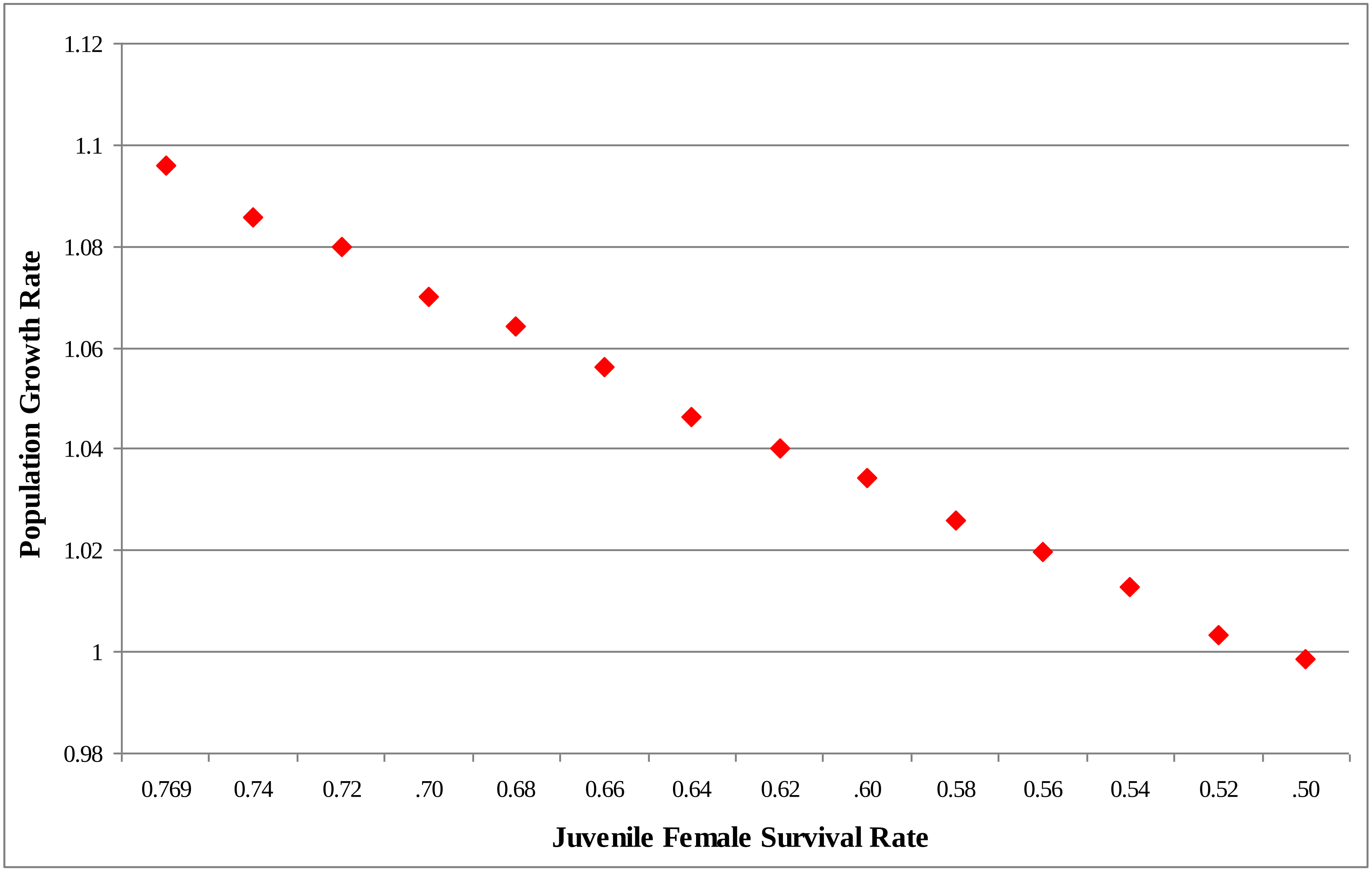
1200
1000
800
600
400
200
0
Population estimate
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
Population growth rate
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Simulation Year



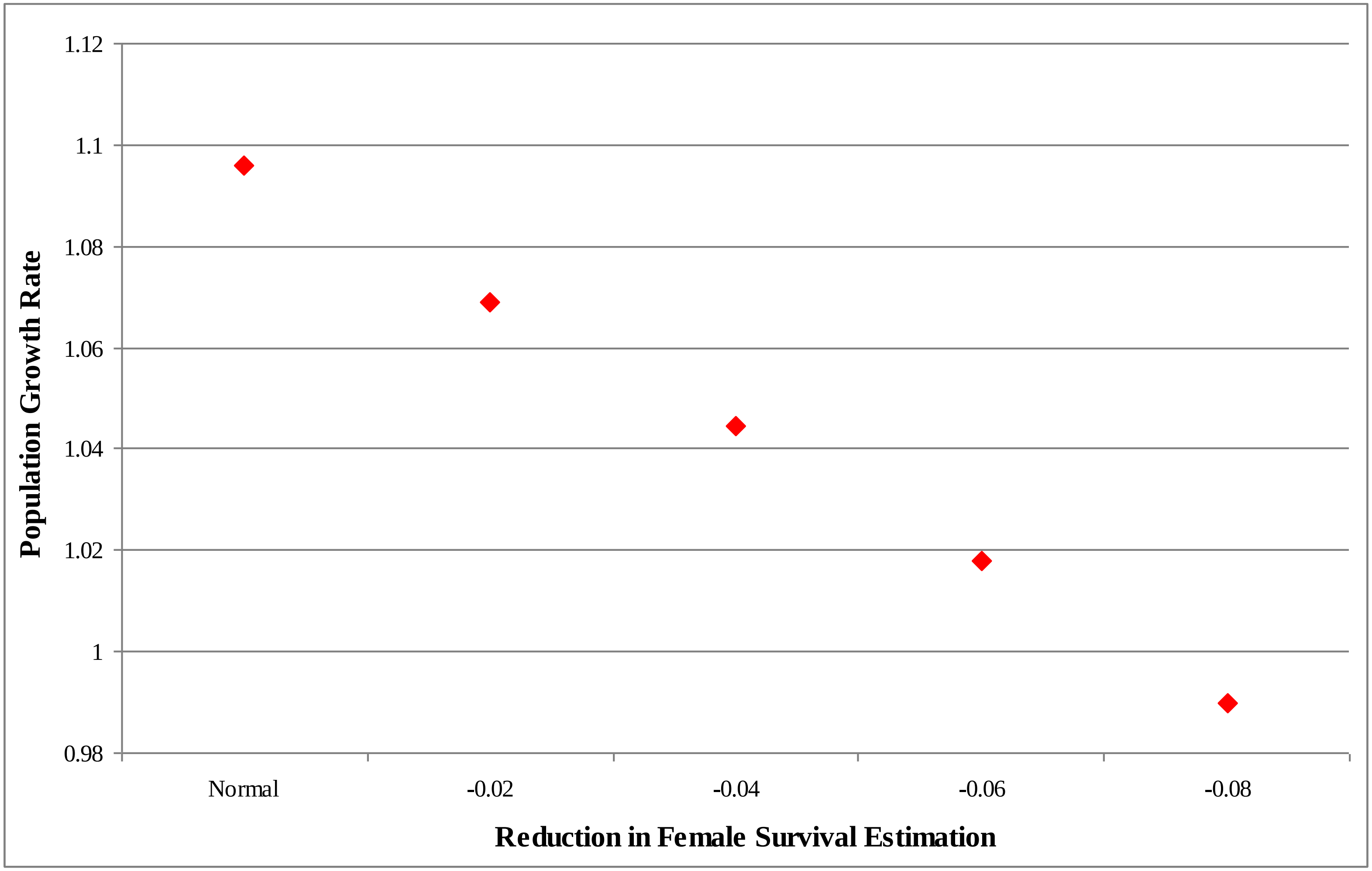
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1.25
1.23
1.21
1.19
1.17
1.15
1.13
1.11
1.09
1.07
1.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Population estimate
Population growth rate
Simulation Year


1.12
1.1
1.08
1.06
1.04
1.02
1
0.98
Population Growth Rate
0.913
0.9
0.88
0.86
0.84
0.82
0.8
0.78
0.76
0.74
Adult Female Survival Rate

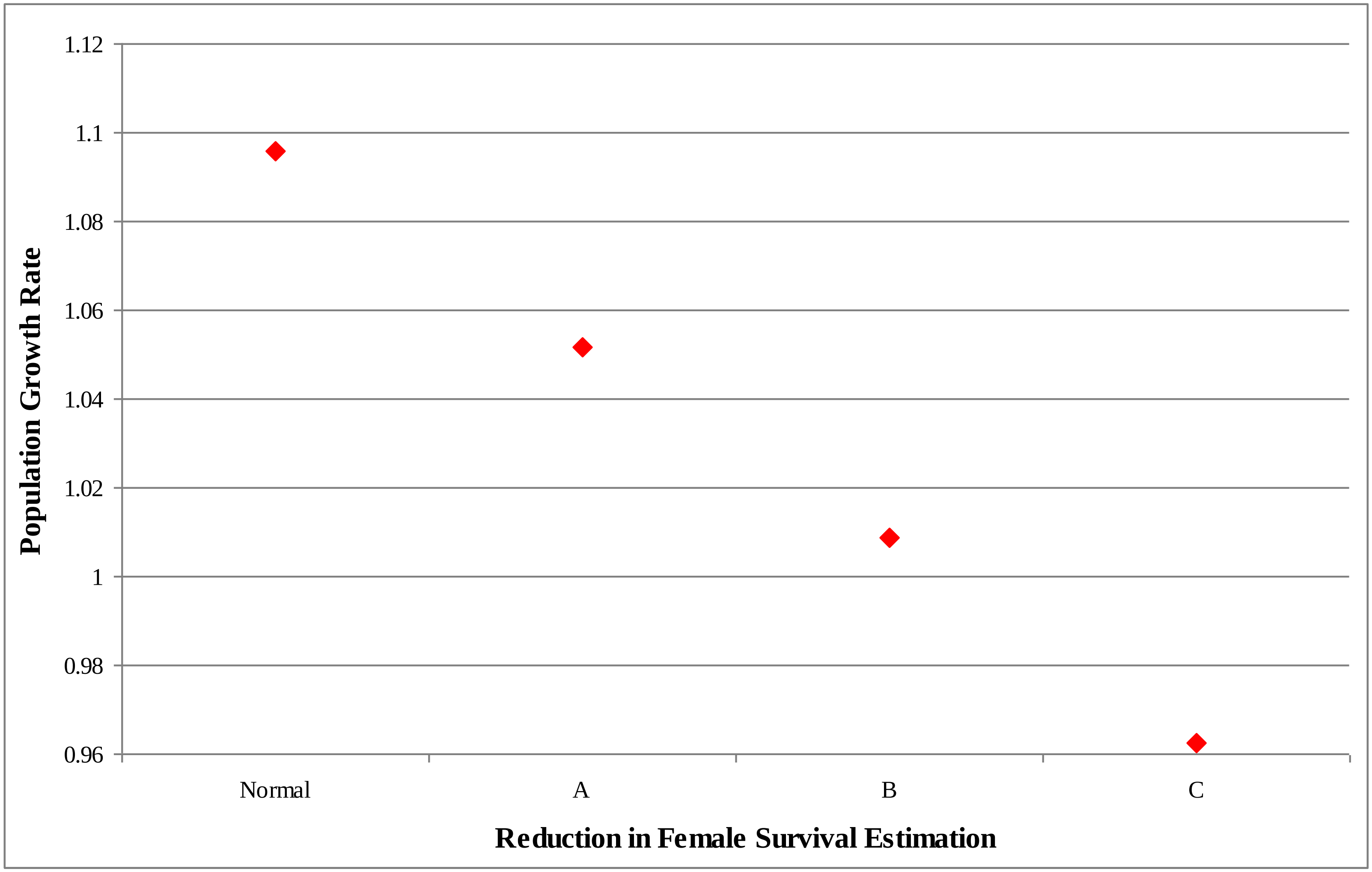

1.12
1.1
1.08
1.06
1.04
1.02
1
0.98
Population Growth Rate
0.777
0.76
0.74
0.72
0.70
0.68
0.66
0.64
0.62
0.60
0.58
0.56
0.54
0.52
0.50
0.48
Subadult Female Survival Rate



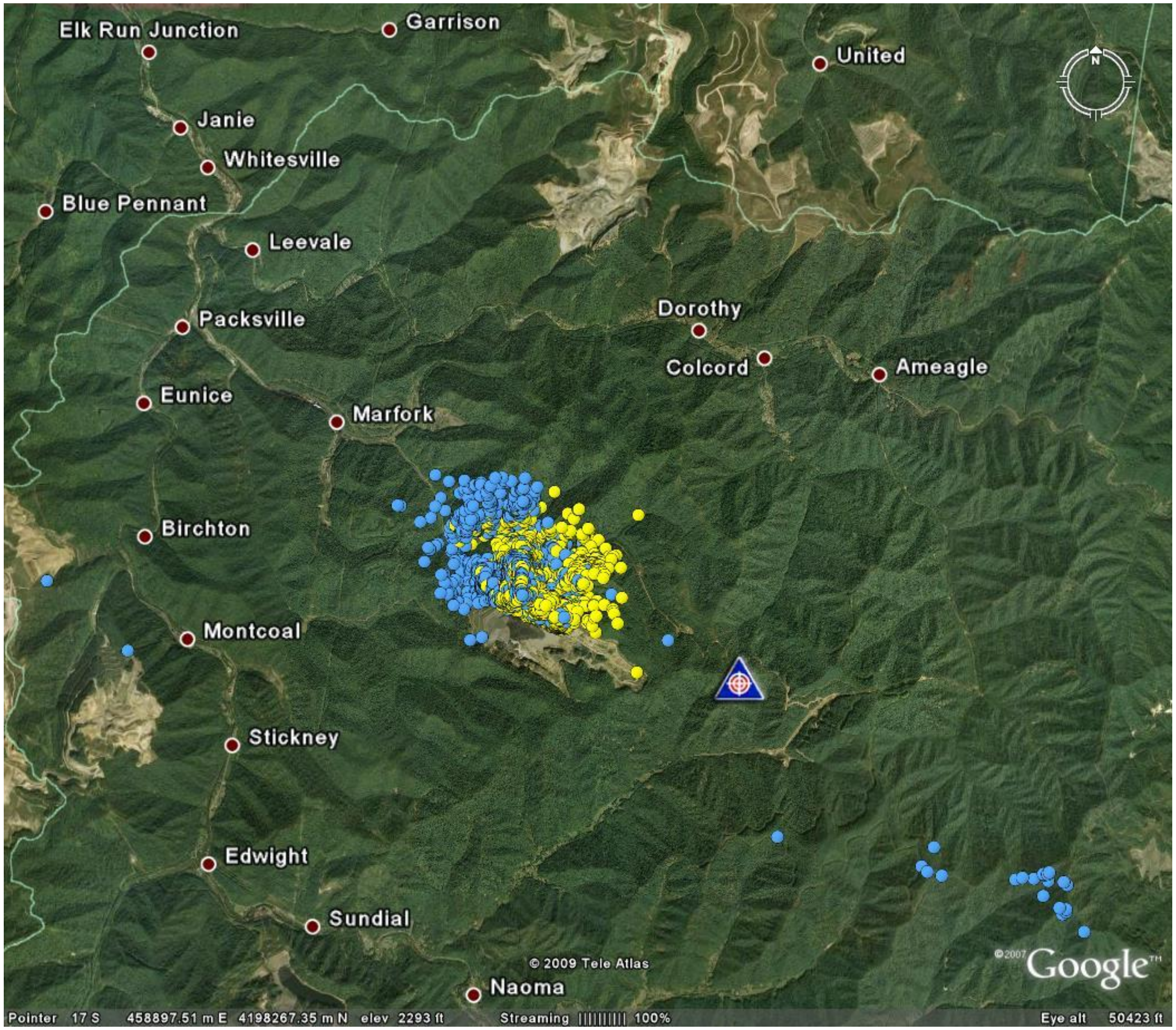
1.12
1.1
1.08
1.06
1.04
1.02
1
0.98
Population Growth Rate
0.769
0.74
0.72
.70
0.68
0.66
0.64
0.62
.60
0.58
0.56
0.54
0.52
.50
Juvenile Female Survival Rate



1.12
1.1
1.08
1.06
1.04
1.02
1
0.98
Population Growth Rate
Normal
-0.02
-0.04
-0.06
-0.08
Reduction in Female Survival Estimation



1.12
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
Population Growth Rate
Normal
A
B
C
Reduction in Female Survival Estimation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Garrison
United
Janie
Whitesville
Blue Pennant
Leevale
Packsville
Dorothy
Colcord
Ameagle
Eunice
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Birchton
Montcoal
Stickney
Edwight
Sundial
Naoma
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©2007 Google
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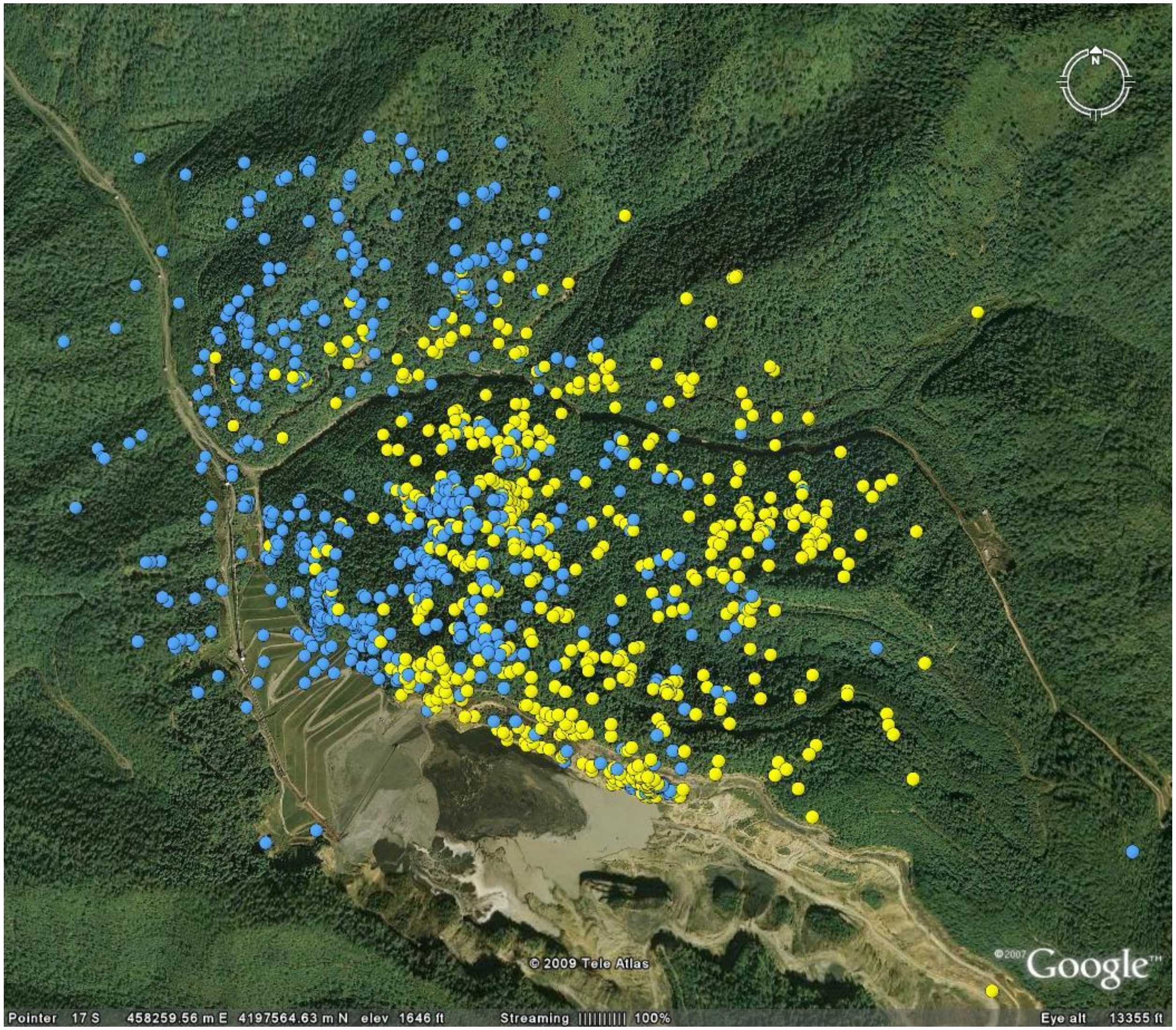
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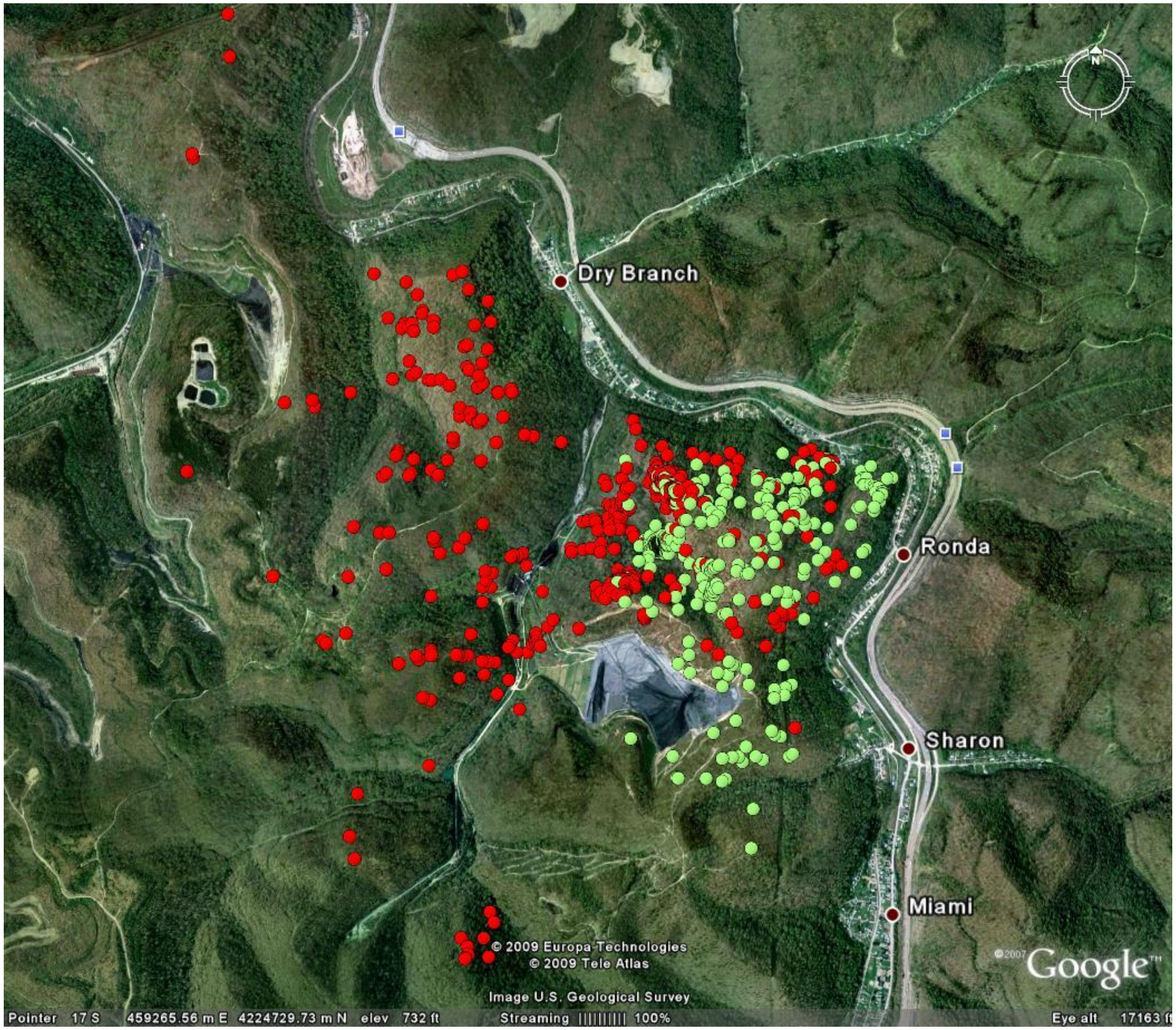
Dry Branch
Ronda
Sharon
Miami
© 2009 Europa Technologies
© 2009 Tele Atlas
Image U.S. Geological Survey
Google
Pointer 17 S 459265.56 m E 4224729.73 m N elev 732 ft
Streaming |||||||||| 100%
Eye alt 17163 ft

Table 1. Black bear parameters used in RISKMAN for population models for two study areas in West Virginia, USA, 1971–2007.

Parameter	Southern	Mountain	Description
Adult 1-cub litters	0.024	0.052	Proportion of black bears ≥ 5-years old with 1-cub litter.
Adult 2-cub litters	0.286	0.284	Proportion of black bears ≥ 5-years old with 2-cub litter.
Adult 3-cub litters	0.524	0.515	Proportion of black bears ≥ 5-years old with 3-cub litter.
Adult 4-cub litters	0.143	0.142	Proportion of black bears ≥ 5-years old with 4-cub litter.
Adult 5-cub litters	0.023	0.007	Proportion of black bears ≥ 5-years old with 5-cub litter.
Subadult 1-cub litters	0.105	0.143	Proportion of black bears 3 or 4-years old with 1-cub litter.
Subadult 2-cub litters	0.632	0.571	Proportion of black bears 3 or4-years old with 2-cub litter.
Subadult 3-cub litters	0.263	0.143	Proportion of black bears 3 or 4-years old with 3-cub litter.
Subadult 4-cub litters	0.000	0.143	Proportion of black bears 3 or 4-years old with 4-cub litter.
Subadult 5-cub litters	0.000	0.000	Proportion of black bears 3 or4-years old with 5-cub litter.
Adult female success	0.97	0.97	Proportion of black bears ≥ 5– years old that were available to reproduce and successfully had cubs.

Table 1 continued.

Parameter	Southern	Mountain	Description
Subadult female success	1.00	0.64	Proportion of female bears 3 or 4-years old that were available to reproduce and successfully had cubs.
Age of primiparity	3	3	Age when at first possible reproduction.
Adult female survival	0.86	0.91	Probability of female black bear ≥5-years old surviving one year.
Subadult female survival	0.76	0.77	Probability of female black bear 3 or 4-years old surviving one year.
Juvenile female survival	0.84	0.77	Probability of female black bear 1 or 2-years old surviving one year.
Adult male survival	0.79	0.63	Probability of male black bear ≥ 5-years old surviving one year.
Subadult female survival	0.78	0.45	Probability of male black bear 3 or 4-years old surviving one year.
Juvenile female survival.	0.41	0.29	Probability of male black bear 1 or2-years old surviving one year.

Table 2. A priori models and model selection explaining synchronous reproduction black bear reproduction in West Virginia, USA.

Description	AICc	Delta AICc	AICc weights	No. Parameters
Mast	-7.73	0.00	0.30	2
Mast lag one year	-7.68	0.05	0.30	2
Population size	-7.51	0.22	0.27	2

Table 3. A priori models[a] and model selection of known fate female black bear survival in northern West Virginia, USA, June 1991–December 2007 with Delta $QAIC_c \leq 5.00$.

Model	**Description**	**Delta $QAIC_c$**	**$QAIC_c$**	**AIC_c weights**	**Model likelihoods**	**No. parameters**
2	Age3	290.555	0.000	0.495	1.000	3
3	Age3 + Mast	292.354	1.800	0.201	0.407	4
8	.	292.571	2.017	0.181	0.365	1

[a] Estimate of overdispersion was 1.23. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and 5+ years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and 5+ years old (Age5); mast failures that occurred in 1997 and 2002 (Mast); where all parameters are constant (.); and differences in over time (Time).

Table 4. A priori models[a] and model selection of female black bear survival in southern West Virginia, USA, June 1996–December 2007 with Delta $QAIC_c \leq 5.00$.

Model	**Description**	**$QAIC_c$**	**Delta $QAIC_c$**	**AIC_c weights**	**Model likelihoods**	**No. parameters**
3	ES + Age3	274.217	0.000	0.508	1.000	5
8	ES	276.807	2.590	0.139	0.274	2
5	ES + Age3 + Mast	277.233	3.016	0.112	0.221	9

[a] Estimate of overdispersion was 1.03. Models generated using the known fate model in Program MARK. Models parameters included: early hunting seasons that occurred 2002–2007 (ES); combined age structure of 1 and 2-year olds, 3 and 4-year olds, and 5+ years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and 5+ years old (Age5); research, nuisance black bears translocated, and nuisance black bears not translocated (Group); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

Table 4 continued.

[c] Recapture probability.

[d] Reporting probability.

[e] Fidelity.

Table 5. A priori models[a] and model selection of female black bear survival in northern West Virginia, USA, June 1991–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
2	s(Age3)r(.)p(.)f(.)	1022.98	0.00	0.70	1.00	6
3	s(Age5)r(.)p(.)f(.)	1024.68	1.70	0.30	0.43	8

[a] Estimate of overdispersion was 1.03. Models generated using the Burnham model in Program MARK. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥ 5 years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and ≥ 5years old (Age5); constant (.); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

Table 6. A priori models[a] and model selection of female black bear survival in southern West Virginia, USA, June 1996–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
2	s[b](Age3)r[c](Group)p[d](Group)f[e](Group)	954.771	0.000	0.321	1.000	12
13	s(Group)r(Group)p(Group)f(Group)	954.831	0.060	0.311	0.970	12
6	s(Age3 + ES)r(Group)p(Group)f(Group)	954.956	0.185	0.292	0.912	15

[a] Estimate of overdispersion was 1.03. Models generated using the Burnham model in Program MARK. Models parameters included: early hunting seasons that occurred 2002–2007 (ES); combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥ 5 years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and ≥ 5years old (Age5); research, nuisance black bears translocated, and nuisance black bears not translocated (Group); constant or time and group (.); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

Table 6 continued.

[d] Recapture probability.

[e] Fidelity.

Table 7. A priori models[a] and model selection of male black bear survival in northern West Virginia, USA, June 1991–December 2007 with Delta $QAIC_c \leq 5.00$.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
5	s[b](Age3)r[c](Group)p[d](Group)f[e](Group)	1262.009	0.000	0.674	1.000	9
9	s(Age5)r(Group)p(Group)f(Group)	1264.318	2.308	0.213	0.315	11
4	s(Age3 + Group)r(Group)p(Group)f(Group)	1265.704	3.695	0.106	0.158	12

[a] Estimate of overdispersion was 1.19. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and 5+ years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and 5+ years old (Age5); research or nuisance (Group); mast failures that occurred in 1997 and 2002 (Mast); where all parameters are constant (.); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

Table 7 continued.

[e] Fidelity.

Table 8. A priori models[a] and model selection of male black bear survival in southern West Virginia, USA, June 1996–December 2007 with Delta $QAIC_c \leq 5.00$.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
5	s[b](Age3 +ES)r[c](Group)p[d](Group)f[e](Group)	967.619	0.000	0.871	1.000	15
4	s(Age3)r(Group)p(Group)f(Group)}	971.618	3.999	0.118	0.135	12

[a] Estimate of overdispersion was 1.34. Models generated using the Burnham model in Program MARK. Models parameters included: early hunting seasons that occurred 2002–2007 (ES); combined age structure of 1 and 2-year olds, 3 and 4-year olds, and 5+ years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and 5+ years old (Age5); research, nuisance black bears translocated, and nuisance black bears not translocated (Group); constant or time and group (.); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

West Virginia residents' attitudes and opinions toward American black bear hunting

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Abstract: American black bear (*Ursus americanus*) hunting has come under close scrutiny over the past decade. As black bear populations have increased and expanded, wildlife agencies have been faced with new challenges on how to set population and harvest goals. Wildlife agencies have altered proposed regulations or have had seasons entirely stopped because of public opposition, necessitating a proactive approach to wildlife management based on a scientific understanding of public opinion rather than reactive decision-making in response to public resistance. In November–December 2006, we conducted a telephone survey of 1,206 West Virginia residents to determine their opinions and attitudes toward black bear populations and hunting seasons and to help strengthen the state's black bear management strategies. Although the majority of West Virginians, nearly 3 of 4 respondents in this study, indicated they know at least something about black bears in West Virginia, there were significant regional differences in the public's assessment of their knowledge of the species. Although most respondents thought the black bear population size was "about right," again, there were regional differences among

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respondents. In general, most respondents supported black bear hunting if the population was carefully monitored, if they knew the population was stable, or both; however, a number of regional and sociodemographic characteristics appeared to influence public opinion on black bear hunting and hunting seasons in the state, and support for specific seasons varied considerably according to hunting method. Interestingly, our study found that, even among hunters, public opposition exceeded support for the current, year-round training season of black bear hunting dogs without harvesting animals in the state. Although it is important for wildlife managers to consider human dimensions and public opinion data in conjunction with biological data when making management decisions, we demonstrate that it also is important for managers to consider regional and sociodemographic differences with respect to attitudes and opinions when making management decisions and population objectives.

Key words: American black bear, attitudes, dogs, hunting, management, public opinion, *Ursus americanus*, West Virginia

Ursus 20(2):000−000 (2009)

In West Virginia, the West Virginia Division of Natural Resources (WVDNR) manages American black bear (*Ursus americanus*) harvest by setting bag limits, season lengths, and weight limits of legal cubs, and by using gates to control access to public lands. Black bear harvests in West Virginia have increased since record keeping began in the late 1960s, and harvest data have been the major information tool used to manage populations (Ryan et al. 2004). The WVDNR makes management recommendations at the management unit level but generally considers 6 geographical regions for black bear management within West Virginia: Eastern Panhandle, Mountain, Central, Southern Study Area, Coal Fields, and Western (Fig. 1). Historically, black bear hunting was restricted to the Mountain region during either an archery season without bait in October and November or a gun season using dogs in December. However, as black bear populations expanded, a 5-week statewide archery season and a firearms season in which using dogs were prohibited in certain counties during November and or December was initiated. In 2002, the WVDNR enacted an early gun season using dogs and a concurrent gun season without dogs during the opening week of white-tailed deer (*Odocoileus virginianus*) gun season in selected counties. Specific seasons were proposed and set primarily based on the expertise of wildlife biologists and without scientific survey data of public opinion.

Further complicating black bear management decisions in West Virginia are the state's regulations for training dogs to chase black bear without harvesting the animal. Beginning in 1951, it became unlawful to train dogs to chase black bear between 1 May and 15 August throughout West Virginia; however, dogs could be trained on private lands with written permission from the landowner and on public lands at any time. In 1974, due to declining black bear populations, the West Virginia State Legislature enacted a restriction on dog training from the end of small game hunting season through 24 August in the 10 traditional black bear hunting counties. In 1997, the Legislature changed dog training laws to allow residents to train their dogs statewide throughout the year. This change in legislation, enacted with limited research on public attitudes toward dog training, resulted in user conflicts on high-use recreation areas (wildlife management areas, state forests, and national forest lands) during the summer months. In addition, the WVDNR also received complaints from private landowners experiencing problems with black bear hunters during the summer training season.

Differing attitudes, cultural carrying capacity, and land ownership patterns within the state were not fully considered in West Virginia's black bear management strategy before 2007 because the majority of the black bear population was confined to its historical range. Wildlife biologists believed that public opinion concerning black bears and black bear hunting was homogenous across the historic range, and biologists were never concerned with the rest of the state because of the few black bears living outside of this historical range. However, due to black bear population increase and range expansion, managers have since determined that statewide stakeholder input should be considered in future management decisions. Further, because attitudes toward black bear management and conservation practices may be clustered differently within a state or regions (Morzillo et al. 2007), agencies should also take these differences into consideration for regulation proposals.

Regional differences in attitudes (Morzillo et al. 2007) may lead to public conflict and controversy that limit the use of black bear management actions on a statewide basis. As an example, during a 2004 referendum vote in Maine, only 3 of 16 counties passed a measure that would have severely restricted black bear management activities and seasons (Vashon and Cross 2005). All 3 counties were in urban, southern Maine where black bears were uncommon. However, the measure was only marginally defeated statewide by a vote of 53–47% (Vashon and Cross 2005). Attitudes toward black bear management practices may also differ based on level of participation in wildlife-related recreation and sociodemographic characteristics (Teel et al. 2002). Support for traditional wildlife management activities is often found to be stronger among hunters, rural residents, and people with low educational attainment (Manfredo et al. 1997, Teel et al. 2002). Multiple studies have found that opposition to traditional wildlife management practices is more prevalent among women than among men (Kellert and Berry 1987, Hooper 1994, Manfredo et al. 1997, Teel et al. 2002). Understanding both regional and sociodemographic differences in public attitudes will enable managers to better develop management recommendations.

In making informed management decisions, it is imperative to not only to consider biological data but also to take into account public opinion. Different methods have been employed by state agencies to gather public opinion on their black bear management plans, with most attempting to identify regional or stakeholder differences that may influence management decisions. Some agencies have relied solely on input from stakeholder surveys. For example, the Maryland Department of Natural Resources commissioned a statewide survey to gather input from a cross-section of residents (Maryland Department of Natural Resources 2004, Responsive Management 2004). Utah State University used a telephone survey to identify different stakeholders' attitudes toward selected black bear and mountain lion (*Puma concolor*) management practices (Teel et al. 2002). Other states developed more extensive mechanisms to help managers identify opinions on black bear management among regions and stakeholder groups. For example, the Virginia Department of Game and Inland Fisheries used a stakeholder approach in 2002 (Lafon et al. 2004) that incorporated focus groups with various perspectives, from the Virginia Bear Hunters Association to the People for the Ethical Treatment of Animals. The New York State Department of Environmental Conservation (NYDEC) sponsored an extensive situation analysis to assess stakeholder-defined impacts as the focus of their bear management plan (NYSDEC 2003). Public input for the plan included nominal group meetings in 3 regions of the state, a statewide mail survey (Siemer and Decker 2003), and regional implementations of a new stakeholder input group (SIG) process that convened a diverse array of 12–15 stakeholders to deliberate about regional concerns regarding and interests in black bears (Siemer and Decker 2006).

Recognizing the importance of public attitudes regarding black bear management and hunting regulations in West Virginia, we assessed public opinion on attitudes toward black bear populations, black bear management, black bear hunting, and training for black bear hounds. Although some research exists regarding public opinion on black bear management and black bear hunting (Teel et al. 2002, Siemer and Decker 2003, Responsive Management 2004, Morzillo et al. 2007), there is limited research on differences in public attitudes toward black bears and black bear management based on regional or sociodemographic characteristics. In this study, we analyzed results on both a statewide and regional basis to further delineate regional differences in public attitudes and demonstrate the importance of taking regional data into consideration when setting management or population goals. In addition, we examined how human demographics relate to acceptance of black bear hunting. Our objective was to identify West Virginia residents' attitudes and opinions, to determine the regional and sociodemographic nuances that affect public opinion on black bear management issues, and ultimately, to provide wildlife management professionals a springboard for developing effective management recommendations based on a better understanding of the public they serve.

Methods

Telephone survey

We designed a telephone survey to assess residents' opinions on and attitudes toward black bear populations, black bear management in the state, black bear hunting, and training for black bear hounds. Telephone surveys are currently the most reliable method for accurately assessing the general population, because almost everyone in the US has a telephone (Belinfante 2009). The questionnaire was pre-tested with a representative sample of West Virginia residents and refined for survey implementation.

Sample size and selection

Responsive Management surveyed West Virginia residents age 18 years and older using random digit dialing (RDD) to collect data representative of the general population and to ensure that each resident had an equal chance of being selected, in accordance with the standard telephone survey methodology guidelines established by Dillman (1978). A statewide random selection of household telephone numbers was obtained from Survey Sampling International (Shelton, Connecticut, USA), a global survey sample provider. Responsive Management used the last-birthday method for within-household respondent selection, one of the most common selection methods used for telephone surveys (Gaziano 2005) because it is minimally intrusive and has a relatively high accuracy rate (Lind et al. 2000). Although Responsive Management currently obtains wireless telephone numbers to reach elusive populations and further ensure the representativeness of the sample population, wireless telephone numbers were not used to supplement the sample in this study. However, a study conducted by Pew Research Center (2006) during the same year suggested that excluding US residents without landline telephone service had little impact on telephone survey results (see also Hudenko et al. 2008).

We designed the study to achieve a 95% confidence interval with a maximum sampling error of 2.82 percentage points for the total population of West Virginia residents, age 18 and older. Responsive Management completed a total of 1,206 telephone interviews with West Virginia residents age 18 and older (n = 1,206 for all study results).

Survey implementation

Responsive Management maintains its own centrally located, in-house telephone interviewing facilities. These facilities are staffed by professional interviewers trained according to standards established by the Council of American Survey Research Organizations. Further, because Responsive Management specializes in researching public opinion on natural resource issues, interviewers conduct surveys only on these issues and understand the nuances involved in conducting the interviews.

In-depth project briefings were conducted with the interviewing staff prior to their work on this study to reinforce consistency among the interviewers. Interviewers were instructed on survey goals and objectives, the type of study, handling of survey questions, interview length, termination points and qualifiers for participation, reading of interviewer instructions, reading of the survey, reviewing of skip patterns for questions that do not apply based on a previous response (for example, if a respondent indicates that he or she does not hunt a particular species, skip patterns ensure that the respondent is not asked these additional), and probing and clarifying techniques necessary for specific questions on the survey. Telephone workstations were closely monitored to maintain strict quality control over the data collection process, and researchers checked each completed survey for clarity, understanding, completeness, and format.

Interviews were conducted Monday–Friday, 9:00 am–9:00 p.m., Saturday, noon–5:00 pm, and Sunday, 5:00–9:00 pm, local time in November and December 2006. A 5-callback design was used to maintain the sample framework, avoid bias toward people easy to reach by telephone, and provide an equal opportunity for all to participate.

Data collection

Responsive Management conducted the telephone interviews and entered responses using Questionnaire Programming Language 4.1 (QPL) software, a comprehensive system for computer-assisted telephone interviewing that provides complete capabilities for designing, administering, and managing telephone-based research operations. The survey instrument was programmed to automatically skip, code, and substitute phrases in the survey based on responses, as necessary, for the logic and flow of the interview. Survey data were entered into the computer as each interview was conducted, thereby eliminating potential subsequent data-entry errors.

Data analysis

We analyzed data using Statistical Package for the Social Sciences 11.5 (SPSS, Chicago, Illinois, USA) software as well as proprietary software developed by Responsive Management. Post-stratification (Pedhazur and Schmelkin 1991) was used to ensure appropriate weighting of the results during analysis. For data analysis, we divided the state into 6 regions. Criteria used for regional segmentation included human population densities, input from WVDNR biologists, hunting methods, and black bear harvests (Fig. 1). We analyzed results on statewide, regional, and hunter versus non-hunter basis. During data analysis, results were weighted so that the proportion of the sample among the counties matched the distribution of the population statewide. Survey results were analyzed to obtain descriptive statistics as well as to examine relationships among variables. We assessed differences from expectations using Pearson χ^2 cross-tabulations of survey results.

Results

Nearly 1 in 4 respondents (23%) said they knew a “great deal” or “moderate amount” about black bears in West Virginia; just over half (51%) said that they knew “a little,” while 26% said they knew “nothing” about West Virginia black bears. Self-professed knowledge was highest (responded “a great deal”) in the Mountain and Southern Study Area regions and among hunters.

Respondents who stated they knew at least a “moderate amount” about black bears were more likely to have hunted ($\chi^2 = 82.700$, 1 df, $P < 0.001$), to think the black bear population should be increased ($\chi^2 = 32.407$, 1 df, $P < 0.001$,), and to be male ($\chi^2 = 31.966$, 1 df, $P < 0.001$)

than respondents that did not proclaim that they knew at least a “moderate amount” about black bears. Respondents who said they knew “little” or “nothing” about black bears were more likely not to have hunted ($\chi^2 = 72.321$, 1 df, $P < 0.001$), to oppose having black bears within 1.6 km of their home ($\chi^2 = 34.902$, 1 df, $P < 0.001$), and to be female ($\chi^2 = 34.638$, 1 df, $P < 0.001$) than respondents that did not answer that they knew “little” or nothing about black bears.

One in 20 (5%) respondents experienced problems with nuisance black bears within the last 2 years. The most common complaint involved black bears disturbing trash (42%) and bird feeders (14%), and miscellaneous damage to structures or fencing around their homes. Respondents in the Southern Study Area, Mountain, and Coal Field regions had the highest percents (9%, 7%, and 7%, respectively) of nuisance complaints; the Western and Eastern Panhandle regions had the lowest percents (1% and 2%, respectively).

A majority of respondents (65%) thought that the WVDNR had done a “good” or “excellent” job of managing black bears, 17% thought that WVDNR had done a “poor” or “fair” job, and 18% answered “don’t know.” More hunters (73%) than non-hunters (63%) thought the WVDNR had done a “good” or “excellent” job managing black bears.

Black bear population

Most respondents (38%) thought the black bear population was “about right,” 17% thought it was “too low,” 11% thought it was “too high,” and 33% answered “don’t know.” In a similar question, nearly half (43%) of respondents thought the black bear population should remain the same size, 20% thought it should be increased, 13% thought it should be decreased, and 24% answered “don’t know.” On a regional basis, respondents who thought the black bear population was “about right” varied from 29% in the Western region to 46% in the Eastern Panhandle and Southern Study Area regions.

The Mountain region had the highest percentage of respondents (23%) who thought the black bear population should be decreased, whereas only 6% of the Eastern Panhandle and Central region respondents thought the black bear population should be decreased. At least 20% of respondents in the Eastern Panhandle (22%), Coal Fields (20%), Western (22%), and Central (21%) regions thought that black bear population should be increased (Fig. 2).

Respondents who thought the black bear population was "about right" were more likely to think that the WVDNR had done a "good" or "excellent" job of managing black bears ($P < 0.001$, $\chi^2 = 79.847$, df = 1), to support regulated hunting if they knew the population as a whole was stable ($P < 0.001$, $\chi^2 = 24.985$, df = 1), and to think they knew a moderate or great deal about black bears ($\chi^2 = 19.139$, 1 df, $P < 0.001$) than respondents that did not think the black bear population was "about right."

Respondents who answered that the black bear population was "too high" were more likely to have suffered property damage from black bears within the 2 years prior to the survey ($\chi^2 = 70.408$, 1 df, $P < 0.001$), to think the WVDNR had done a poor or fair job of managing black bears ($\chi^2 = 67.412$, 1 df, $P < 0.001$), and to support a number of different hunting seasons ($\chi^2 = 24.337$, 1 df, $P < 0.001$) than respondents who did not think the black bear population was "too high." Respondents who wanted the black bear population increased rather than decreased or maintained were more likely to support having black bears within 1.6 km of their home ($\chi^2 = 123.172$, 1 df, $P < 0.001$), to be male ($\chi^2 = 61.006$, 1 df, $P < 0.001$), and to have hunted in West Virginia in the past 12 months ($\chi^2 = 50.974$, 1 df, $P < 0.001$). Hunters (34%) were more likely to want the black bear population increased than non-hunters (16%).

Black bear hunting seasons

Most respondents (77%) supported black bear hunting if they knew that the WVDNR carefully monitored the population (χ^2 = 321.535, 1 df, P < 0.001), and 71% would support black bear hunting if they knew the population was stable (χ^2 = 276.898, 1 df, P < 0.001). Hunting supporters also were more likely to be male (χ^2 = 94.378, 1 df, P < 0.001) and to have hunted in West Virginia in the past 12 months (χ^2 = 81.705, 1 df, P < 0.001; Fig. 3) than opponents. The primary reason given for supporting black bear hunting was population control (Fig. 4). Non-hunters primarily opposed black bear hunting (54%) because they were opposed to hunting in general or because of their belief in animal rights (χ^2 = 16.022, 1 df, P < 0.001), whereas hunter opposition to black bear hunting (38%) was because they did not think the population was high enough (χ^2 = 50.331, 1 df, P < 0.001).

The majority of respondents supported the hunting of black bear with a gun without dogs and bait (77%), or bows without bait (60%). However, approval was lower for hunting black bears using dogs (23%), with a gun over bait (16%), or with a bow over bait (15%). A large majority of respondents in each region opposed hunting black bears using dogs or bait. Although opposition was higher among non-hunters for hunting with dogs (71%) or bait (82%), a majority of hunters also opposed the use of dogs (57%) or bait (72%).

A majority of respondents opposed (56%) rather than supported (28%) creating a spring black bear season; hunters (52%) also opposed creating a spring season.

Respondents who opposed black bear hunting would still do so even if they knew the WVDNR monitored the population (χ^2 = 327.333, 1 df, P < 0.001) and that the population was stable (χ^2 = 226.890, 1 df, P < 0.001). Opponents also were more likely than supporters of black bear hunting seasons to have not hunted in West Virginia in the 12 months prior to the survey (χ^2 = 31.785, 1 df, P < 0.001), to be female (P < 0.001, χ^2 = 27.293, df = 1), to have at least a bachelor's degree (χ^2 = 14.076, 1 df, $P < 0.001$), not to own land in West Virginia (χ^2 = 6.930, 1 df, $P < 0.01$), and to have a pre-tax income >$80,000 ($\chi^2$ = 5.035, 1 df, $P < 0.05$). In addition, they were more likely than supporters to oppose all hunting methods proposed in the survey (χ^2 = 137.034, 1 df, $P < 0.001$), and to think it is acceptable to feed white-tailed deer (χ^2 = 5.351, 1 df, $P < 0.05$).

Respondents who owned land were more likely to support regulated black bear hunting if the population was stable (χ^2 = 41.808, 1 df, $P < 0.001$) and the WVDNR monitored the population (χ^2 = 131.892, 1 df, $P < 0.001$) than if they did not have any knowledge about the black population or WVDNR monitoring program. Moreover, they were more likely to have a bachelor's degree but no graduate degree (χ^2 = 13.314, 1 df, $P < 0.001$), to have had problems from black bears in the 2 years prior to the survey (χ^2 = 12.381, 1 df, $P < 0.001$), and to be male (χ^2 = 11.872, 1 df, $P < 0.001$) than respondents who did not own land.

Respondents who did not own land were more likely than respondents that owned land to oppose black bear hunting even if they knew the population was stable (χ^2 = 36.642, 1 df, $P < 0.001$) or if WVDNR monitored the population (χ^2 = 14.604, 1 df, $P < 0.001$). They were also more likely than respondents who owned land to consider their place of residence to be a large city, urban area, or suburban area (χ^2 = 22.057, 1 df, $P < 0.001$), to be below the median age of 52 (χ^2 = 10.097, 1 df, $P < 0.001$), to have not hunted in West Virginia in the year prior to the survey (χ^2 = 9.895, 1 df, $P < 0.01$), and to be female (χ^2 = 9.534, 1 df, $P < 0.01$).

Dog training season

Opposition (61%) exceeded support (28%) for the current year-round training season of black bear hunting dogs without harvesting animals. The most common reasons for opposing year-round dog training on black bears was a general opposition to hunting with dogs (67% of those opposed) or the belief that it disturbs black bears (19% of those opposed). The most common responses for supporting a year-round training season were that there is no reason to oppose it (46% of those supporting) or that training increases hunting success and that dogs need to be trained (27% of those supporting). A majority of hunters also opposed year-round training seasons; however, support was higher among hunters than among non-hunters.

Only a small number of respondents (4%) had experienced problems resulting from the year-round training of black bear hunting dogs. The most common problems were trespassing, a general disturbance or nuisance, disturbance of wildlife, or threat to people or livestock. Mountain region respondents were more likely to have had problems resulting from the training of dogs than other regions.

Respondents who opposed year-round training of dogs were more likely to oppose any black bear hunting season ($\chi^2 = 88.002$, 1 df, $P < 0.001$), to disagree that it is acceptable to feed white-tailed deer ($\chi^2 = 25.259$, 1 df, $P < 0.001$), to oppose regulated hunting of black bears if they knew the population was stable ($\chi^2 = 17.609$, 1 df, $P < 0.001$), and to have had problems resulting from the training of dogs ($\chi^2 = 17.378$, 1 df, $P < 0.001$) than those who supported year-round training. Supporters of a year-round training season were more likely to support all hunting methods for black bears ($\chi^2 = 72.877$, 1 df, $P < 0.001$), to agree that it was acceptable to feed white-tailed deer ($\chi^2 = 35.875$, 1 df, $P < 0.001$), and to be male ($\chi^2 = 31.235$, 1 df, $P < 0.001$).

Discussion

The majority of West Virginians sampled believed they have at least a general awareness of black bears in the state, with nearly 3 of 4 respondents in this study indicating they know at least something about black bears in West Virginia. There were also regional differences in the public's assessment of their knowledge of the species: respondents of the Mountain and Southern Study Area regions claimed to have known more about black bears than those from other regions. These regions had the highest estimated black bear populations, and the WVDNR has a large-scale research and monitoring program in each region that receives considerable media coverage. In addition, WVDNR routinely has more requests and gives more public talks concerning black bears in these regions. The combination of a higher black bear population, resulting in possible black bear–human interactions, and increased outreach and communication efforts in these regions may have led respondents to the conclusion that they know at least a moderate amount about black bears.

Attitudes toward predator management often form bimodal or even trimodal distributions, with opinions of strong support or opposition (Teel et al. 2002). Bimodal distributions of opinions present managers with unique challenges on how to incorporate public input into management strategies. In the present study, respondents with strong support for management programs were more likely to have hunted, whereas the majority of respondents opposed to regulated black bear hunting were against hunting in general or had strong animal rights beliefs. Conducting surveys and public involvement meetings may help to identify areas where managers have the most opposition to proposals. Furthering public education or stakeholder involvement may help break down these barriers and make approval of hunting regulations easier.

Black bear population

In our study, a majority of respondents said the black bear population was "about right"; however, there were regional differences related to respondents' attitudes toward WVDNR performance in managing black bears and the population size. In this study, more respondents from regions with higher black bear harvests, higher estimated black bear populations, and more nuisance complaints wanted the population decreased rather than increased. Similarly, respondents of the neighboring state of Maryland expressed differing regional opinions toward black bear populations and management (Responsive Management 2004). Maryland respondents living in the western region of the state, the area with the highest black bear population and harvest (Spiker 2008), also thought that the black bear population was too high compared with other regions in the state (Responsive Management 2004).

These findings suggest that residents who experience damage from black bear or other carnivores may develop a negative view of these species and therefore may be more likely to respond that the population is too high. In other examples, Wisconsin citizens reporting loss from wolves (*Canis lupus*) or other predators were more likely to favor reducing or eliminating Wisconsin's wolf population (Naughton-Treves et al. 2003). Rural landowners in northwestern Minnesota had negative attitudes toward wolves and felt they were a threat to their livelihood (Chavez et al. 2005). Arizona residents living adjacent to Saguaro National Park favored mountain lion protection on private and public land, but 69% thought mountain lions should be trapped or shot after causing problems that affected humans (Casey et al. 2005). Respondents in Montana who desired decreased mountain lion populations were more likely to have negative attitudes toward mountain lions and to have perceived that mountain lion populations were increasing (Riley and Decker 2000). Although both of the regions in Maryland and West Virginia experiencing the highest number of nuisance black bear complaints had lower human population densities, survey data demonstrate that the black bear population may have reached its cultural carrying capacity and respondents wanted the population reduced or stabilized.

Black bear managers who set population or harvest objectives based on cultural carrying capacity are faced with difficult challenges when survey data indicate that respondents want the population increased in their region but there is limited suitable habitat. The population in the Western and Eastern Panhandle regions had lower harvests (Ryan 2007) and observations during surveys (Ryan et al. 2006), which may have influenced respondents in these regions: many respondents in these regions wanted the black bear population increased. This was similar to Maryland, where residents in areas with fewer black bear sightings had different views from those from other regions (Responsive Management 2004). Although residents in regions with lower exposure to black bear and fewer black bear sightings may want to increase the black bear population, managers need to consider additional factors such as habitat availability, land-use patterns, and the potential for human–bear conflicts.

There is also a correlation between the public's opinion on black bear management issues and their confidence in wildlife management agencies and personnel. Gore et al. (2007) identified agency capacity (trust, responsiveness, and agents) and individual capacity (seriousness, volition, and frequency) as factors that influence risk perception associated with human–bear conflicts. Although their study focused on specific conflicts, it showed that trust in and responsiveness of wildlife managers was a key component to how the public perceived wildlife situations or conflicts. The majority of respondents in our study that thought the black bear population should remain the same were also more likely to believe that the WVDNR had done a good or excellent job of managing black bears, whereas respondents who thought the black bear population should be increased or decreased believed that the WVDNR had done a poor or fair job managing black bears. Public education programs via media outlets (radio, television, web site, etc.) and other educational programs may help to educate the public about black bears, improve public confidence in a managing agency, and increase the tolerance and cultural carrying capacity of black bears.

Black bear hunting seasons

Many wildlife agencies are currently facing opposition to traditional black bear hunting methods. Maine DNR narrowly defeated a referendum that would have severely limited its ability to manage black bears (Vashon and Cross 2005). Colorado and Oregon lost referenda (Boulay et al. 1999), New Jersey had seasons stopped by political pressure, and Maryland had its management practices challenged in court. Although each of these states had ongoing black bear research projects, they still had considerable opposition to their recommendations, which in most cases came from non-hunters or residents of urban areas (Vashon and Cross 2005).

A majority of respondents in the current study supported regulated black bear hunting when they knew the population was stable and monitored by the WVDNR. Maryland residents also supported (65%) regulated black bear hunting to control populations (Responsive Management 2004). In both surveys, respondents were more likely to support hunting if they knew that the population was stable and that the DNR monitored the population. The ability of wildlife agencies to educate both non-hunters and residents may be a key factor in the success or failure of wildlife management issues when they are voted on by the general public.

The use of dogs to hunt black bears has been a topic of concern for certain groups, especially non-hunters (Teel et al. 2002). In West Virginia, black bear hunting using dogs has been the traditional hunting method to control populations; however, only 23% of respondents in our survey supported this method. Moreover, the majority of hunters also opposed this hunting method. In 1994, Oregon voters eliminated the use of dogs or bait to hunt black bears during a citizen-sponsored ballot, and in 1996 voters rejected a measure that would have repealed the

1994 measure (Boulay et al. 1999). Our results indicate that the WVDNR could lose the use of hounds to hunt black bears as a management tool if it were voted on by the citizens of the state.

In California, supporters of the use of dogs argued that predators, especially mountain lions, can only be successfully harvested using dogs (Beck et al. 1995). Wildlife managers often argue that this is especially true in West Virginia, where baiting or feeding of black bears is illegal. In West Virginia, the large amount of public land (485,622 hectares) and large number of parcels of land over ≥404 hectares provides hunters with adequate access to hunt black bears using dogs while reducing possible confrontations on posted, private land. Boulay et al. (1999) found no change in the statewide composition of harvested black bears in Oregon after hunting with hounds was prohibited. Loss of hunting with hounds may present managers with challenges, however, because the use of hounds is very effective in some areas.

In our study, respondents who opposed the use of dogs were more likely to oppose all other black bear hunting seasons, to have not hunted in West Virginia in the previous year, and to think that the black bear population was too low. However, these respondents were also more likely to think that the WVDNR had done a good or excellent job managing black bears. Bimodal distributions of respondents' answers may appear in wildlife surveys (Teel et al. 2002), and it is likely that opposition to some management methods or hunting seasons were made from respondents who rarely, if ever, contacted the WVDNR to voice their opinion unless specifically asked. In Colorado, 74% of non-hunters with a high interest in wildlife opposed the use of dogs to hunt black bears, whereas fewer than half of hunters opposed the use of dogs (Teel et al. 2002). Education, length of residency, and geographic location of residence were important factors in predicting attitudes toward the use of hounds to hunt black bears in Colorado (Teel et al. 2002). Managers should consider human demographics when proposing regulations for areas that may not be accustomed to hunting seasons.

Respondents in this study who approved the use of dogs were more likely than opponents to support all black bear hunting seasons, to think that the black bear population was too high, to have hunted in West Virginia in the year prior to this study, and to have not personally had problems with the training of hunting dogs. Respondents who approved use of dogs also were more likely to believe that the WVDNR had done a poor or fair job of managing black bears. While hunters may not agree with all types of predator management (Teel et al. 2002), areas with a larger proportion of hunters or numerous nuisance black bears may garner more support for regulation changes to control the population. Wisconsin residents who lost a domestic animal to wolves or other predators were more likely to shoot a wolf when encountered while hunting than residents who had not lost an animal to a predator (Naughton-Treves et al. 2003).

Attitudes toward animals are often influenced by respondent gender (Kellert and Berry 1987). In the current study, females were more likely to oppose regulated hunting of black bears than males. Female residents in Utah were more likely than males to disapprove of black bear hunting and using dogs to hunt black bears (Teel et al. 2002). As citizen participation and input increases in wildlife management, this may be an important factor for managers to consider when making recommendations. Regulations that are supported by predominately male hunters may be subject to extensive challenges if voted on by the general public or through the legislative process.

In our study, landowners were more likely to support black bear hunting than respondents who did not own land. Landowners in Minnesota believed that wolves were a threat to their livelihood (Chavez et al. 2005). Respondents in our study who supported black bear hunting also were more likely to have had problems with black bears in the two years prior to the study. Direct support of black bear hunting may have been influenced by real or perceived nuisance problems with black bears.

Dog training season

Year-round training of dogs used to hunt black bears has been controversial during the past decade in the southern Appalachian Mountains. The WVDNR received complaints concerning the year-round training season and how it may affect wildlife populations; however, at the present time there are no biological data from West Virginia to suggest that this training season negatively impacts black bear populations.

A majority (61%) of respondents in our study opposed the year-round training season. However, only 4% of respondents ever personally experienced any problems from the training of hunting dogs. General opposition to the training of dogs and black bear hunting with dogs, even though the overwhelming majority of respondents had not experienced problems, should be a point of concern for hunters and agencies who allow this method. Allowing the year-round training of dogs may increase the public's opposition to using dogs for the hunting of black bear and other species. If the use of hunting dogs during harvest seasons is taken away from managers, they may have to use alternate, perhaps less effective, methods to manage the black bear population. Moreover, in states or provinces where long training seasons are not legal, managers should carefully consider all options before implementing or extending training seasons because this may result in greater public opposition, which could negatively affect hunters and restrict management options.

Management implications

Wildlife agencies have used numerous methods to incorporate public input or stakeholder involvement into management decisions (Decker et al. 2001) and must continue to find creative ways to initiate stakeholder participation (Burkardt and Ponds 2006). Although no method is perfect in every situation, management goals and decisions based on some form of public involvement should garner greater support. In addition, if the agency's management plan is challenged, they will be more likely to successfully defend their recommendations in court or through the political process if they have completed scientific, legally defensible public opinion research when forming policy recommendations.

Our findings suggest that there are significant regional and sociodemographic differences in public knowledge of black bears and attitudes toward black bear management issues, including black bear populations, black bear hunting, and dog training. Although the majority of West Virginians indicate that they know at least something about black bears in West Virginia, there are significant regional differences in the public's assessment of their knowledge of the species. Further, there are a number of regional and sociodemographic characteristics that appeared to influence public opinion on black bear hunting and hunting seasons in the state. These differences need to be considered when making black bear management decisions.

Successful bear management plans depend not only on biology and ecology but on a corresponding knowledge of socioeconomic factors, public values, and political forces (Kellert 1994). Factors such as gender, participation in hunting, and urban or rural residency have long been known to influence attitudes toward wildlife management. However, wildlife managers must also consider regional differences when gathering public input and opinions, which can be an important factor in the success and acceptance of these management plans. Managers should carefully consider regional differences in attitudes and opinions about wildlife species, especially black bears, where harvest or population objectives are set based on the cultural carrying capacity of the area. Data that are specific to a particular region or management unit may be used to adjust management or population goals. By considering these differences on a management unit or regional basis, managers can better serve the needs of all citizens.

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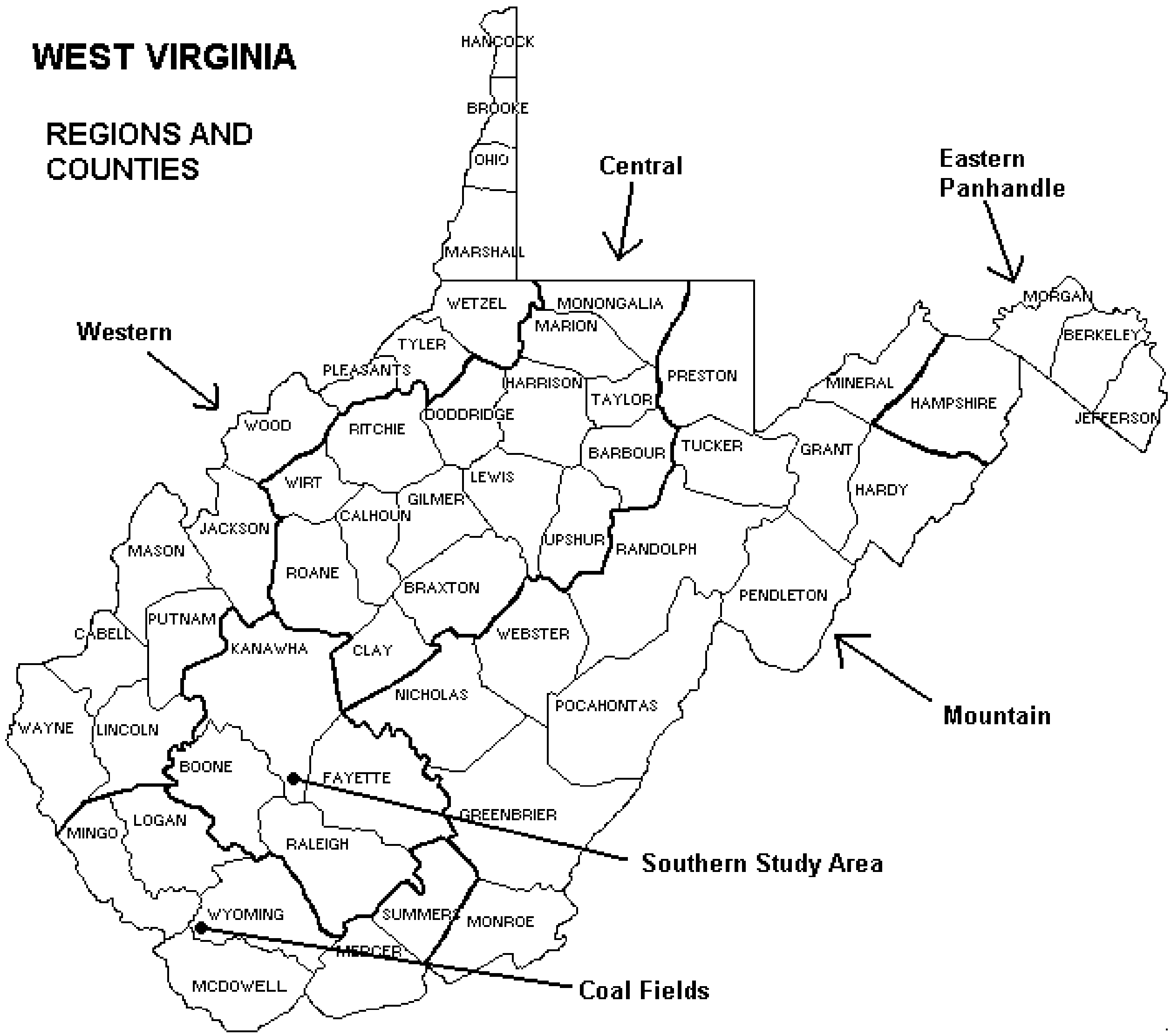
Fig. 1. Regions and counties for a Nov–Dec 2006 survey of West Virginia residents' opinions on black bears and black bear hunting.

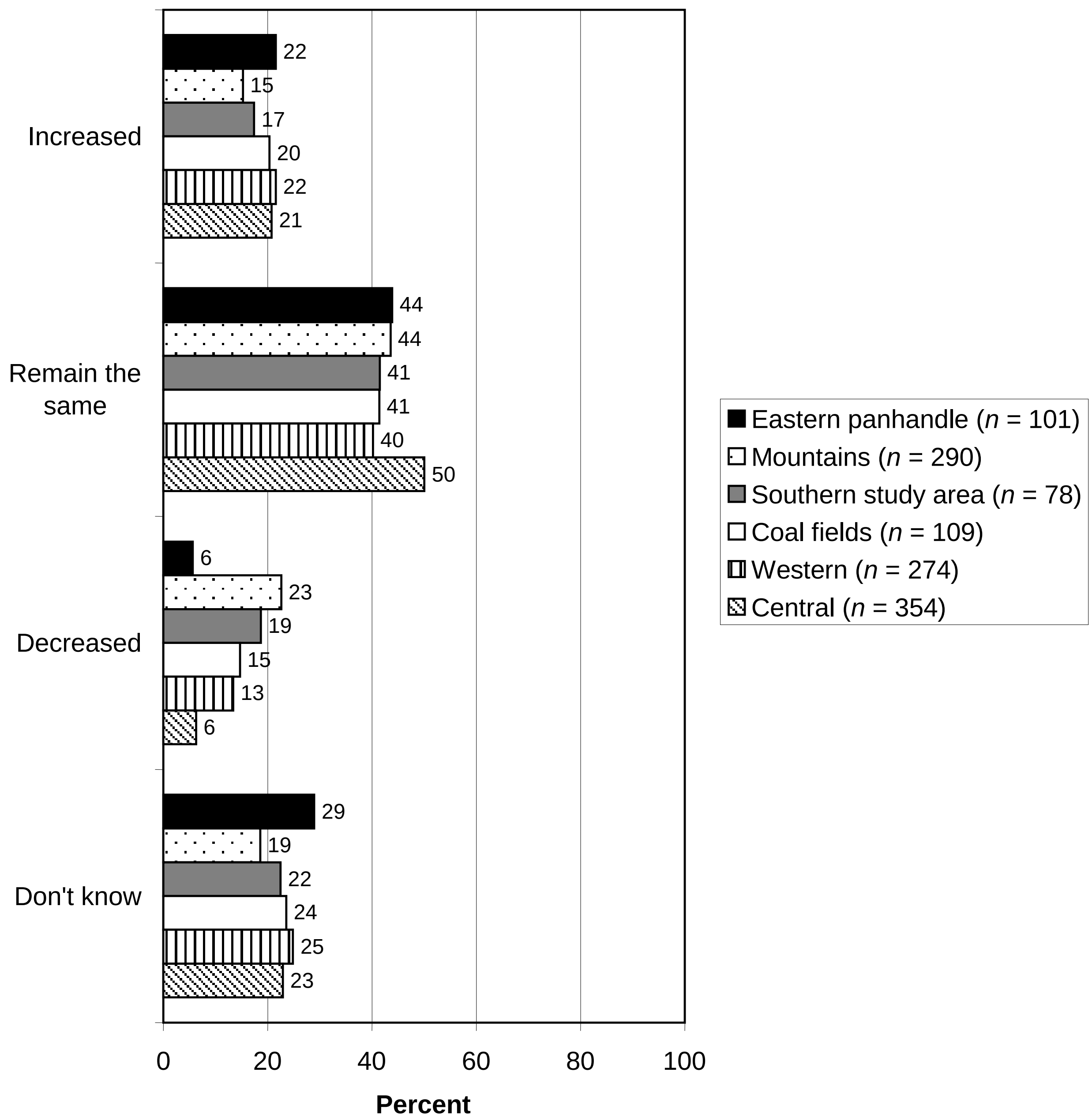
Fig. 2. Respondents' opinions of whether the black bear population should be increased, remain the same, or decreased in West Virginia, 2006.

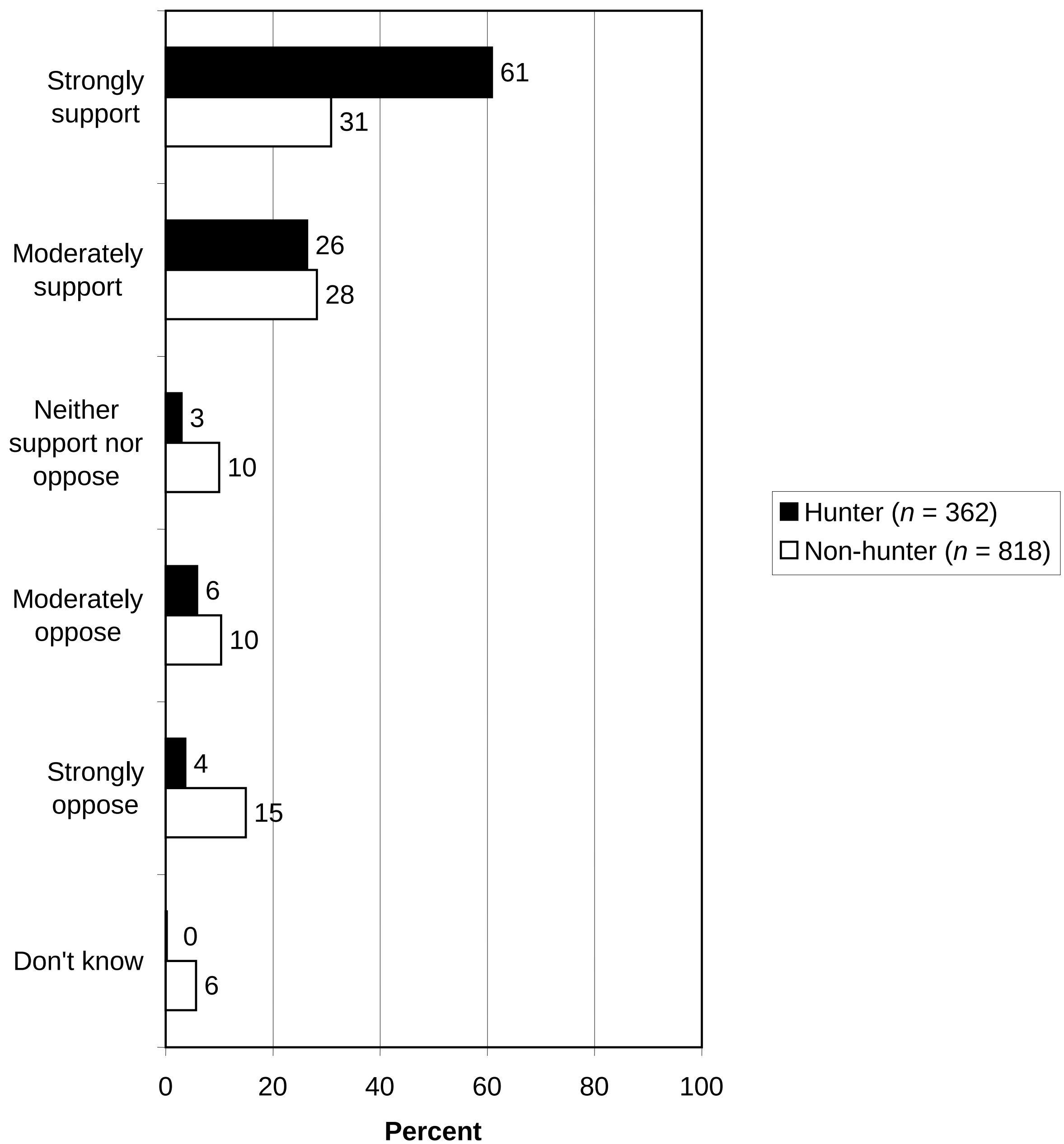
Fig. 3. Support and opposition to black bear hunting in West Virginia in 2006 among hunters (n = 362) and non-hunters (n = 818).

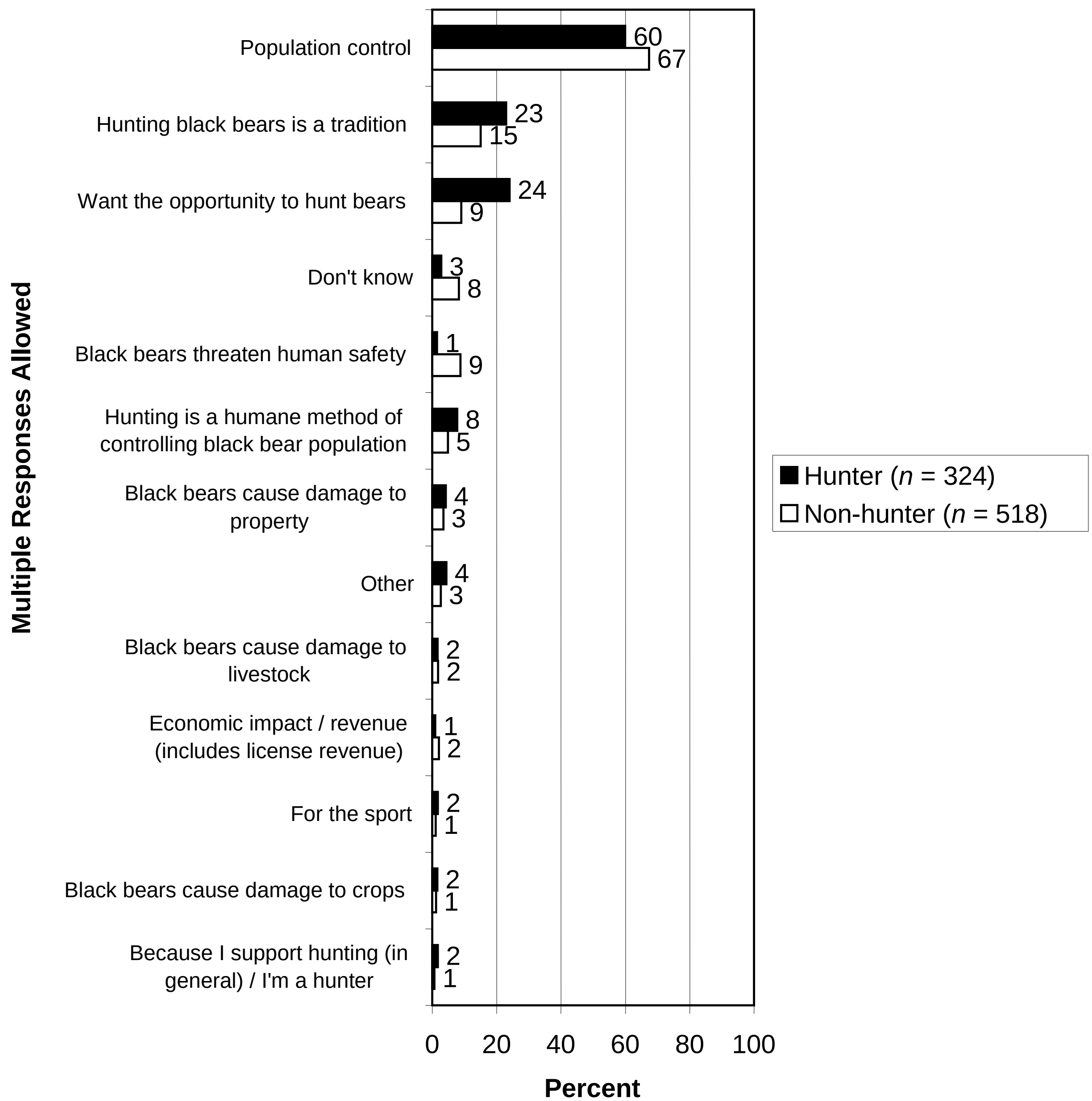
Fig. 4. Reasons why hunters (n = 324) and non-hunters (n = 518) indicated they would support regulated black bear hunting in West Virginia, 2006.



WEST VIRGINIA
REGIONS AND COUNTIES
Central
Eastern Panhandle
Western
Mountain
Southern Study Area
Coal Fields
HANCOCK
BROOKE
OHIO
MARSHALL
WETZEL
MONONGALIA
MARION
PRESTON
TYLER
PLEASANTS
HARRISON
TAYLOR
DODDRIDGE
RITCHIE
WOOD
WIRT
BARBOUR
TUCKER
MINERAL
HAMPSHIRE
MORGAN
BERKELEY
JEFFERSON
GRANT
HARDY
LEWIS
GILMER
CALHOUN
JACKSON
MASON
ROANE
UPSHUR
RANDOLPH
PENDLETON
BRAXTON
PUTNAM
CABELL
KANAWHA
CLAY
WEBSTER
NICHOLAS
POCAHONTAS
WAYNE
LINCOLN
BOONE
FAYETTE
GREENBRIER
MINGO
LOGAN
RALEIGH
WYOMING
SUMMERS
MONROE
MERCER
MCDOWELL


Increased
22
15
17
20
22
21
Remain the same
44
44
41
41
40
50
Decreased
6
23
19
15
13
6
Don't know
29
19
22
24
25
23
0
20
40
60
80
100
Percent
Eastern panhandle (n = 101)
Mountains (n = 290)
Southern study area (n = 78)
Coal fields (n = 109)
Western (n = 274)
Central (n = 354)


Strongly support
Moderately support
Neither support nor oppose
Moderately oppose
Strongly oppose
Don't know
61
31
26
28
3
10
6
10
4
15
0
6
0
20
40
60
80
100
Percent
Hunter (n = 362)
Non-hunter (n = 818)


Multiple Responses Allowed
Population control
Hunting black bears is a tradition
Want the opportunity to hunt bears
Don't know
Black bears threaten human safety
Hunting is a humane method of controlling black bear population
Black bears cause damage to property
Other
Black bears cause damage to livestock
Economic impact / revenue (includes license revenue)
For the sport
Black bears cause damage to crops
Because I support hunting (in general) / I'm a hunter
60
67
23
15
24
9
3
8
1
9
8
5
4
3
4
3
2
2
1
2
2
1
2
1
2
1
0
20
40
60
80
100
Percent
Hunter (n = 324)
Non-hunter (n = 518)

Hunter participation and success rates, characteristics of an early hunting season, and economic impact of American black bear hunting in West Virginia

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Abstract: Hunter participation and success rates are vital for managers developing management programs and to evaluate current regulations and special seasons. We conducted a systematic random mail survey of hunters that purchased an American black bear (*Ursus americanus*) stamp in West Virginia in 2006 to determine effects of hunting seasons and the economic impact of black bear hunting. Thirty-seven percent of respondents stated that they specifically targeted black bears while hunting; whereas, 63% stated that they hunted black bears concurrently while hunting white-tailed deer (*Odocoileus virginianus*). Fifty percent of respondents primarily hunted with archery

equipment, 26% used guns without dogs, and 24% used dogs to pursue black bears with success rates of 5.2%, 6.3%, and 19.2%, respectively. Twelve percent of hunters using archery equipment, 25% of gun hunters primarily hunting without dogs, and 41% of hunters primarily using dogs indicated they had participated at least once in the previous 5 special black bear hunting seasons. Hunters using dogs passed up more legal opportunities to harvest black bears than hunters using archery equipment or gun hunting without dogs. However, estimated harvests were similar because of the larger number of hunters that did not use dogs. The total economic impact of black bear hunting in West Virginia was $51,847,605. Managers should continue to evaluate the effectiveness of hunting seasons and make adjustments accordingly to reach management objectives.
Key words: American black bear, economic impact, hunting, participation, success, *Ursus americanus*, West Virginia

XXXXXXXXXXXX

Wildlife managers in North America have gone from proposing conservative American black bear (*Ursus americanus*) regulations that protected females (Kolenosky 1983) to liberalizing seasons to increase harvests and control populations throughout much of the range (Ryan 2008, Ternent 2008). In West Virginia, black bear harvest and populations have continued to increase since 1972 (Figure 1). The West Virginia Division of Natural Resources (WVDNR) has experienced an increase in nuisance complaints from the public during the last decade and black bears have been reported in new areas. With the increasing population and nuisance complaints, wildlife managers are faced with special challenges on proposing and implementing seasons that can control the population. Although special hunting seasons have been proposed in some areas, it is often difficult to evaluate their effectiveness without survey data from both successful and non-successful hunters, and from those using different hunting methods.

The use of dogs for black bear hunting has long been a tradition in West Virginia and elsewhere, but has come under close scrutiny in some states (Teel et al. 2002, Vashon and Cross 2005, Ryan et al. 2009). The presumed, but unknown, effectiveness of black bear hunting with dogs in West Virginia has provided biologists the flexibility of controlling the population by manipulating season dates. However, as the black bear population in West Virginia has expanded into areas where hunting with dogs may not be applicable due to land ownership patterns or regional differences in social acceptability of certain hunting methods, biologists must assess the effectiveness of alternative hunting methods to make successful management recommendations (Ryan et al. 2009). Further complicating management recommendations is the fact that black bear hunters using dogs may be more selective towards males than other methods (Litvaitis and Kane 1994) and may pass up legal opportunities to harvest female bears thereby negating the effectiveness of some hunting seasons.

Harvest data is one of the major informational tools used to manage black bear populations in the eastern United States (de Almeida and Obbard 2008, Hurst 2008, Ryan 2008, Timmins 2008, Vashon and Cross 2008). Although some states require an additional license or permit to hunt black bears, most states having multiple seasons or methods to harvest black bears do not require hunters to specify in which season they participate (Cardoza 2008, Ryan 2008, Ternent 2008, Vashon and Cross 2008). Therefore, most agencies cannot fully consider the success and impacts of their specific seasons or harvest. In West Virginia, hunters must purchase a bear hunting permit but are not required to identify which method they used so it is difficult to evaluate how changes in regulations affected black bear populations.

Harvest methods vary greatly across eastern North America and range from the use of bait and archery equipment, the use of guns without bait or dogs, and the use of dogs to closed seasons (Rolley et al. 2008, Sajecki 2008, Ternent 2008, Vashon and Cross 2008). Historically, West Virginia has offered a combination of all the aforementioned seasons except the use of bait was prohibited. During 2002–2006, WVDNR offered a statewide 5-week archery season for black bears, a gun-hunting season without dogs in most counties, and a gun-hunting season with dogs in traditional mountain counties. In addition, there was an early black bear gun season with dogs and a separate gun season without dogs that ran concurrently with antlered white-tailed deer (*Odocoileus virginianus*) seasons in four southern counties. The statewide bag limit was one bear for all seasons combined.

Hunting has a tremendous impact on West Virginia's economy (Southwick Associates 2007). The assumed, but unknown, economic impact of black bear hunting in West Virginia has long been reported as beneficial to rural communities. In addition to the black bear harvest season in West Virginia, hunters may train dogs year-around without harvesting animals. Black bear hunters using dogs during the training and harvest seasons also may contribute additional revenue to rural communities. However, without a formal survey of black bear hunters the true economic benefits are uncertain. Due to current economic conditions in West Virginia, any proposed change in state regulations that may have a negative economic impact would likely meet strong resistance. Therefore, survey data is needed to determine how black bear hunting and training dogs for black bear hunting may affect black both the bear population and West Virginia's economy.

We employed a mail survey to address the following objectives: (1) number and success rates of hunters using different hunting methods, (2) number of black bears that could have been harvested using different hunting methods, (3) number of dogs and size of hunting party typically used while hunting black bears with dogs, (4) participation and success rates of special hunting seasons, and (5) economic impact of black bear hunting in West Virginia.

Methods

In addition to their license, hunters are required to purchase a black bear damage stamp to pursue black bears. Of the 23,383 hunters that purchased a black bear damage stamp in 2006, we were able to determine names and addresses for 19,863 of them. Names and addresses were obtained from WVDNR GoWild (on line license system), point of sale (computer based), or vendors using a paper license system. We were unable to determine all names and addresses because hunters are not required to provide an address when purchasing only an additional stamp through paper sale. Therefore, we were unable to cross-reference every name with an address. We selected from both residents and nonresidents to better assess the overall impact of black bear hunting. We used the entire database of 19,863 to draw our systematic random sample.

We conducted a pre-test questionnaire of members of the West Virginia Bear Hunters Association and made revisions based on the pre-test. Based on pre-test questionnaire sample variance of the question with the largest variance, we randomly selected and sent 1,748 hunters a mail questionnaire consisting of 26 questions in May

2007. Non-respondents were sent a reminder letter 2 weeks later, and another copy of the survey, if requested, in June 2007 (Dillman 1978). We systematically randomly selected 111 non-respondents based on sample sizes and contracted Responsive Management, Harrisonburg, Virginia, USA to conduct a telephone survey in August 2007 to determine non-respondent bias. Non-respondent bias was tested using χ^2 and t-tests. All data were analyzed using SAS (SAS 9.1.3 2004).

We tested survey responses for differences in hunter type, participation in early season, hunters that passed up legal opportunities to harvest bears, and success of hunters specifically targeting bears with a χ^2 test. Number of bears seen during hunting season was tested with an ANOVA.

We examined the effectiveness of early black bear seasons by testing participation rates and if hunters passed up legal opportunities to harvest black bears with a χ^2 test. The number of bears harvested, years hunted, and number of legal black bears passed up during the early season were tested with an ANOVA and a Duncan's multiple comparison test.

We computed mean statistics on hunters owning bear dogs to determine the number of dogs owned and hunter effort during training and harvest seasons to provide baseline data to make management proposals.

We used the IMPLAN model, originally developed by the U.S. Forest Service and now maintained by the Minnesota IMPLAN Group (MIG, Inc., Stillwater, Minnesota, USA) to estimate the economic impacts of black bear hunters' expenditures on West Virginia's economy. For our study, we only used data from hunters that indicated that they primarily hunted black bears and did not include data from hunters that stated that they black bear hunted concurrently while white-tailed deer hunting. We computed the economic impacts separately for in-state and out-of-state hunters, but only included expenditures made in West Virginia. For in-state hunters, we included the expenditures for training trips, hunting trips, maintenance and care of dogs at home (e.g. dog food, veterinary bills, etc.), and additional hunting supplies. We did not include expenditures from out-of-state hunters for training trips or maintenance and care of dogs at home. In addition, we only included the hunting trip expenditures for out-of-state hunters if the purchase was made in West Virginia (e.g. only 50% of gas expenditures were included in economic impact estimates). We also did not include the indirect or direct cost associated with 23,383 bear damage stamps sold at $10.00 each or the 715 out-of-state bear licenses that totaled $107,250 because these monies are used primarily to reimburse landowners for damage from black bears and to fund WVDNR black bear research projects.

Results

We received 218 (12%) returned surveys marked "address unknown." We received 496 useable responses out of the remaining 1,530 surveys (32% response rate). Ten (2%) respondents stated that they did not bear hunt, did not bear hunt in 2006, or that the addressee was deceased. Responsive Management made 111 calls to non-respondents and obtained 55 usable surveys (49% response rate). Surveys from other non-respondents were not obtained because of incorrect telephone numbers, hunters did not hunt bears, or the addressee was deceased.

Comparison of questionnaires from respondents and non-respondents found similarities in primary hunting type ($\chi^2 = 2.71$, $P = 0.257$), participation in the early hunting seasons ($\chi^2 = 0.51$, $P = 0.4756$), harvest rates ($\chi^2 < 0.01$, $P = 0.956$), if a hunter passed up a bear ($\chi^2 = 0.35$, $P = 0.556$), how long they had been hunting ($F = 0.35$, $P =$ .05532), and age ($F = 0.13$, $P = 0.256$). Therefore, we combined all respondents (n=551) for a response rate of 36%.

Hunter type and characteristics

Of the 23,383 licensed black bear hunters in 2006 an estimated 471 (2%) did not hunt. From the remaining 22,912 hunters, an estimated 11,456 (50%) primarily archery hunted, 5,957 (26%) gun hunted without dogs, and 5,499 (24%) used dogs. Forty-four percent of archery hunters indicated gun hunting without dogs as a secondary hunting method but <1% also gun hunted with dogs. Gun hunters without dogs also archery hunted (42%) but only 6% of them gun hunted with dogs; whereas, only 21% of hunters primarily hunting with dogs participated in a different season.

Thirty-seven percent of hunters stated that they specifically targeted black bears while hunting; whereas, 63% stated that they hunted black bears concurrently with white-tailed deer seasons. Ten percent, 35%, and 96% of hunters that primarily archery hunted, gun hunted without dogs, and hunted using dogs specifically targeted black bears, respectively. The total estimated number of hunters in West Virginia that specifically target black bears was 8,651.

Harvest success and opportunity

Hunters reported seeing an average of 3.4 (95% CI: 2.9–4.0) black bears while hunting during the 2006 hunting season. Hunters using dogs saw more black bear ($\bar{x} =$ 9.1 SE = 0.889) than archery ($\bar{x} = 1.9$, SE = 0.167) and gun hunters not using dogs ($\bar{x} =$ 1.4, SE = 0.192; $F = 92.84$, $P < 0.001$). Hunters using dogs (68%) were more likely to pass up at least one legal opportunity to harvest a black bear than archery hunters (30%) or gun hunters not using dogs (22%; $\chi^2 = 71.94$, $P < 0.001$) but estimated harvests were similar because of the larger number of hunters that did not use dogs.

Gun hunters using dogs (19% success rate) where more likely to harvest black bears than gun hunters not using dogs (6% success rate) or archery hunters (5% success rate; $\chi^2 = 22.74$, $P < 0.001$). The estimated harvest from survey data in 2006 was 572, 357, and 1,044 for archery, gun hunters without dogs, and gun hunters using dogs, respectively, for a total of 1,973. The reported harvest from mandatory check stations was 519 for archery and 1,189 for gun (use of dogs not reported) for a total of 1,703. However, these results should be viewed with caution because a hunter may have harvested a bear with their secondary method.

Dog hunting dynamics

One hundred two of 541 (19%) respondents reported owning dogs used to pursue black bears. Hunters using hounds owned an average of 5 dogs (n = 102, 95% CI: 4.0–5.6). They trained their dogs an average of 37.1 days (n= 92, 95% CI: 29.2–44.9) days a year and treed 23.2 (n=94, 95% CI: 17.5–29.0) black bears during the training season for one bear treed for every 1.6 days of training. Hunters using dogs typically hunted in parties of 11.3 (n=103, 95% CI: 9.8–12.7) and hunted an average of 13.6 days (n=105, 95% CI: 12.4–14.9) during the hunting season.

Special hunting seasons

Hunters using dogs (40%) participated in special hunting seasons more often than gun hunters without dogs (26% participation) or archery hunters (12% participation; $\chi^2 = 40.30$, $P < 0.001$). During the 5 years that special hunting seasons were held, archery hunters, gun hunters with dogs, and gun hunters without dogs participated an average of 2.9 (95% CI: 2.3–3.4), 3.3 (95% CI: 2.9–3.7), and 3.7 (95% CI: 3.2–4.2) years, respectively.

Archery hunters, gun hunters without dogs, and gun hunters with dogs harvested an average of 0.17 (95% CI: 0.0–0.33), 0.51 (95% CI: 0.26–0.76), and 0.58 (95% CI: 0.26–0.90) black bears during the 5 years and harvest rates did not differ among methods (F = 2.27, P = 0.108). However, gun hunters using dogs were more likely to pass up legal opportunities to harvest black bears than archery or gun hunters without dogs (χ^2= 11.33, P = 0.003). Fifty-eight percent of gun hunters using dogs indicated that they passed up legal opportunities to harvest black bears during the special seasons; whereas, only 17% of gun hunters without dogs and 25% of archery hunters passed up opportunities during special seasons. Archery hunters, gun hunters without dogs, and gun hunters with dogs that passed up legal opportunities to harvest black bears had the chance but did not harvest an average of 3.4 (95% CI: 0.8–6.1), 3.8 (95% CI: 0.9– 6.8), and 6.1 (95% CI: 4.1–8.2), respectively, over the 5 years (F = 1.71, P = 0.189).

Economic Impact of black bear hunting

Black bear hunting in West Virginia had an economic impact of $51,847,605 in 2006. Hunters specifically targeting black bears directly spent $3,433,128 on equipment for total impact of $4,207,643. In-state and out-of-state hunters directly spent $5,379,912 and $944,919, respectively during the harvest season for a total impact of $7,556,889 and $1,314,539, respectively. In-state black bear hunters trained their dogs an average of 37.1 days annually and spent $13,118,060 for a total economic impact of $18,426,271 during 2006. Black bear hunters that used dogs in West Virginia spent an estimated total of $13,024,894 for a total economic impact of $20,342,263 on veterinary bills, purchasing dogs, dog food, tracking collars, etc.

Discussion

In the eastern United States and Canada only Georgia, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia allow the use of dogs to hunt black bears but prohibit baiting (Brandenburg 2008, Hammond et al. 2008, Jones 2008, Ryan 2008, Sajecki 2008, Still 2008). Although the least common among hunting methods used in West Virginia, hunters that pursued black bears with dogs reported the highest success rates. Among these states, only West Virginia has an accurate, annual index of the number of bear hunters (Brandenburg 2008, Hammond et al. 2008, Jones 2008, Ryan 2008, Sajecki 2008, Still 2008). Therefore, it is difficult to compare success rates across states and among studies because the number of hunters and specifically the number of hunters using dogs is unknown. Moreover, most of the aforementioned states have specific restrictions on areas and dates when dogs may be used for black bear hunting (Brandenburg 2008, Hammond et al. 2008, Jones 2008, Ryan 2008, Sajecki 2008, Still 2008). However, black bear hunters with dogs account for the majority of the harvest in North Carolina, South Carolina, Tennessee, and West Virginia and 50% of black bears harvested with firearms in Virginia (Brandenburg 2008, Jones 2008, Ryan 2008, Sajecki 2008, Still 2008). The apparent success in other states and our findings in West Virginia support the relatively higher success of black bear hunters using dogs. Although hunters using dogs have higher success rates, the same number of bears may be harvested using different less successful methods if there are more hunters using those methods.

In the eastern United States and Canada only Maryland, Massachusetts, and Pennsylvania prohibit the use of dogs by bear hunters and have an accurate estimate of hunter numbers (Cardoza 2008, Spiker 2008, Ternent 2008). The accuracy of Maryland's estimate is uncertain because they use a party-permit system that allows 1 to 3 hunters per permit; therefore, the exact number of hunters is unknown. In addition, their season is confined to a small geographic area and a short season. The success rate for black bear hunters in Massachusetts and Pennsylvania was 3% in 2006 (Cardoza 2008, Ternent 2008). The success rate for archery hunters (5%) and gun hunters without dogs (6%) in West Virginia may have been higher than in Massachusetts and Pennsylvania because of the longer seasons in West Virginia. In addition, natural mast abundance can influence hunter success rates and regional differences in food conditions may have influenced harvest rates in 2006 (McDonald et al. 1994, Ryan et al. 2004). Although gun hunters not using dogs and archery hunters have lower success rates in West Virginia, they still harvest a comparable number of bears because there are more hunters using those methods.

In addition to hunting black bear with dogs, Georgia, Maine, Michigan, New Hampshire, North Carolina, Ontario, South Carolina, Tennessee, Virginia, and West Virginia also have either or both archery hunting or gun hunting without dogs (Bostick 2008, Brandenburg 2008, Hammond et al. 2008, Jones 2008, Ryan 2008, Sajecki 2008, Still 2008 Timmins 2008). The use of multiple methods to hunt black bears was very popular among hunters in West Virginia. However, it is difficult to compare this trend across states or studies because most states, including West Virginia, do not require hunters to specify what hunting method they used. Diverse hunting regulations that allow hunters different opportunities to harvest black bear with archery, gun without dogs, or by the aid of dogs provide hunters with long hunting seasons and a variety of methods to choose from. During our study only 21% of hunters primarily using dogs also hunted with a different method; however, 49% of archery and gun hunters without dogs reported hunting using a secondary method that did not include the use of dogs. We would have to conduct additional surveys over time to gain an accurate representation if the number of hunters using a particular method was increasing or decreasing in popularity and their affects on population management. In areas where using dogs may not be applicable, expanding opportunities to gun hunting without dogs before adult females enter their dens may allow managers to achieve desired harvest goals.

Denning chronology of black bear (O'Pezio 1983) has served as the basis for setting hunting seasons in many states without regard to success rates of hunters. In 2008, West Virginia conducted an early black bear hunting season with dogs in 15 management units and recorded a harvest of 670 animals with a sex ratio of 52%M: 48%F (Ryan 2009). Hunters participating in this early season were successful in harvesting enough black bears to reach management objectives without over-harvesting (Ryan 2009). In addition, they were not over selective towards males. Managers attempting to manipulate black bear populations should consider success rates of different methods in addition to timing of proposed seasons. However, if the goal of a special hunting season is to harvest nuisance offenders managers may have to consider other seasons because black bears in those areas may not be accessible to hunters using hounds.

From 2002–2006 the WVDNR held special black bear hunts in 4 southern counties to increase the female proportion of the harvest and target nuisance black bears. A one-week gun season with dogs was held the first week of November and a gun season without dogs was held during the first week of antlered white-tailed deer gun season. Although there was adequate participation by gun hunters with and without dogs, 58% of participating hunters with dogs indicated that they passed up at least one legal opportunity to harvest a black bear thereby possibly negating some of the benefits of the special hunting season. We did not attempt to identify the specific reasons for passing up legal opportunities to harvest black bears during special seasons but we hypothesize that hunters did not want to fill their tag and not be able to hunt during the traditional December season: the statewide bag limit of one black bear remained the same. An increase in the bag limit for all hunters that allows them to harvest an additional black bear may achieve desired harvest levels while creating opportunities and possibly increasing the economic impact from hunting.

Hunting of all species has over a $453,000,000 annual economic impact in West Virginia (Southwick Associates 2007). Hunters that specifically targeted black bears had an economic impact exceeding $51,000,000. The majority of these hunters used dogs and lived in the more rural counties of West Virginia. Money spent on hunting helps to support salaries and jobs and has a ripple effect throughout the local economy (Southwick Associates 2007). Although it is hard to predict how changes in regulations (training or harvest) might affect the economic impact of black bear hunting, it is safe to assume that greater opportunities to spend time in the field should result in increased expenditures.

Management implications

Although our results are specific to West Virginia, they illustrate the point that managers should conduct surveys periodically to evaluate their hunting seasons and propose changes accordingly to meet their management objectives. For example, if special hunting seasons are opened and bag limits do not change, hunters might use that opportunity to train their dogs or attempt to harvest a trophy animal while passing up many legal black bears, thus defeating the purpose of the special season. Additionally, in areas where certain methods (hunting with dogs) may not be applicable, managers may have to adjust permit numbers based on success rates to achieve the desired harvest levels.

Management plans with such flexible options built in will be more adept to handle changes in success rates or special hunting seasons. Managers may want to consider very liberal options when developing a management plan in case data indicates that they will not achieve their management objective with the current set of regulations.

Acknowledgments

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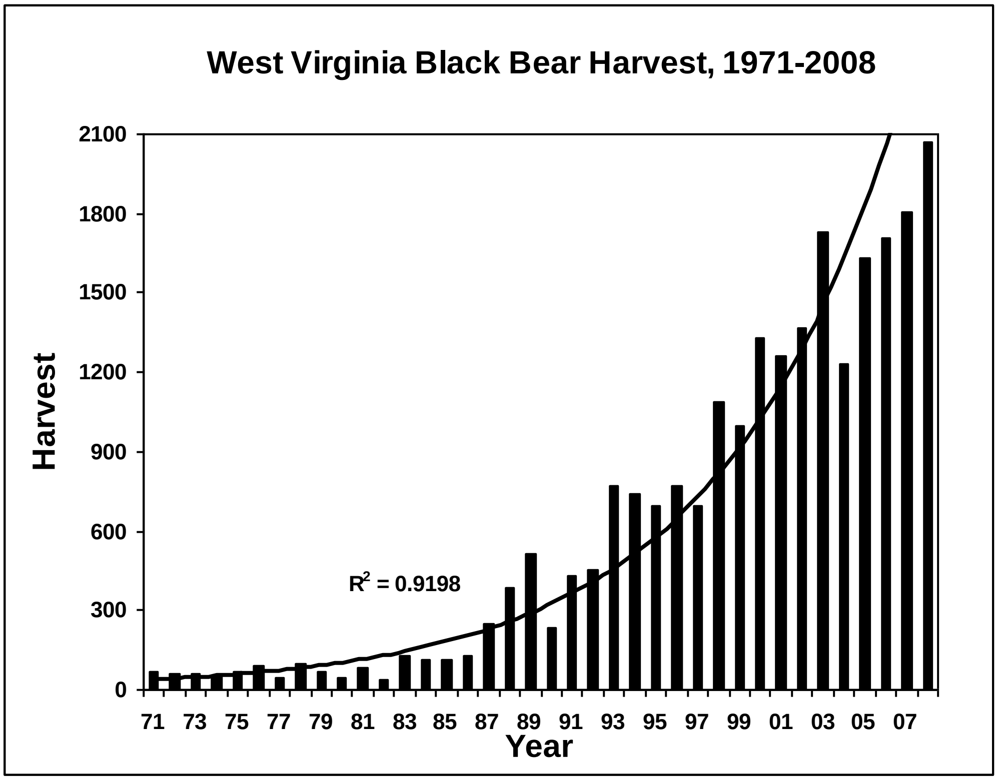
Figure 1. Black bear harvest in West Virginia, USA, 1972-2008.


West Virginia Black Bear Harvest, 1971-2008
Harvest
2100
1800
1500
1200
900
600
300
0
R^2 = 0.9198
71 73 75 77 79 81 83 85 87 89 91 93 95 97 99 01 03 05 07
Year

Using a Rank-Exponent Technique to Develop Management Plans

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ABSTRACT Managers are often faced with the challenging task of developing a management plan from a number of practical options. We developed a management plan for American black bears (*Ursus americanus*) using a rank-exponent technique to determine where to most effectively implement different harvest strategies. We identified and ranked 6 factors believed important to the successful implementation of different harvest strategies available for black bears in West Virginia. Each factor was ranked from 1 to 6, normalized, and used to compute a final score for each management unit using a rank-exponent technique. Although we used the ranking technique to develop a management plan for black bears, it is applicable to other hunted and non-hunted species.

KEY WORDS black bear, management, Multiple Criteria Decision Analysis, rank-exponent, *Ursus americanus*, West Virginia

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Hunting American black bears (*Ursus americanus*; hereafter, black bears) with dogs has been the traditional method used for harvest management in West Virginia. However, as black bears expand their range into areas occupied by humans and people continue to encroach on prime bear habitat, traditional black bear hunting may meet resistance. Statewide approval ratings of black bear hunting with dogs is low (23%); however, support for gun hunting without dogs (77%) and archery hunting without bait (60%) is much higher (Responsive Management 2006). Archery and gun hunting without dogs is also permitted but provides limited opportunities for hunters because it is illegal to bait or feed black bears and in most areas seasons do not run concurrently with white-tailed deer (*Odocoileus virginianus*) gun seasons, the time of year with the most hunting pressure (Responsive Management 2007). Therefore, under certain scenarios it is difficult for wildlife managers to achieve adequate harvest rates to meet management objectives.

Recently, some state wildlife agencies have had their black bear hunting regulations challenged via referendum, court cases, or over turned by politicians (Boulay et al. 1999, Vashon and Cross 2005, Carr and Burguess 2008, Spiker 2008). Maine Department of Game and Inland Fisheries narrowly defeated a public referendum in 2005 that would have vastly altered the framework of their black bear hunting seasons (Vashon and Cross 2005). The Maryland state legislature proposed but did not pass legislation in 2004, 2005, 2006, and 2007 to eliminate black bear hunting (Spiker 2008). New Jersey Fish and Wildlife conducted black bear hunts in 2003 and 2005 but have not allowed another black bear hunting season even though the population remains strong and nuisance complaints have increased (Carr and Burguess 2008).

In West Virginia, black bear harvest trends have continued to increase since 1970 (Figure 1). Concomitantly, human populations in many counties (e.g., Monongalia, Hampshire, Berkeley, etc.) have continued to increase (United States Census Bureau 2008). Increasing black bear and human populations present wildlife managers with difficult challenges because traditional hunting methods may not be applicable in many areas although certain stakeholders argue that they could be used without controversy. The need to identify and quantify straight-forward justifications for implementing harvest strategies led wildlife managers to explore techniques that may not have been considered in traditional wildlife management practices.

Multiple criteria decision analysis (MCDA) techniques are used in natural resource management, but rarely for the specific purpose of managing wildlife (Berbel and Zamora 1995, Malczewski 1999, Kurttila et al. 2002, Snyder et al. 2004, Moseley 2008). MCDA is a framework that allows for the integration of goals, objectives, criteria, attributes and preferences in a systematic method (Malczewski 1999). MCDA is especially important in helping to provide collaborative decision making by considering multiple attributes that some other approaches such as cost-benefit analysis may miss (Munda 1996, Prato 1999).

MCDA provides an equitable and efficient means for incorporating stakeholder's preferences in social decisions (Strager and Rosenberger 2006). Tools that help to maximize consensus and minimize conflict among interest groups can lead to better decisions (Strager and Rosenberger 2006). One of the most important aspects of the MCDA approach is its ability to integrate stakeholder's preferences for attributes with objective measures of those attributes (Strager and Rosenberger 2006). It is through this integration process that knowledge can be incorporated into the framework for overall management.

MCDA techniques are classified into three broad categories: (1) value measurement models; (2) goal, aspiration or reference level models; and (3) outranking models (Malczewski 1999, Belton and Stewart 2002, Mendoza and Martins 2006). MCDA may be used to assess two different types of problems in wildlife management: (1) optimization of game populations for economics or recreation for certain species; and (2) preservation of endangered species (Berbel and Zamora 1995). In Spain, MCDA was used to optimize the economical benefit from a hunted species and an endangered species (Berbel and Zamora 1995), and in the United States, Moseley (2008) evaluated management indicator species for the Monongahela National Forest Management Plan.

Extensions of MCDA, such as the rank-exponent method, have also been used with Geographic Information Systems to analyze land use planning (Malczewski 1999). Advantages of ranking methods over other weight solicitation techniques include the ability: (1) to easily come up with a straight rank first; (2) to easily compute the scores in a spreadsheet; and (3) of participants to “buy into” the process due to the ability to understand how rankings result in weights (Malczewski 1999).

Despite the availability of quantifiable data and additional techniques, state agencies often make management decisions based solely on professional or stakeholder opinion. MCDA techniques can help to evaluate a suite of options where there are multiple goals or objectives. In addition, certain MCDA techniques may be easier for stakeholders not trained in wildlife management or statistics to understand.

Our objective was to employ a rank-exponent technique to assist managers in determining the most desirable harvest strategy among management units in West Virginia. Accordingly, we applied a rank-exponent technique to provide managers with quantifiable data on which to base management recommendations.

STUDY AREA

We subdivided the state of West Virginia (6,246,800 ha) into 3 regions on the basis of physiographic provinces: (1) Western Hill Section: characterized by central hardwood forests with vegetation communities ranging from oak (*Quercus* spp.)–hickory (*Carya* spp.) on drier sites to flood plain communities along the Ohio River; (2) Allegheny Mountain and Upland Section: dominated by yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*), and American beech (*Fagus grandifolia*); however, oak and black cherry (*Prunus serotina*) may dominate lower elevations and on drier sites; and (3) Eastern Ridge and Valley Section: predominated by oak–hickory–pine (*Pinus* spp.) (Strausbaugh and Core 1978). Elevations in the regions ranged from 73–1,524 m (Strausbaugh and Core 1978). Within the regions, we considered 61 management units based primarily on the political boundaries at the county level (Figure 2).

METHODS

We solicited expert opinion from 15 West Virginia Division of Natural Resources (WVDNR) biologists to determine the important factors of allowing hunters to use dogs for black bear hunting. We also discussed black bear hunting with key stakeholder groups (e.g., West Virginia Bowhunters Association, West Virginia Bear Hunters Association, West Virginia Trophy Hunters Association, etc.) to record their concerns with different black bear hunting options. WVDNR biologists identified 6 factors that influence black bear hunting methods and ranked them from most to least important as follows: (1) number of tracts of land ≥ 404 hectares, (2) percent of land in tracts ≥ 404 hectares, (3) percent forest cover, (4) the ratio of percent forest cover/human population density, (5) human population density, and (6) residents' approval of black bear hunting with dogs. We obtained number and size of landholdings from public records through the West Virginia Division of Forestry, percent forest cover from WV GAP Project (West Virginia University 2001), human population density from United States Census Data (United States Census Bureau 2008) and public opinion data from surveys (Responsive Management 2006). Percent forest cover (West Virginia University 2001) and human population density (United States Census Bureau. 2008) ranged from 30–96% and 3.59–158.37 people per square km, respectively, among management units. The number of tracts of land ≥ 404 hectares ranged from 0 to 35.

We calculated the rank-exponent weight for each factor using the straight- rank numbers from our participants as follows:

$$[(n-r_j+1)^2]/\sum (n-r_j+1)^2$$

Where:

n = the number of factors considered

r_j = straight rank from most to least important for each factor from 1 to n

(Malczewski 1999)

We normalized weights from 0 to 1 with the sum adding to 1.

We normalized each factor by dividing each value by the largest value. We multiplied each factor by 100 to produce a normalized score from 0 to 100. We then calculated each factor's rank-exponent value by multiplying the normalized score by the weight for each factor.

Finally, we summed the 6 factor's rank-exponent value to arrive at a final score for each management unit (Malczewski 1999). Management units with final scores ≥ 37.0 were assigned harvest strategy A: use dogs as the primary harvest method; management units with a final score 33.0–36.9 were assigned harvest strategy B: use of dogs on a limited basis; and managements units scoring < 33.0 were assigned harvest strategy C: hunting with dogs is not permitted.

We proposed harvest regulations for each management unit at 12 public meetings held in March 2008. Stakeholders had the opportunity to comment at the meetings and during a 60 day open comment period.

RESULTS

Management units with the highest number and percentage of tracts of land ≥ 404 hectares had higher final scores and were generally permitted to use dogs (Figure 2). However, management units with lower human densities and a large percent of forest cover also were assigned to the strategy permitting the use of dogs. Counties with high human densities, fewer large tracts of land, and lower approval rates of the use of dogs fell into the strategy where use of dogs was prohibited. Management units that had large tracts of land but ranked lower in other criteria were assigned to the harvest strategy where the use of dogs may be considered on a limited basis.

Our rank-exponent technique identified 7 management units in which bear hunting with dogs is not currently permitted, but where the use of dogs would be the primary harvest method. Our technique also identified 5 management units where the use of dogs may be applied on a limited basis and 33 areas where the use of dogs would be prohibited. A majority of individuals (71%) and sportsmen's groups (78%) approved the specific hunting seasons that were proposed on the basis of our analysis.

DISCUSSION

MCDA has been useful in forest management decisions because it allows stakeholders to participate in the process, integrates multiple management issues using a structured system, and considers multiple elements (Mendoza and Martins 2006). It also provides a record of documented approach instead of a decision reached strictly by opinion. Processes that lead to justifiable and rational decisions (Belton and Stewart 2002) make it easier for stakeholders to understand and comprehend management decisions. MCDA techniques have been used to evaluate a suite of options in wildlife management, but have rarely been applied by management personnel to carry out decisions (Moseley 2008).

The use of MCDA techniques is appealing because they result in rational and unbiased decisions (Mendoza and Martins 2006). Although no management plan will satisfy all stakeholders, we believe that our approach of considering numerous important factors and using a rank-exponent technique helped to quantify how management units were assigned to respective harvest strategies. The quantitative methodology was extremely easy for stakeholders to comprehend and follow when assigning management units to different harvest strategies. In addition, by attending various stakeholder meetings before developing the strategy we helped to ensure that their opinions were considered. The high approval rating received from public meetings and the open comment period was evidence that a majority of individuals supported the specific proposals.

Managing black bears at cultural carrying capacity as wildlife habitat continues to fragment is an important challenge for managers (Cardoza 2008, Timmins 2008). Although managers may have the knowledge and data to apply certain management techniques, they may not be applicable in every situation and may create additional public controversy. Initiatives that threaten to eliminate traditional hunting methods represent a significant management challenge (Timmins 2008). Incorporating multiple data into the decision making process before proposing a management strategy may help to avoid some of the pitfalls often associated with an expert opinion based model.

Hunting black bears with dogs has been a topic of concern for certain groups, especially non-hunters (Teel et al. 2002). In Colorado, less then half of hunters opposed the use of dogs; whereas, 74% of non-hunters with a high interest in wildlife opposed the use of dogs to hunt black bears (Teel et al. 2002). Length of residency, education, and geographic location of residence were important factors in predicting attitudes towards the use of hounds to hunt black bears in Colorado (Teel et al. 2002). In West Virginia, black bear hunting with dogs was also one of the least popular harvest methods (Responsive Management 2006). Quantitatively identifying management units where hunting with dogs would be the most feasible may help to eliminate some potential conflict between user groups. By using factors in the management process that incorporated both public opinion and criteria that would make hunting with dogs more feasible (large tracts of land) we hoped to eliminate management units where that harvest strategy may not have been applicable.

Management Implications

We applied the MCDA preference weighting rank-exponent technique for developing black bear harvest strategies because different management options were being considered and because West Virginia is a very diverse state in terms of large tracts of land, habitat, and human population densities. However, we feel that this method may also be applied to numerous hunted and non-hunted species. In areas that may have different management goals or objectives a MCDA technique may help to define which strategy would be most appropriate with respect to economics or biological considerations (Berbel and Zamora 1995).

Acknowledgments

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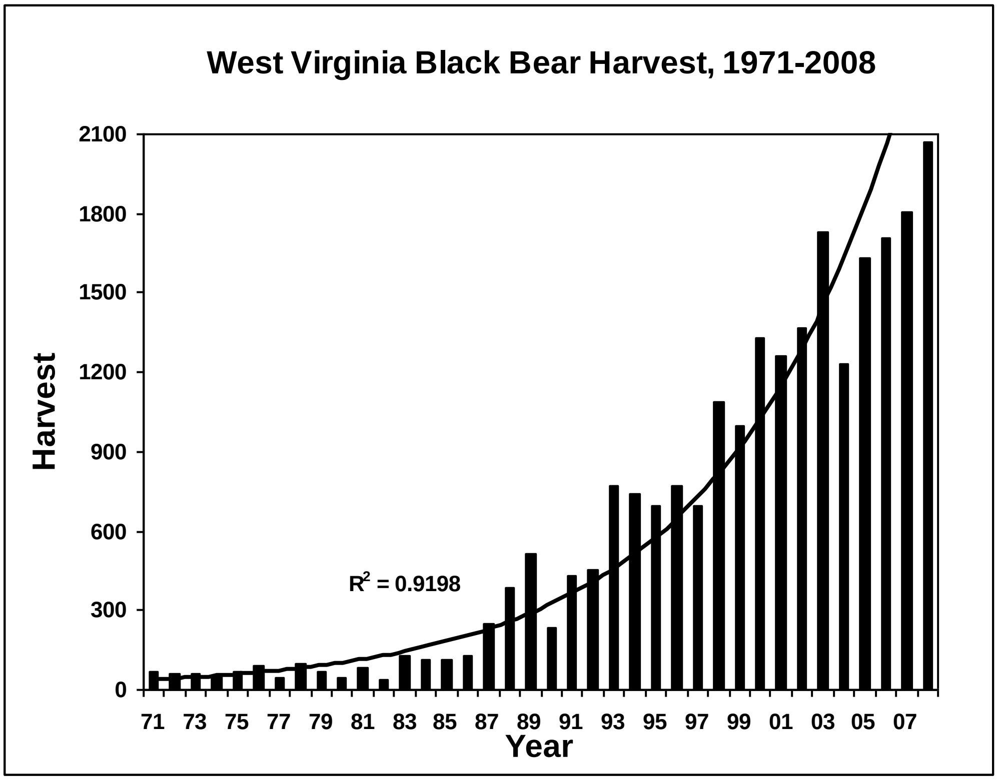
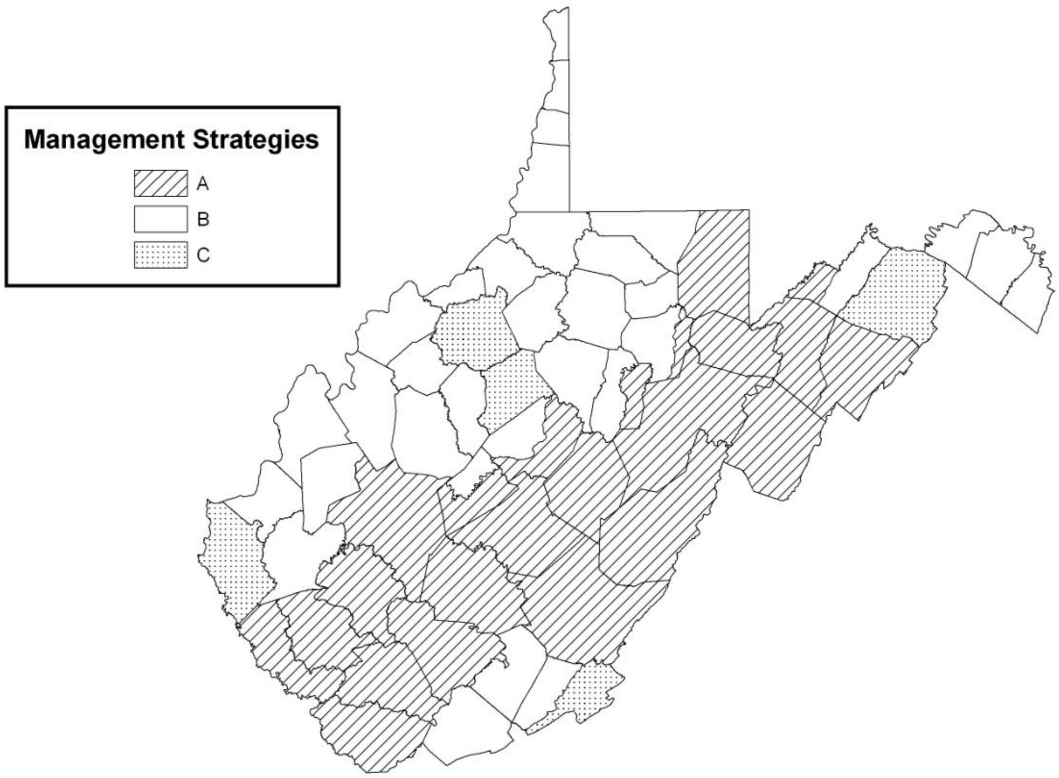
Associate Editor:

Figure 1. Black bear harvest in West Virginia, 1971–2008.

Figure 2. Black bear harvest strategies developed using a rank-exponent method where the use of hounds is allowed (A), prohibited (B), and under special consideration (C), West Virginia, USA.


West Virginia Black Bear Harvest, 1971-2008
Harvest
2100
1800
1500
1200
900
600
300
0
R2 = 0.9198
71 73 75 77 79 81 83 85 87 89 91 93 95 97 99 01 03 05 07
Year


Management Strategies
A
B
C

Retention Time of Telazol in Black Bears

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ABSTRACT Telazol® (Fort Dodge Animal Health, Fort Dodge, IA) is an effective immobilization drug for American black bears (*Ursus americanus*) but concern exists regarding retention time of this drug in tissues relative to human consumption of bears. Therefore, we evaluated retention time of Telazol in captured American black bears immobilized with Telazol and held in captivity for 3 days, 7 days, 14 days, or 21 days. We detected Telazol in muscle and liver of one bear on day 7, in serum from 2 bears on day 7, and in urine of one bear each on day 3 and day 14. Our findings suggest Telazol

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is metabolized and eliminated quickly from the bear's system and should allow managers additional flexibility in mark-recapture studies and nuisance situations. (The Journal of Wildlife Management 73(2): 210–213; 2009)

DOI:10.2193/2008-182

KEY WORDS American black bear, hunting, wildlife management, mark-recapture, Telazol, *Ursus americanus*, West Virginia, sedation, tranquilize, chemical immobilization

Telazol (1:1 mixture of tiletamine hydrochloride [HCL] and zolazepam HCL; Fort Dodge Animal Health, Fort Dodge, IA) is widely used to immobilize American black bears (*Ursus americanus*; hereafter, black bears) in nuisance and research situations. Telazol is effective and possibly the best immobilization drug currently available for black bears due to rapid induction and the bears' gradual and predictable recovery from immobilization (Bush et al. 1980, Gibeau and Paquet 1991, White et al. 1996). The Animal Medicinal Drug Use Clarification Act of 1994 requires veterinarians who prescribe extra label use of drugs to establish substantially extended withdrawal periods before possible human consumption of treated animals. Food animals immobilized with Telazol are an extra label use of this drug and individual veterinarians must establish appropriate withdrawal times based on scientific information (Craigmill et al. 1997). Currently, many management agencies require euthanasia of black bears immobilized with Telazol within 45 days of hunting season due to uncertain retention times of Telazol and public health concerns associated with human consumption of meat from treated animals. The 45-day waiting period is not consistent among agencies and was only a suggested waiting time by most agencies because there is no published literature on retention time of Telazol in black bears. State agencies in West Virginia, North Carolina, Maryland, and others require a ≥45-day withdrawal period before possible human consumption of black bears immobilized with Telazol. The Canadian Cooperative Wildlife Health Centre suggests using 14 days for withdrawal times for all free ranging wildlife immobilized with Telazol as suggested by the Western Wildlife Health Committee of the Western Association of Fish and Wildlife Agencies (http://www.ccwhc.ca/newsletters/technical_bulletin9-1.pdf). However, they cite only one study on polar bears (*Ursus maritimus*; Semple et al. 2000) that reported low concentrations of tiletamine HCL and zolazepam HCL in polar bears between 0.5 days to 11 days following immobilization with Telazol and suggested that tissue levels of the drugs declined so rapidly that individuals consuming meat from exposed polar bears would be unlikely to experience negative effects from the drugs. Half life of tiletamine and zolazepam in dogs was 1.2 hours and 1 hour, respectively (Baukema and Glazko 1975 as cited by Lin et al. 1993), whereas half life for tiletamine and zolazepam in polar bears was 1.8 hours and 1.2 hours, respectively (Semple et al 2000). To address possible public health concerns and inform managers and administrators, we evaluated retention time in captured black bears immobilized with Telazol to determine a safe threshold for use of Telazol on black bears relative to potential human consumption.

METHODS

Personnel with West Virginia Division of Natural Resources and Virginia Department of Game and Inland Fisheries captured 15 (11 M, 4 F) wild black bears in nuisance situations in culvert traps and transported them to the Center for Bear Research at Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA from 25 April 2005 through 19 August 2005. Mean weight and age were 104 kg (n = 14, range 55–176 kg; Table 1) and 6.5 years (n = 13, range 1–14 yr), respectively. Black bears we used in this research were destined to be destroyed for repeated or unacceptable nuisance activity. All methods were approved by the Institutional Animal Care and Use Committee at Virginia Tech (IACUC no. 05-053-F&W).

We immobilized black bears in culvert traps with 500 mg of Telazol, placed them in an individual holding facility (4.8 m in diam by 3.0 m tall) at the Center for Bear Research and assigned each to one of 4 treatment groups: 3 days, 7 days, 14 days, or 21 days postTelazol administration (Table 1). We immobilized each bear with 500 mg of Telazol because this most closely mimics field conditions of administering an entire bottle and should be the maximum amount needed to sedate an average size black bear. However, 2 black bears (T-5, a 165-kg M; and T-12, a 141-kg M) required 1,000 mg and 1,250 mg, respectively, to be immobilized so that we could safely handle them. Higher drug dosages are often used in wild animals to achieve more rapid inductions (Bush et al. 1980). We immobilized bears before removing them from culvert traps so exact weight was not known, but Telazol has a wide safety margin (Lin et al. 1993).

We fed each bear 1,000 g of high protein dog food per day and provided water ad libitum. One male black bear (T-11) assigned to the 21-day group escaped from the facility 3 days before it was scheduled to be euthanized. For euthanasia, we first immobilized bears with a 2:1 mixture of ketamine/xylazine at 1 cc per 45.3 kg followed by euthanasia via pentobarbital by a veterinarian from the Virginia-Maryland Regional

College of Veterinary Medicine (VMRCVM) to collect samples. Pathologists at VMRCVM removed muscle (semimembranous muscle from the right rear leg), liver, serum, and urine samples (when available) and stored samples at -20° C.

In addition to black bears held at the Center for Bear Research, we also obtained blood samples from 6 live black bears as part of the West Virginia Division of Natural Resources' black bear research and monitoring program. These additional samples were useful to allow verification of extraction and analytical procedures and to determine accurate drug recoveries from serum that had high concentrations of Telazol. We collected samples exactly 1 hour after we immobilized each black bear with Telazol.

We processed all samples following procedures of Semple et al. (2000). Specifically, we added 1 g of serum or urine to 1 ml of a saturated aqueous solution of sodium bicarbonate and 50 μl of ketamine-d_4 (internal standard) in methanol to each falcon tube. We extracted the aqueous phase with ethyl acetate (3 × 2 ml) and back extracted the pooled organic phases with 2 ml of 0.1M HCL. We basified the aqueous phase with a saturated aqueous solution of sodium bicarbonate (2 ml) and then extracted it with ethyl acetate (2 × 2 ml). We evaporated the solvent under nitrogen and reconstituted the residue in 100 μl of ethyl acetate and analyzed it by gas chromatography-mass spectrometry (GC-MS).

We added 1 g of muscle or liver tissue to 4 ml of a saturated aqueous solution of sodium bicarbonate and 50 μl of ketamine-d_4 (internal standard, 10 ppm) in methanol to each glass tube. We homogenized and centrifuged the mixture and transferred the supernatant to a falcon tube. We extracted the aqueous phase with ethyl acetate (3 × 3 ml), back extracted pooled organic phases with 0.1 M HCL (2 ×2 ml), and basified the aqueous phase with a saturated aqueous solution of sodium bicarbonate (4 ml). We extracted the resultant solution with ethyl acetate (2 × 2 ml), evaporated the solvent under nitrogen, and reconstituted the residue in 100 μl of ethyl acetate and analyzed it by GC-MS.

We derived the standard calibration curve by adding serum, urine, or tissue to 100 μl of a mixture of tiletamine HCl and zolzepam HCl at concentrations (ppm) of 0.1, 0.5, 1.0, 5.0, 10.0, and 50.0 in water. We similarly processed serum, urine, and tissue the same way as these standard calibration samples. Each standard curve was linear throughout the range and had an R squared value >0.99.

We analyzed all samples using an Agilent Technologies Gas Chromatograph – Mass Spectrometer (GC-MS; Wilmington, DE) equipped with a gas chromatograph Model 6890 that was coupled to a Model 5973 mass detector. We set operational parameters of the GC to an initial oven temperature of 120° C and held it there for one minute; we programmed oven temperature to increase at a rate of 25° C per minute until 300° C and then hold at 300° C for 408 seconds. We set front inlet temperature to 270° C, used helium gas as the carrier, and set the instrument for splitless mode with a constant flow rate of carrier gas of 1.5 ml/min. The capillary column was an Agilent HP-5MS (5% Phenyl Methyl Siloxane; 27.0 m × 0.25 m, at a film thickness 0.25 μm).

We set temperatures for the Mass Spectrometer Detector (MSD) transfer line, quadripole, and source at 270° C, 150° C, and 230° C, respectively. We set the MSD acquisition parameters to an acquisition mode of single ion monitoring (SIM) and a solvent delay of 4 minutes. We monitored the specific ions for the following compounds: tiletamine – 166.10 and 195.20 with a dwell time of 100 milliseconds (msec); zolazepam

– 257.20, 267.20, and 285.20 with a dwell time of 100 msec; and ketamine-d4 – 184.10 and 213.20 with a dwell time of 100 msec.

RESULTS

Of the 14 captive black bear, we found detectable levels of tiletamine and zolazepam in the serum of 2 black bears in the 7-day group and trace amounts of either tiletamine or zolazepam in the urine of one 3-day and one 14-day black bear (Table 1). One black bear from the 7-day group was the only one of 14 sampled to have detectable levels of either tiletamine or zolazepam in its liver or muscle tissue. All 6 serum samples from live black bears had both tiletamine and zolazepam present in their blood (Table 2). Concentrations of both drugs were much higher in serum samples taken 1 hour after capture from live animals than those found in experimental bears.

DISCUSSION

Our findings demonstrate that black bears are capable of quickly metabolizing and eliminating Telazol to undetectable levels within several (7–14) days and support the conclusions of Semple et al. (2000). High concentrations of Telazol in serum samples taken from live black bears 1 hour postimmobilization revealed our ability to detect presence of tiletamine and zolazepam. We suggest that it is safe, from a public concern standpoint, to use Telazol to immobilize black bears up to 15 days prior to hunting seasons. However, complete certainty would require an experimentation study with increased sample sizes which is unlikely from a practical standpoint. Of bears in the 14-day and 21-day groups, only one 14-day bear had trace amounts of zolazepam in its urine; all others had no detectable level of Telazol. Moreover, we only detected Telazol within muscle or liver tissue, the parts most likely to be consumed by humans, from one bear in the 7-day group. We held our black bears in captivity with limited mobility for a known number of days, which may have affected metabolism rates. However, our results concur with Semple et al. (2000) who used polar bears that were relocated and killed by hunters. Our results would not have concurred with Semple et al. (2000) if retention rates of tiletamine or zolazepam were strongly affected by activity level of bears, even though bears were different species.

Management Implications

Wildlife managers are often faced with an ever increasing workload and limited time to complete their duties meaning that providing managers greater flexibility to conduct field work is beneficial. Our results provide evidence that Telazol does not remain in a black bear's system for an extended period of time and that it is likely safe to immobilize black bears closer to hunting seasons than previously thought.

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Table 1. Concentrations (ppm) of tiletamine and zolazepam in serum, liver, muscle, and urine samples for black bears held for 3 days, 7 days, 14 days, and 21 days postimmobilization with Telazol® (Fort Dodge Animal Health, Fort Dodge, IA), Virginia, USA (Apr – Aug 2005). We performed double tests on each sample when available.

				Serum		Liver		Muscle		Urine	
Day	Sex	Wt (kg)	Age (yr)	Tiletamine	Zolazepam	Tiletamine	Zolazepam	Tiletamine	Zolazepam	Tiletamine	Zolazepam
3	F	68	3	ND[1]	ND	ND	ND	ND	ND	0.090	ND
3	F	68	3	ND	ND	ND	ND	ND	ND	0.080	ND
3	F	67	8	ND	ND	ND	ND	ND	ND	ND	ND
3	F	67	8	ND	ND	ND	ND	ND	ND	ND	ND
3	M	166	6	ND	ND	ND	ND	ND	ND	ND	ND
3	M	166	6	ND	ND	ND	ND	ND	ND	ND	ND
3	M	176	13	ND	ND	ND	ND	ND	ND	ND	ND
3	M	176	13	ND	ND	ND	ND	ND	ND	ND	ND

7	M	83	2	ND	ND	ND	ND	ND	ND	ND	ND
7	M	83	2	ND	ND	ND	ND	ND	ND	ND	ND
7	M	84	3	0.020	0.060	ND	0.032	0.015	0.014	NA[2]	NA
7	M	84	3	0.020	0.060	ND	0.357	0.014	0.013	NA	NA
7	M	73	NA	ND	ND	ND	ND	ND	ND	ND	ND
7	M	73	NA	ND	ND	ND	ND	ND	ND	ND	ND
7	M	114	5	0.160	0.600	ND	ND	ND	ND	NA	NA
7	M	114	5	0.130	0.680	ND	ND	ND	ND	NA	NA
14	M	170	8	ND	ND	ND	ND	ND	ND	ND	ND
14	M	170	8	ND	ND	ND	ND	ND	ND	ND	ND
14	M	139	12	ND	ND	ND	ND	ND	ND	ND	ND
14	M	139	12	ND	ND	ND	ND	ND	ND	ND	ND
14	F	59	6	ND	ND	ND	ND	ND	ND	ND	0.060
14	F	59	6	ND	ND	ND	ND	ND	ND	ND	0.060
14	F	66	14	ND	ND	ND	ND	ND	ND	ND	ND
14	F	66	14	ND	ND	ND	ND	ND	ND	ND	ND

21	M	142	4	ND	ND	ND	ND	ND	ND	ND	ND
21	M	142	4	ND	ND	ND	ND	ND	ND	ND	ND
21	M	55	1	ND	ND	ND	ND	ND	ND	NA	NA
21	M	55	1	ND	ND	ND	ND	ND	ND	NA	NA

[1]Not detectable

[2]Not available

Table 2. Concentrations (ppm) of tiletamine and zolazepam in serum from black bears 1 hour postimmobilization with Telazol® (Fort Dodge Animal Health, Fort Dodge, IA), West Virginia, USA, March 2005. We performed double tests on each sample when available.

Sex	Age (yr)	Tiletamine	Zolzepam
F	11	1.15	3.05
F	11	1.07	3.02
F	5	0.54	1.27
F	5	0.52	1.28
F	6	0.87	2.26
F	6	0.84	2.27
F	11	0.61	1.22
F	11	0.60	1.19
F	5	1.01	2.40
F	3	1.13	2.63

F	3	1.07	2.68

Appendix 1. Black bear parameters used in RISKMAN for population models for two study areas in West Virginia, USA, 1971–2007.

Parameter	Southern	Mountain	Description
Adult 1-cub litters	0.024	0.052	Proportion of black bears ≥ 5-years old with 1-cub litter.
Adult 2-cub litters	0.286	0.284	Proportion of black bears ≥ 5-years old with 2-cub litter.
Adult 3-cub litters	0.524	0.515	Proportion of black bears ≥ 5-years old with 3-cub litter.
Adult 4-cub litters	0.143	0.142	Proportion of black bears ≥ 5-years old with 4-cub litter.
Adult 5-cub litters	0.023	0.007	Proportion of black bears ≥ 5-years old with 5-cub litter.
Subadult 1-cub litters	0.105	0.143	Proportion of black bears 3 or 4-years old with 1-cub litter.
Subadult 2-cub litters	0.632	0.571	Proportion of black bears 3 or4-years old with 2-cub litter.
Subadult 3-cub litters	0.263	0.143	Proportion of black bears 3 or 4-years old with 3-cub litter.
Subadult 4-cub litters	0.000	0.143	Proportion of black bears 3 or 4-years old with 4-cub litter.
Subadult 5-cub litters	0.000	0.000	Proportion of black bears 3 or4-years old with 5-cub litter.

Appendix 1 continued.

Parameter	Southern	Mountain	Description
Adult female success	0.97	0.97	Proportion of black bears ≥ 5– years old that were available to reproduce and successfully had cubs.
Subadult female success	1.00	0.64	Proportion of female bears 3 or 4-years old that were available to reproduce and successfully had cubs.
Age of primiparity	3	3	Age when at first possible reproduction.
Adult female survival	0.86	0.91	Probability of female black bear ≥5-years old surviving one year.
Subadult female survival	0.76	0.77	Probability of female black bear 3 or 4-years old surviving one year.
Juvenile female survival	0.84	0.77	Probability of female black bear 1 or 2-years old surviving one year.
Adult male survival	0.79	0.63	Probability of male black bear ≥ 5-years old surviving one year.
Subadult female survival	0.78	0.45	Probability of male black bear 3 or 4-years old surviving one year.
Juvenile female survival.	0.41	0.29	Probability of male black bear 1 or2-years old surviving one year.

Appendix 2. A priori models and model selection explaining synchronous reproduction black bear reproduction in West Virginia, USA.

Description	AICc	Delta AICc	AICc weights	No. Parameters
Mast	-7.73	0.00	0.30	2
Mast lag one year	-7.68	0.05	0.30	2
Population size	-7.51	0.22	0.27	2

Appendix 3. A priori models[a] and model selection of known fate female black bear survival in northern West Virginia, USA, June 1991–December 2007.

Model	**Description**	**Delta $QAIC_c$**	**$QAIC_c$**	**AIC_c weights**	**Model likelihoods**	**No. parameters**
2	Age3	290.555	0.000	0.495	1.000	3
3	Age3 + Mast	292.354	1.800	0.201	0.407	4
8	.	292.571	2.017	0.181	0.365	1
4	Age5	294.578	4.023	0.066	0.134	5
7	Time + Mast	296.368	5.813	0.027	0.055	15
5	Age5 + Mast	296.392	5.838	0.027	0.054	6
9	Time	300.617	10.062	0.003	0.007	17
6	Age5 + Time	315.144	24.589	0.000	0.000	21
1	Global	422.003	131.448	0.000	0.000	85

Appendix 3 continued.

[a] Estimate of overdispersion was 1.23. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and 5+ years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and 5+ years old (Age5); mast failures that occurred in 1997 and 2002 (Mast); where all parameters are constant (.); and differences in over time (Time).

Appendix 4. Annual survival estimates of female black bears in northern West Virginia, USA, June 1991–December 2007. Model provided highest AIC_c weight (0.495) from known fate data in Program MARK.

Parameter	Survival Estimate	SE	95% CI	
1[a]	0.77	0.13	0.44	0.93
2[b]	0.78	0.08	0.59	0.89
3[c]	0.91	0.01	0.88	0.94

[a] One and two-year olds.

[b] Three and four-year olds.

[c] ≥ 5-years old.

Appendix 5. Annual survival estimates of female black bears in northern West Virginia, USA, June 1991–December 2007. Model provided second highest AIC_c weight (0.201) from known fate data in Program MARK.

Parameter	**Survival Estimate**	**SE**	**95% CI**	
1[a]	0.77	0.13	0.44	0.93
2[b]	0.78	0.08	0.59	0.89
3[c]	0.91	0.01	0.88	0.94
4[d]	0.93	0.04	0.81	0.98

[a] One and two-year olds.

[b] Three and four-year olds.

[c] ≥ 5-years old.

[d] Female survival during mast failures of 1997 and 2002.

Appendix 6. Annual survival estimates of female black bears in northern West Virginia, USA, June 1991–December 2007. Model provided third highest AIC_c weight (0.181) from known fate data in Program MARK.

Parameter	Survival Estimate	SE	95% CI	
1[a]	0.90	0.01	0.87	0.93

[a] Female survival grouped by years and age classes.

Appendix 7. Annual survival estimates of female black bears in northern West Virginia, USA, June 1991–December 2007. Model provided fourth highest AIC_c weight (0.066) from known fate data in Program MARK.

Parameter	**Survival Estimate**	**SE**	**95% CI**	
1[a]	0.80	0.20	0.26	0.98
2[b]	0.75	0.17	0.34	0.95
3[c]	0.77	0.13	0.44	0.93
4[d]	0.78	0.10	0.54	0.92
5[e]	0.91	0.01	0.88	0.94

[a] One-year old

[b] Two-year old

[c] Three-year old

[d] Four-year old

Appendix 7 continued.

[e] Five-year old

Appendix 8. A priori models[a] and model selection of female black bear survival in southern West Virginia, USA, June 1996–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
3	ES + Age3	274.217	0.000	0.508	1.000	5
8	ES	276.807	2.590	0.139	0.274	2
5	ES + Age3 + Mast	277.233	3.016	0.112	0.221	9
9	ES + Age5	278.012	3.795	0.076	0.150	7
2	Age3	278.909	4.692	0.049	0.096	2
11	Mast	279.218	5.001	0.042	0.082	2
12	Group	280.781	6.564	0.019	0.038	3
6	Age5	280.831	6.614	0.019	0.037	3
10	ES + Age5 +Mast	281.828	7.610	0.011	0.022	12
13	Time + Mast	282.259	8.042	0.009	0.018	11

Appendix 8 continued.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
4	Age3 + Group	282.485	8.268	0.008	0.016	4
7	Age5 + Group	282.485	8.268	0.008	0.016	4
1	Global	414.320	140.103	0.000	0.000	80

[a] Estimate of overdispersion was 1.03. Models generated using the known fate model in Program MARK. Models parameters included: early hunting seasons that occurred 2002–2007 (ES); combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥5-years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and ≥5-years old (Age5); research, nuisance black bears translocated, and nuisance black bears not translocated (Group); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Recapture probability.

Appendix 8 continued.

[d] Reporting probability.

[e] Fidelity.

Appendix 9. Annual survival estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided highest AIC_c weight (0.508) from known fate data in Program MARK.

Parameter	Survival Estimate	SE	95% CI	
1[a]	0.45	806.57	0.00	1.00
2[b]	1.00	0.00	1.00	1.00
3[c]	0.89	0.04	0.78	0.94
4[d]	0.79	0.11	0.50	0.93
5[e]	0.97	0.03	0.80	1.00
6[f]	0.78	0.03	0.71	0.83

[a] One and two-year olds without an early hunting season.

[b] Three and four-year olds without an early hunting season.

[c] ≥ 5-years old without an early hunting season.

[d] One and two-year olds with an early hunting season.

[e] Three and four-year olds with an early hunting season.

[f] ≥ 5-years old with an early hunting season.

Appendix 10. Annual survival estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided second highest AIC_c weight (0.139) from known fate data in Program MARK.

Parameter	**Survival Estimate**	**SE**	**95% CI**	
1[a]	0.89	0.04	0.78	0.95
2[b]	0.80	0.03	0.75	0.85

[a] Survival without an early hunting season.

[b] Survival with an early hunting season.

Appendix 11. Annual survival estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided third highest AIC_c weight (0.112) from known fate data in Program MARK.

Parameter	Survival Estimate	SE	95% CI	
1[a]	0.45	0.00	0.45	0.45
2[b]	0.45	0.00	0.45	0.45
3[c]	0.88	0.04	0.76	0.94
4[d]	1.00	0.00	1.00	1.00
5[e]	1.00	0.00	1.00	1.00
6[f]	0.78	0.03	0.71	0.83
7[g]	0.45	0.00	0.45	0.45
8[h]	0.75	0.13	0.44	0.92
9[i]	1.00	0.00	1.00	1.00
10[j]	0.83	0.15	0.36	0.98
11[k]	1.00	0.00	1.00	1.00
12[l]	0.78	0.10	0.53	0.92

[a] One and two-year old without an early hunting season and without a mast failure.

Appendix 11 continued.

[b] Three and four-year old without an early hunting season and without a mast failure.

[c] ≥ Five-year old without an early hunting season and without a mast failure.

[d] One and two-year old with an early hunting season and without a mast failure.

[e] Three and four-year old with an early hunting season and without a mast failure.

[f] ≥ Five-year old with an early hunting season and without a mast failure.

[g] One and two-year old without an early hunting season but with a mast failure.

[h] One and two-year old with an early hunting season and a mast failure.

[i] Three and four-year old without an early hunting season but with a mast failure.

[j] Three and four-year old with an early hunting season and a mast failure.

k ≥ Five-year old without an early hunting season but with a mast failure.

[l] ≥ Five-year old with an early hunting season and a mast failure.

Appendix 12. Annual survival estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided fourth highest AIC_c weight (0.076) from known fate data in Program MARK.

Parameter	**Survival Estimate**	**SE**	**95% CI**	
1[a]	0.45	0.00	0.45	0.45
2[b]	0.45	0.00	0.45	0.45
3[c]	0.45	0.00	0.45	0.45
4[d]	1.00	0.00	1.00	1.00
5[e]	0.87	0.04	0.76	0.94
6[f]	0.67	0.28	0.15	0.96
7[g]	0.82	0.12	0.49	0.96
8[h]	1.00	0.00	1.00	1.00
9[i]	0.95	0.05	0.70	0.99
10[j]	0.78	0.03	0.71	0.83

[a] One-year old without an early hunting season.

[b] Two-year old without an early hunting season.

[c] Three-year old without an early hunting season.

[d] Four-year old without an early hunting season.

[e] ≥ Five-year old without an early hunting season.

Appendix 12 continued.

[f] One-year old with an early hunting season.

[g] Two-year old with an early hunting season.

[h] Three-year old without an early hunting season.

Appendix 12 continued.

[i] Four-year old with an early hunting season.

[j] ≥ Five-year old with an early hunting season.

Appendix 13. Annual survival estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided fifth highest AIC_c weight (0.049) from known fate data in Program MARK.

Parameter	**Survival Estimate**	**SE**	**95% CI**	
1[a]	0.45	0.00	0.45	0.45
2[b]	1.00	0.00	1.00	1.00
3[c]	0.82	0.02	0.77	0.86

[a] One and two-year old.

[b] Three and four-year old.

[c] ≥ Five-year old.

Appendix 14. A priori models[a] and model selection of female black bear survival in northern West Virginia, USA, June 1991–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
2	s(Age3)r(.)p(.)f(.)	1022.98	0.00	0.70	1.00	6
3	s(Age5)r(.)p(.)f(.)	1024.68	1.70	0.30	0.43	8
4	s(.)r(.)p(.)f(.)	1042.95	19.97	0.00	0.00	4
5	s(Time)r(.)p(.)f(.)	1060.72	37.74	0.00	0.00	20
6	s(Time + Mast)r(.)p(.)f(.)	1060.72	37.74	0.00	0.00	20
7	s(Time)r(Time)p(Time)f(Time)	1109.93	86.95	0.00	0.00	64
1	Global	1139.54	116.56	0.00	0.00	96

Appendix 14 continued.

[a] Estimate of overdispersion was 1.03. Models generated using the Burnham model in Program MARK. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥ 5 years old (Age3); age structure of 1-year old, 2-year

old, 3-year old, 4-year old, and ≥ 5years old (Age5); constant (.); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

Appendix 15. Annual survival, reporting, recapture, and fidelity estimates of female black bears in northern West Virginia, USA, June 1991–December 2007. Model provided highest AIC_c weight (0.700) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.62	0.05	0.52	0.71
2[b]	0.86	0.04	0.77	0.91
3[c]	0.85	0.02	0.80	0.89
4[d]	0.97	0.01	0.95	0.99
5[e]	0.50	0.05	0.41	0.59
6[f]	0.93	0.02	0.88	0.96

[a] One and two-year old survival.

[b] Three and four-year old survival.

[c] ≥ Five-year old survival.

[d] Reporting constant.

[e] Recapture constant.

[f] Fidelity constant.

Appendix 16. Annual survival, reporting, recapture, and fidelity estimates of female black bears in northern West Virginia, USA, June 1991–December 2007. Model provided second highest AIC_c weight (0.300) from Burnham model in Program MARK.

Parameter	**Estimate**	**SE**	**95% CI**	
1[a]	0.58	0.07	0.44	0.71
2[b]	0.66	0.07	0.51	0.78
3[c]	0.92	0.05	0.74	0.98
4[d]	0.82	0.05	0.69	0.90
5[e]	0.86	0.02	0.80	0.90
6[f]	0.97	0.01	0.95	0.99
7[g]	0.51	0.05	0.41	0.60
8[h]	0.93	0.02	0.88	0.96

[a] One-year old survival.

[b] Two-year old survival.

[c] Three-year old survival.

[d] Four-year old survival

[e] Five-year old survival.

[f] Reporting constant.

[g] Recapture constant.

[h] Fidelity constant.

Appendix 17. A priori models[a] and model selection of female black bear survival in southern West Virginia, USA, June 1996–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
2	s[b](Age3)r[c](Group)p[d](Group)f[e](Group)	954.771	0.000	0.321	1.000	12
13	s(Group)r(Group)p(Group)f(Group)	954.831	0.060	0.311	0.970	12
6	s(Age3 + ES)r(Group)p(Group)f(Group)	954.956	0.185	0.292	0.912	15
14	s(Group)r(Group)p(.)f(.)	959.120	4.350	0.036	0.114	8
15	s(Group)r(Group)p(Group)f(.)	959.366	4.596	0.032	0.101	10
18	s(Group + ES)r(pf(.)	965.534	10.764	0.001	0.005	9
16	s(Group)r(.)p(.)f(.)	966.291	11.521	0.001	0.003	6
3	s(Age3 + ES)r(.)p(.)f(.)	966.416	11.646	0.001	0.003	9
10	s(Age5)r(.)p(.)f(.)	966.546	11.776	0.001	0.003	8
7	s(Age3)r(.)p(.)f(.)	966.801	12.031	0.001	0.002	6

Appendix 17 continued.

Model	**Description**	**$QAIC_c$**	**Delta $QAIC_c$**	**AIC_c weights**	**Model likelihoods**	**No. parameters**
5	s(Age3 + ES + Group)r(Group)p(Group)F(Group)	966.921	12.151	0.001	0.002	25
4	s(Age3 + Mast)r(pf(.)	969.114	14.343	0.000	0.001	9
17	s(Group +Mast)r(pf(.)	969.576	14.806	0.000	0.001	9
19	s(Time)r(.)p(.)f(.)	969.697	14.926	0.000	0.001	13
8	s(Age3 +Group)r(.)p(.)f(.)	971.920	17.150	0.000	0.000	12
11	s(Age5 +Group)r(.)p(.)f(.)	972.651	17.880	0.000	0.000	17
1	(Global)	974.485	19.714	0.000	0.000	33
9	s(Age3 + ES + Group)r(.)p(.)f(.)	975.517	20.746	0.000	0.000	19
12	s(Age5 + ES +Group)r(.)p(.)f(.)	983.437	28.667	0.000	0.000	31

Appendix 17 continued.

[a] Estimate of overdispersion was 1.03. Models generated using the Burnham model in Program MARK. Models parameters included: early hunting seasons that occurred 2002–2007 (ES); combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥ 5 years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and ≥ 5years old (Age5); research, nuisance black bears translocated, and nuisance black bears not translocated (Group); constant or time and group (.); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

Appendix 18. Annual survival, reporting, recapture, and fidelity estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided highest AIC_c weight (0.321) from Burnham model in Program MARK.

Parameter	**Estimate**	**SE**	**95% CI**	
1[a]	0.75	0.08	0.57	0.87
2[b]	0.73	0.07	0.58	0.84
3[c]	0.76	0.03	0.70	0.82
4[d]	0.89	0.03	0.81	0.94
5[e]	0.97	0.03	0.83	1.00
6[f]	0.52	0.22	0.16	0.86
7[g]	0.61	0.07	0.47	0.74
8[h]	0.67	0.12	0.41	0.86
9[i]	0.38	0.16	0.14	0.70
10[j]	0.81	0.04	0.71	0.88
11[k]	1.00	0.00	1.00	1.00
12[l]	0.70	0.18	0.29	0.93

[a] One and two-year old survival.

[b] Three and four-year old survival.

[c] ≥ Five-year old survival.

[d] Reporting probability of research black bears.

Appendix 18 continued.

[e] Reporting probability of nuisance black bears not translocated.

[f] Reporting probability of translocated nuisance black bears.

[g] Recapture probability of research black bears.

[h] Recapture probability of nuisance black bears not translocated.

[i] Recapture probability of translocated nuisance black bears.

[j] Fidelity of research black bears.

[k] Fidelity of nuisance black bears not translocated.

[l] Fidelity of translocated nuisance black bears.

Appendix 19. Annual survival, reporting, recapture, and fidelity estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided second highest AIC_c weight (0.311) from Burnham model in Program MARK.

Parameter	**Estimate**	**SE**	**95% CI**	
1[a]	0.77	0.04	0.68	0.84
2[b]	0.74	0.06	0.61	0.84
3[c]	0.73	0.18	0.31	0.94
4[d]	0.89	0.03	0.81	0.94
5[e]	0.97	0.03	0.83	1.00
6[f]	0.52	0.22	0.16	0.86
7[g]	0.64	0.08	0.47	0.78
8[h]	0.67	0.12	0.41	0.86
9[i]	0.36	0.18	0.11	0.73
10[j]	0.79	0.04	0.70	0.87
11[k]	1.00	0.00	1.00	1.00
12[l]	0.71	0.23	0.21	0.96

[a] Research black bear survival.

[b] Nuisance black bears not translocated survival.

[c] Translocated nuisance black bear survival.

[d] Reporting probability of research black bears.

Appendix 19 continued.

[e] Reporting probability of nuisance black bears not translocated.

[f] Reporting probability of translocated nuisance black bears.

[g] Recapture probability of research black bears.

[h] Recapture probability of nuisance black bears not translocated.

[i] Recapture probability of translocated nuisance black bears.

[j] Fidelity of research black bears.

[k] Fidelity of nuisance black bears not translocated.

[l] Fidelity of translocated nuisance black bears.

Appendix 20. Annual survival, reporting, recapture, and fidelity estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided third highest AIC_c weight (0.292) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.84	0.11	0.53	0.96
2[b]	0.76	0.13	0.45	0.93
3[c]	0.86	0.05	0.74	0.93
4[d]	0.67	0.09	0.47	0.82
5[e]	0.68	0.07	0.52	0.80
6[f]	0.72	0.04	0.64	0.79
7[g]	0.89	0.03	0.81	0.94
8[h]	0.97	0.03	0.83	1.00
9[i]	0.52	0.22	0.16	0.86
10[j]	0.56	0.06	0.45	0.67
11[k]	0.67	0.12	0.41	0.85
12[l]	0.36	0.15	0.13	0.67
13[m]	0.83	0.04	0.74	0.90
14[n]	1.00	0.00	1.00	1.00
15[o]	0.71	0.19	0.29	0.93

[a] One and two-year old survival without an early season.

Appendix 20 continued.

[b] Three and four-year old survival without an early season.

[c] ≥ Five-year old survival without an early season.

[d] One and two-year old survival with an early season.

[e] Three and four-year old survival with an early season.

[f] ≥ Five-year old survival with an early season.

[g] Reporting probability of research black bears.

[h] Reporting probability of nuisance black bears not translocated.

[I] Reporting probability of translocated nuisance black bears.

[j] Recapture probability of research black bears.

[k] Recapture probability of nuisance black bears not translocated.

[l] Recapture probability of translocated nuisance black bears.

[m] Fidelity of research black bears.

[n] Fidelity of nuisance black bears not translocated.

[o] Fidelity of translocated nuisance black bears.

Appendix 21. Annual survival, reporting, recapture, and fidelity estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided fourth highest AIC_c weight (0.036) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.75	0.04	0.67	0.82
2[b]	0.79	0.06	0.65	0.89
3[c]	0.83	0.14	0.42	0.97
4[d]	0.88	0.04	0.79	0.94
5[e]	0.97	0.03	0.84	1.00
6[f]	0.35	0.16	0.12	0.68
7[g]	0.61	0.07	0.47	0.73
8[h]	0.84	0.04	0.75	0.90

[a] Research black bear survival.

[b] Nuisance black bears not translocated survival.

[c] Translocated nuisance black bear survival.

[d] Reporting probability of research black bears.

[e] Reporting probability of nuisance black bears not translocated.

[f] Reporting probability of translocated nuisance black bears.

[g] Recapture probability constant.

[h] Fidelity constant.

Appendix 22. Annual survival, reporting, recapture, and fidelity estimates of female black bears in southern West Virginia, USA, June 1996–December 2007. Model provided fifth highest AIC_c weight (0.032) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.75	0.04	0.67	0.81
2[b]	0.83	0.07	0.64	0.93
3[c]	0.68	0.13	0.38	0.87
4[d]	0.88	0.04	0.79	0.94
5[e]	0.97	0.03	0.83	1.00
6[f]	0.46	0.19	0.16	0.79
7[g]	0.60	0.07	0.47	0.72
8[h]	0.84	0.21	0.20	0.99
9[i]	0.34	0.15	0.12	0.65
10[j]	0.84	0.04	0.75	0.90

[a] Research black bear survival.

[b] Nuisance black bears not translocated survival.

[c] Translocated nuisance black bear survival.

[d] Reporting probability of research black bears.

[e] Reporting probability of nuisance black bears not translocated.

[f] Reporting probability of translocated nuisance black bears.

Appendix 22 continued.

[g] Recapture probability of research black bears.

[h] Recapture probability of nuisance black bears not translocated.

[i] Reporting probability of translocated nuisance black bears.

[j] Fidelity constant.

Appendix 23. A priori models[a] and model selection of male black bear survival in northern West Virginia, USA, June 1991–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
5	s[b](Age3)r[c](Group)p[d](Group)f[e](Group)	1262.009	0.000	0.674	1.000	9
9	s(Age5)r(Group)p(Group)f(Group)	1264.318	2.308	0.213	0.315	11
4	s(Age3 + Group)r(Group)p(Group)f(Group)	1265.704	3.695	0.106	0.158	12
8	s(Age5 + Group)r(Group)p(Group)f(Group)	1271.088	9.079	0.007	0.011	16
1	global	1280.552	18.542	0.000	0.001	25
3	s(Age3 + Mast)rpf(.)	1325.917	63.908	0.000	0.000	9
2	s(Age3)rpf(.)	1326.064	64.055	0.000	0.000	6
6	s(Age5)rpf(.)	1328.269	66.259	0.000	0.000	8
7	s(Age5 + Mast)rpf(.)	1332.303	70.294	0.000	0.000	13
10	s(Group)rpf(.)	1333.504	71.495	0.000	0.000	5

Appendix 23 continued.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
11	s(Time)rpf(.)	1359.039	97.030	0.000	0.000	20

[a] Estimate of overdispersion was 1.19. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and 5+ years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and 5+ years old (Age5); research or nuisance (Group); mast failures that occurred in 1997 and 2002 (Mast); where all parameters are constant (.); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

Appendix 24. Annual survival, reporting, recapture, and fidelity estimates of male black bears in northern West Virginia, USA, June 1991–December 2007. Model provided highest AIC_c weight (0.674) from Burnham model in Program MARK.

Parameter	**Estimate**	**SE**	**95% CI**	
1[a]	0.29	0.04	0.22	0.38
2[b]	0.45	0.05	0.36	0.55
3[c]	0.63	0.05	0.53	0.72
4[d]	0.32	0.05	0.23	0.42
5[e]	0.11	0.12	0.01	0.61
6[f]	0.43	0.03	0.38	0.49
7[g]	0.15	0.03	0.10	0.23
8[h]	0.98	0.07	0.04	1.00
9[i]	0.42	0.36	0.04	0.93

[a] One and two-year old survival.

[b] Three and four-year olds survival.

[c] ≥ 5-years old survival.

[d] Reporting probability of research black bears.

[e] Reporting probability of nuisance black bears.

[f] Recapture probability of research black bears.

[g] Recapture probability of nuisance black bears.

Appendix 24 continued.

[h] Fidelity of research black bears.

[i] Fidelity of nuisance black bears.

Appendix 25. Annual survival, reporting, recapture, and fidelity estimates of male black bears in northern West Virginia, USA, June 1991–December 2007. Model provided second highest AIC_c weight (0.213) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.31	0.07	0.20	0.45
2[b]	0.28	0.05	0.19	0.39
3[c]	0.40	0.06	0.29	0.52
4[d]	0.53	0.08	0.38	0.67
5[e]	0.63	0.05	0.53	0.72
6[f]	0.32	0.05	0.23	0.42
7[g]	0.11	0.13	0.01	0.62
8[h]	0.44	0.03	0.38	0.49
9[i]	0.15	0.03	0.10	0.23
10[j]	0.98	0.07	0.07	1.00
11[k]	0.41	0.35	0.04	0.92

[a] One -year old survival.

[b] Two-year old survival.

[c] Three-year old survival.

[d] Four-year old survival.

[e] Five-year old survival.

Appendix 25 continued.

[f] Reporting probability of research black bears.

[g] Reporting probability of nuisance black bears.

[h] Recapture probability of research black bears.

[i] Recapture probability of nuisance black bears.

[j] Fidelity of research black bears.

[k] Fidelity of nuisance black bears.

Appendix 26. Annual survival, reporting, recapture, and fidelity estimates of male black bears in northern West Virginia, USA, June 1991–December 2007. Model provided third highest AIC_c weight (0.106) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.29	0.04	0.21	0.37
2[b]	0.46	0.05	0.36	0.56
3[c]	0.65	0.05	0.55	0.75
4[d]	0.40	0.21	0.11	0.78
5[e]	0.38	0.12	0.18	0.63
6[f]	0.41	0.16	0.16	0.72
7[g]	0.32	0.05	0.23	0.42
8[h]	0.09	0.11	0.01	0.58
9[i]	0.44	0.03	0.38	0.49
10[j]	0.15	0.03	0.09	0.22
11[k]	0.97	0.07	0.24	1.00
12[l]	0.59	0.54	0.02	0.99

[a] One and two-year old research black bear survival.

[b] Three and four-year old research black bear survival.

[c] ≥ Five-year old research black bear survival.

[d] One and two-year old nuisance black bear survival.

Appendix 26 continued.

[e] Three and four-year old nuisance black bear survival.

[f] $\geq$ Five-year old nuisance black bear survival.

[g] Reporting probability of research black bears.

[h] Reporting probability of nuisance black bears.

[i] Recapture probability of research black bears.

[j] Recapture probability of nuisance black bears.

[k] Fidelity of research black bears.

[l] Fidelity of nuisance black bears.

Appendix 27. A priori models[a] and model selection of male black bear survival in southern West Virginia, USA, June 1996–December 2007.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
5	s[b](Age3 +ES)r[c](Group)p[d](Group)f[e](Group)	967.619	0.000	0.871	1.000	15
4	s(Age3)r(Group)p(Group)f(Group)}	971.618	3.999	0.118	0.135	12
17	s(Group)r(Group)p(Group)f(.)	976.746	9.127	0.009	0.010	10
18	s(Group)r(Group)p(Group)f(Group)	980.296	12.677	0.002	0.002	12
16	s(Group)r(Group)p(.)f(.)	984.713	17.094	0.000	0.000	8
6	s(Age3 + Group + ES)r(Group)p(Group)f(Group)	985.729	18.110	0.000	0.000	27
3	s(Age3 + ES)r(.)p(.)f(.)	990.523	22.904	0.000	0.000	9
2	s(Age3)r(.)p(.)f(.)}	995.642	28.023	0.000	0.000	6
11	s(Age5 + ES)r(.)p(.)f(.)	997.881	30.263	0.000	0.000	13
10	s(Age5)r(.p(.)f(.)	999.087	31.468	0.000	0.000	8

Appendix 27 continued.

Model	Description	$QAIC_c$	Delta $QAIC_c$	AIC_c weights	Model likelihoods	No. parameters
9	s(Age3 + Group)r(.)p(.)f(.)	999.922	32.303	0.000	0.000	12
15	s(Group)r(.)p(.)f(.)	1000.685	33.066	0.000	0.000	6
7	s(Age3 + Mast)r(.)p(.)f(.)	1001.473	33.854	0.000	0.000	9
14	{.}	1002.681	35.062	0.000	0.000	4
19	s(Group + ES)r(.)p(.)f(.)	1004.351	36.732	0.000	0.000	9
20	s(Group +Mast)r(.)p(.)f(.)}	1005.420	37.802	0.000	0.000	9
8	s(Age3 + Group + ES)r(.)p(.)f(.)	1005.658	38.039	0.000	0.000	21
21	s(Time)r(.)p(.)f(.)	1009.955	42.336	0.000	0.000	12
11	s(Age5 + Group)r(.)p(.)f(.)	1010.735	43.116	0.000	0.000	18
12	s(Age5 + Group + ES)r(.)p(.)f(.)	1037.118	69.499	0.000	0.000	37
1	Global	1050.762	83.144	0.000	0.000	57

Appendix 27 continued.

[a] Estimate of overdispersion was 1.34. Models generated using the Burnham model in Program MARK. Models parameters included: early hunting seasons that occurred 2002–2007 (ES); combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥ 5 years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and ≥ 5years old (Age5); research, nuisance black bears translocated, and nuisance black bears not translocated (Group); constant or time and group (.); mast failures that occurred in 1997 and 2002 (Mast); and differences in over time (Time).

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

Appendix 28. Annual survival, reporting, recapture, and fidelity estimates of male black bears in southern West Virginia, USA, June 1996–December 2007. Model provided highest AIC_c weight (0.871) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.41	0.09	0.26	0.59
2[b]	0.78	0.09	0.55	0.91
3[c]	0.79	0.07	0.63	0.89
4[d]	0.47	0.08	0.33	0.62
5[e]	0.65	0.06	0.52	0.75
6[f]	0.50	0.06	0.38	0.62
7[g]	0.11	0.03	0.06	0.19
8[h]	0.67	0.15	0.36	0.88
9[i]	0.25	0.04	0.18	0.34
10[j]	0.53	0.05	0.43	0.63
11[k]	0.82	0.10	0.56	0.94
12[l]	0.38	0.05	0.29	0.48
13[m]	1.00	0.00	1.00	1.00
14[n]	0.90	0.13	0.36	0.99
15[o]	1.00	0.00	1.00	1.00

[a] One and two-year old survival without an early hunting season.

Appendix 28 continued.

[b] Three and four-year olds survival without an early hunting season.

[c] ≥ 5-years old survival without an early hunting season.

[d] One and two-year old survival with an early hunting season.

[e] Three and four-year olds survival with an early hunting season.

[f] ≥ 5-years old survival with an early hunting season.

[g] Reporting probability of research black bears.

[h] Reporting probability of nuisance black bears not translocated.

[i] Reporting probability of translocated nuisance black bears.

[j] Recapture probability of research black bears.

[k] Recapture probability of nuisance black bears not translocated.

[l] Fidelity of research black bears.

[m] Fidelity of nuisance black bears not translocated.

[n] Fidelity of translocated nuisance black bears.

Appendix 29. Annual survival, reporting, recapture, and fidelity estimates of male black bears in southern West Virginia, USA, June 1996–December 2007. Model provided second highest AIC_c weight (0.117) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.45	0.06	0.34	0.57
2[b]	0.68	0.05	0.57	0.77
3[c]	0.62	0.05	0.52	0.71
4[d]	0.10	0.03	0.06	0.18
5[e]	0.67	0.15	0.36	0.88
6[f]	0.25	0.04	0.17	0.34
7[g]	0.55	0.05	0.45	0.65
8[h]	0.83	0.10	0.56	0.95
9[i]	0.39	0.05	0.30	0.49
10[j]	1.00	0.00	1.00	1.00
11[k]	0.89	0.13	0.37	0.99
12[l]	1.00	0.00	1.00	1.00

[a] One and two-year old survival.

[b] Three and four-year olds survival.

[c] ≥ 5-years old survival.

[d] Reporting probability of research black bears.

Appendix 29 continued.

[e] Reporting probability of nuisance black bears not translocated.

[f] Reporting probability of translocated nuisance black bears.

[g] Recapture probability of research black bears.

[h] Recapture probability of nuisance black bears not translocated.

[i] Recapture probability of translocated nuisance black bears.

[j] Fidelity of research black bears.

[k] Fidelity of nuisance black bears not translocated.

[l] Fidelity of translocated nuisance black bears.

Appendix 30. A priori models[a] and model selection of female black bear survival examining different hunting pressure in southern West Virginia, USA, June 1996–December 2007.

Model	**Description**	**$QAIC_c$**	**Delta $QAIC_c$**	**AIC_c weights**	**Model likelihoods**	**No. parameters**
5	s[b](Age3 + Group)r[c](Group)p[d](Group)f[e](Group)	746.31	0.00	0.75	1.00	12
3	s(Age5 + Group)r(Group)p(Group)f(Group)	749.54	3.23	0.15	0.20	16
4	s(Age3 + Group)r(.)p(.)f(.)	751.69	5.38	0.05	0.07	9
2	s(Group)r(.)p(.)f(.)	751.82	5.51	0.05	0.06	5
10	s(.)r(.)p(.)f(.)	758.66	12.35	0.00	0.00	4
9	s(Age5 + Group)r(.)p(.)f(.)	759.72	13.41	0.00	0.00	13
6	s(Age3 + Group)r(.)p(.)f(.)	760.32	14.01	0.00	0.00	15
7	s(Age3)r(.)p(.)f(.)	762.09	15.78	0.00	0.00	6
8	s(Age5)r(.)p(.)f(.)	764.07	17.76	0.00	0.00	8
1	Global	774.09	27.78	0.00	0.00	23

Appendix 30 continued.

[a] Estimate of overdispersion was 1.34. Models generated using the Burnham model in Program MARK. Models parameters included: combined age structure of 1 and 2-year olds, 3 and 4-year olds, and ≥ 5 years old (Age3); age structure of 1-year old, 2-year old, 3-year old, 4-year old, and ≥ 5years old (Age5); constant with groups and ages together(.); and groups with heavy hunting and light hunting pressure (Group) .

[b] Survival estimation.

[c] Reporting probability.

[d] Recapture probability.

[e] Fidelity.

Appendix 31. Annual survival, reporting, recapture, and fidelity estimates of female black bears in areas with heavy and light hunting pressure in southern West Virginia, USA, June 1996–December 2007. Model provided highest AIC_c weight (0.750) from Burnham model in Program MARK.

Parameter	**Estimate**	**SE**	**95% CI**	
1[a]	0.53	0.10	0.35	0.70
2[b]	0.66	0.08	0.48	0.80
3[c]	0.72	0.04	0.63	0.80
4[d]	1.00	0.00	1.00	1.00
5[e]	0.88	0.08	0.63	0.97
6[f]	0.86	0.04	0.75	0.93
7[g]	0.95	0.03	0.86	0.98
8[h]	0.73	0.08	0.55	0.85
9[i]	0.53	0.06	0.42	0.64
10[j]	1.00	0.00	1.00	1.00
11[k]	0.84	0.04	0.73	0.91
12[l]	0.91	0.05	0.75	0.97

[a] One and two-year old survival with heavy hunting pressure.

[b] Three and four-year old survival with heavy hunting pressure.

[c] ≥ Five-year old survival with heavy hunting pressure.

Appendix 31 continued.

[d] One and two-year old survival with light hunting pressure.

[e] Three and four-year old survival with light hunting pressure.

[f] $\geq$ Five-year old survival with light hunting pressure.

[g] Reporting with heavy hunting pressure.

[h] Reporting with light hunting pressure.

[i] Recapture with heavy hunting pressure.

[j] Recapture with light hunting pressure.

[k] Fidelity with heavy hunting pressure.

[l] Fidelity with light hunting pressure.

Appendix 32. Annual survival, reporting, recapture, and fidelity estimates of female black bears in areas with heavy and light hunting pressure in southern West Virginia, USA, June 1996–December 2007. Model provided second highest AIC_c weight (0.150) from Burnham model in Program MARK.

Parameter	Estimate	SE	95% CI	
1[a]	0.40	0.12	0.20	0.65
2[b]	0.65	0.12	0.39	0.85
3[c]	0.69	0.11	0.45	0.86
4[d]	0.62	0.11	0.40	0.81
5[e]	0.72	0.04	0.64	0.80
6[f]	1.00	0.00	1.00	1.00
7[g]	1.00	0.00	1.00	1.00
8[h]	0.77	0.14	0.43	0.94
9[i]	1.00	0.00	1.00	1.00
10[j]	0.86	0.04	0.75	0.93
11[k]	0.95	0.03	0.86	0.98
12[l]	0.73	0.08	0.55	0.85
13[m]	0.53	0.06	0.42	0.64
14[n]	1.00	0.00	1.00	1.00
15[o]	0.84	0.04	0.73	0.91
16[p]	0.91	0.05	0.75	0.97

Appendix 32 continued.

[a] One-year old survival with heavy hunting pressure.

[b] Two-year old survival with heavy hunting pressure.

[c] Three-year old survival with heavy hunting pressure.

[d] Four-year old survival with heavy hunting pressure.

[e] Five-year old survival with heavy hunting pressure.

[f] One-year old survival with light hunting pressure.

[g] Two-year old survival with light hunting pressure.

[h] Three-year old survival with light hunting pressure.

[i] Four-year old survival with light hunting pressure.

[j] Five-year old survival with light hunting pressure.

[k] Reporting with heavy hunting pressure.

[l] Reporting with light hunting pressure.

[m] Recapture with heavy hunting pressure.

[n] Recapture with light hunting pressure.

[o] Fidelity with heavy hunting pressure.

[p] Fidelity with light hunting pressure.

Appendix 33. Survival estimates of female black bears using Downing population reconstruction in northern West Virginia, 1991–2006. Females ≥ 5-years old collapsed into one age class.

Age[a]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.75	0.88	0.68	0.77	0.88	0.81	0.83	0.73	0.75	0.69	0.86	0.88	0.63	0.87	0.72	0.58
2	0.78	0.79	0.76	0.46	0.87	0.68	0.78	0.60	0.81	0.58	0.60	0.39	0.68	0.56	0.54	0.46
3	0.89	0.78	0.79	0.65	0.78	0.67	0.69	0.71	0.60	0.78	0.67	0.78	0.90	0.80	0.77	0.83
4	0.88	0.90	0.81	0.53	0.88	0.58	0.75	0.76	0.65	0.81	0.82	0.77	0.57	0.79	0.89	0.54
≥ 5	0.87	0.71	0.78	0.72	0.87	0.83	0.86	0.71	0.84	0.82	0.78	0.79	0.75	0.81	0.79	0.86

[a] In years.

Appendix 34. Survival estimates of female black bears using Downing population reconstruction in northern West Virginia, 1991–2006.

Age[a]	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[b]	0.77	0.84	0.72	0.62	0.88	0.74	0.81	0.69	0.78	0.65	0.72	0.72	0.66	0.76	0.62	0.51
Subadults[c]	0.89	0.83	0.80	0.60	0.84	0.64	0.71	0.73	0.62	0.79	0.76	0.78	0.69	0.80	0.85	0.73
Adults[d]	0.87	0.71	0.78	0.72	0.87	0.83	0.86	0.71	0.84	0.82	0.78	0.79	0.75	0.81	0.79	0.86

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-year old.

Appendix 35. Survival estimates of female black bears using cohort population reconstruction in northern West Virginia, 1991–2006.

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.74	0.87	0.76	0.78	0.87	0.83	0.84	0.67	0.74	0.68	0.83	0.83	0.59	0.82	0.72	0.58
2	0.76	0.77	0.73	0.63	0.87	0.62	0.81	0.63	0.74	0.55	0.57	0.26	0.52	0.46	0.35	0.46
3	0.88	0.75	0.76	0.60	0.89	0.69	0.60	0.75	0.64	0.68	0.63	0.75	0.81	0.60	0.66	0.63
4	0.95	0.88	0.77	0.44	0.85	0.82	0.76	0.65	0.71	0.84	0.69	0.73	0.51	0.59	0.70	0.20
≥ 5	0.83	0.67	0.74	0.65	0.82	0.76	0.84	0.68	0.79	0.78	0.75	0.72	0.63	0.68	0.57	0.56

Appendix 36. Survival estimates of female black bears using cohort population reconstruction in northern West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[a]	0.75	0.82	0.75	0.69	0.87	0.73	0.82	0.65	0.74	0.64	0.69	0.63	0.55	0.69	0.55	0.51
Subadults[b]	0.90	0.81	0.77	0.53	0.88	0.76	0.66	0.71	0.68	0.74	0.66	0.75	0.59	0.60	0.68	0.47
Adults[c]	0.83	0.67	0.74	0.65	0.82	0.76	0.84	0.68	0.79	0.78	0.75	0.72	0.63	0.68	0.57	0.56

[a] 1 and 2-year old.

[b] 3 and 4-year old.

[c] ≥ 5-year old.

Appendix 37. Survival estimates of male black bears using Downing population reconstruction in northern West Virginia, 1991–2006. Males ≥ 5-years old collapsed into one age class.

Age[a]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.67	0.73	0.57	0.73	0.72	0.62	0.76	0.59	0.61	0.55	0.43	0.65	0.53	0.65	0.50	0.45
2	0.68	0.57	0.53	0.39	0.75	0.39	0.63	0.58	0.52	0.39	0.47	0.45	0.42	0.41	0.43	0.29
3	0.58	0.72	0.59	0.64	0.58	0.86	0.81	0.53	0.54	0.62	0.67	0.50	0.57	0.73	0.52	0.53
4	0.67	0.59	0.82	0.58	0.59	0.46	0.53	0.27	0.59	0.77	0.77	0.66	0.71	0.41	0.60	0.89
5+	0.93	0.72	0.59	0.61	0.84	0.63	0.67	0.55	0.56	0.70	0.91	0.58	0.60	0.76	0.60	0.71

[a] In years.

Appendix 38. Survival estimates of male black bears using Downing population reconstruction in northern West Virginia, 1991–2006.

Age[a]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Juveniles[b]	0.67	0.66	0.56	0.58	0.73	0.50	0.72	0.58	0.58	0.51	0.45	0.62	0.48	0.56	0.48	0.39
Subadults[c]	0.61	0.68	0.68	0.61	0.59	0.76	0.65	0.41	0.56	0.68	0.72	0.54	0.65	0.68	0.56	0.64
Adults[d]	0.93	0.72	0.59	0.61	0.84	0.63	0.67	0.55	0.56	0.70	0.91	0.58	0.60	0.76	0.60	0.71

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-years old.

Appendix 39. Survival estimates of male black bears using cohort population reconstruction in northern West Virginia, 1991–2006.

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.66	0.75	0.57	0.71	0.74	0.63	0.74	0.57	0.63	0.53	0.44	0.62	0.49	0.61	0.50	0.45
2	0.67	0.54	0.58	0.39	0.72	0.44	0.64	0.52	0.48	0.43	0.42	0.46	0.35	0.31	0.30	0.29
3	0.62	0.71	0.54	0.70	0.57	0.84	0.85	0.55	0.42	0.55	0.71	0.40	0.59	0.63	0.27	0.18
4	0.78	0.65	0.81	0.49	0.69	0.44	0.45	0.44	0.62	0.63	0.70	0.73	0.55	0.45	0.35	0.67
≥ 5	0.93	0.74	0.65	0.65	0.84	0.68	0.72	0.56	0.65	0.78	0.91	0.54	0.59	0.69	0.47	0.39

Appendix 40. Survival estimates of male black bears using cohort population reconstruction in northern West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[a]	0.66	0.66	0.57	0.56	0.73	0.53	0.71	0.55	0.58	0.50	0.43	0.59	0.42	0.50	0.44	0.39
Subadults[b]	0.67	0.68	0.65	0.63	0.63	0.74	0.67	0.49	0.48	0.58	0.71	0.51	0.57	0.59	0.32	0.29
Adults[c]	0.93	0.74	0.65	0.65	0.84	0.68	0.72	0.56	0.65	0.78	0.91	0.54	0.59	0.69	0.47	0.39

[a] 1 and 2-year old.

[b] 3 and 4-year old.

[c] ≥ 5-year old.

Appendix 41. Survival estimates of female black bears using Downing population reconstruction in southern West Virginia, 1991–2006. Females ≥ 5-years old collapsed into one age class.

Age[a]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.90	0.97	0.85	0.89	0.91	0.86	0.90	0.82	0.81	0.66	0.84	0.84	0.84	0.81	0.57	0.49
2	0.84	0.76	0.75	0.69	0.82	0.79	0.86	0.84	0.89	0.84	0.83	0.81	0.59	0.78	0.77	0.38
3	0.69	0.86	0.91	0.91	0.79	0.77	0.91	0.83	0.76	0.90	1.00	0.89	0.67	0.79	0.83	0.72
4	0.93	0.00	0.47	0.84	0.83	0.81	0.78	0.83	0.87	0.71	0.97	0.84	0.63	0.87	0.78	0.82
≥ 5	0.91	0.95	0.91	0.84	0.89	0.82	0.78	0.95	0.84	0.82	0.83	0.74	0.77	0.77	0.71	0.80

[a] In years.

Appendix 42. Survival estimates of female black bears using Downing population reconstruction in southern West Virginia, 1991–2007.

Age[a]	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[b]	0.87	0.91	0.81	0.80	0.87	0.82	0.88	0.83	0.85	0.74	0.83	0.82	0.74	0.79	0.70	0.45
Subadults[c]	0.91	0.75	0.70	0.89	0.81	0.79	0.86	0.83	0.81	0.83	0.99	0.87	0.65	0.83	0.81	0.77
Adults[d]	0.91	0.95	0.91	0.84	0.89	0.82	0.78	0.95	0.84	0.82	0.83	0.74	0.77	0.77	0.71	0.80

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-year old.

Appendix 43. Survival estimates of female black bears using cohort population reconstruction in southern West Virginia, 1991–2006.

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.93	0.98	0.85	0.88	0.90	0.85	0.92	0.79	0.75	0.62	0.81	0.81	0.77	0.70	0.57	0.49
2	0.91	0.83	0.75	0.69	0.81	0.78	0.85	0.87	0.86	0.76	0.80	0.77	0.48	0.66	0.58	0.38
3	0.96	0.93	0.95	0.91	0.79	0.75	0.90	0.81	0.82	0.88	1.00	0.87	0.59	0.67	0.69	0.33
4	0.79	0.91	0.75	0.90	0.84	0.80	0.75	0.82	0.85	0.79	0.96	0.75	0.54	0.81	0.59	0.60
≥5	0.81	0.84	0.84	0.80	0.87	0.80	0.76	0.95	0.82	0.79	0.82	0.71	0.70	0.67	0.54	0.57

Appendix 44. Survival estimates of female black bears using cohort population reconstruction in southern West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[a]	0.92	0.92	0.81	0.79	0.86	0.81	0.89	0.83	0.80	0.68	0.81	0.79	0.65	0.68	0.58	0.45
Subadults[b]	0.90	0.92	0.84	0.91	0.81	0.77	0.84	0.82	0.83	0.83	0.98	0.81	0.57	0.74	0.66	0.47
Adults[c]	0.81	0.84	0.84	0.80	0.87	0.80	0.76	0.95	0.82	0.79	0.82	0.71	0.70	0.67	0.54	0.57

[a] 1 and 2-year old.

[b] 3 and 4-year old.

[c] $\geq$ 5-year old.

Appendix 45. Survival estimates of male black bears using Downing population reconstruction in southern West Virginia, 1991–2007. Males ≥ 5-years old collapsed into one age class.

Age[a]	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
0	1.00	1.00	1.00	0.98	0.98	0.93	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.96	0.96	0.98
1	0.66	0.84	0.59	0.76	0.72	0.55	0.67	0.70	0.62	0.57	0.62	0.65	0.54	0.57	0.44	0.29
2	0.69	0.83	0.77	0.73	0.78	0.66	0.89	0.54	0.57	0.61	0.71	0.55	0.45	0.54	0.50	0.29
3	0.90	0.91	0.53	0.87	0.59	0.85	0.75	0.54	0.76	0.50	0.92	0.57	0.47	0.61	0.41	0.63
4	0.00[b]	0.91	0.66	0.86	0.83	0.67	0.65	0.72	0.90	0.70	1.00	0.59	0.61	0.86	0.72	0.54
≥ 5	0.81	0.91	0.66	0.67	0.81	0.86	0.79	0.81	0.84	0.89	0.87	0.80	0.63	0.73	0.72	0.65

[a] In years.

[b] Zero 4-years olds harvested in 1991.

Appendix 46. Survival estimates of male black bears using Downing population reconstruction in southern West Virginia, 1991–2007.

Age[a]	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[b]	0.67	0.84	0.68	0.75	0.74	0.61	0.75	0.66	0.59	0.58	0.65	0.62	0.50	0.56	0.46	0.29
Subadults[c]	0.90	0.91	0.59	0.87	0.74	0.80	0.70	0.63	0.83	0.55	0.95	0.58	0.53	0.68	0.53	0.60
Adults[d]	0.81	0.91	0.66	0.67	0.81	0.86	0.79	0.81	0.84	0.89	0.87	0.80	0.63	0.73	0.72	0.65

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-year old.

Appendix 47. Survival estimates of male black bears using cohort population reconstruction in southern West Virginia, 1991–2006.

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.30	0.66	0.92	0.73	0.85	0.41	0.71	0.71	0.54	0.65	0.52	0.67	0.60	0.67	0.51	0.26
2	0.47	0.51	0.95	0.75	0.83	0.64	0.83	0.66	0.50	0.73	0.56	0.63	0.47	0.64	0.44	0.26
3	0.72	0.86	0.83	0.82	0.76	0.74	0.76	0.36	0.83	0.65	0.89	0.56	0.58	0.63	0.35	0.35
4	1.00	0.81	0.96	0.76	0.85	0.65	0.42	0.77	0.74	0.89	1.00	0.71	0.55	0.91	0.56	0.15
≥ 5	0.76	0.77	0.95	0.77	0.94	0.83	0.69	0.68	0.75	0.89	0.79	0.82	0.71	0.81	0.70	0.30

Appendix 48. Survival estimates of male black bears using cohort population reconstruction in southern West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[a]	0.38	0.63	0.93	0.73	0.85	0.53	0.74	0.70	0.52	0.67	0.53	0.66	0.55	0.66	0.48	0.26
Subadults[b]	0.79	0.84	0.91	0.81	0.81	0.71	0.65	0.61	0.81	0.75	0.94	0.62	0.57	0.73	0.41	0.29
Adults[c]	0.76	0.77	0.95	0.77	0.94	0.83	0.69	0.68	0.75	0.89	0.79	0.82	0.71	0.81	0.70	0.30

[a] 1 and 2-year old.

[b] 3 and 4-year old.

[c] ≥ 5-year old.

Appendix 49. Survival estimates of female black bears using Downing population reconstruction West Virginia, 1991–2006. Females ≥ 5-years old collapsed into one age class.

Age[a]	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	0.79	0.91	0.80	0.83	0.89	0.81	0.87	0.77	0.80	0.71	0.84	0.83	0.78	0.85	0.61	0.51
2	0.80	0.78	0.73	0.73	0.82	0.79	0.85	0.68	0.79	0.82	0.72	0.75	0.59	0.74	0.68	0.37
3	0.89	0.87	0.82	0.79	0.83	0.81	0.81	0.77	0.75	0.81	0.86	0.80	0.75	0.78	0.81	0.78
4	0.85	0.89	0.85	0.76	0.83	0.81	0.74	0.79	0.83	0.78	0.86	0.86	0.70	0.87	0.78	0.77
≥ 5	0.88	0.83	0.82	0.74	0.85	0.84	0.84	0.81	0.83	0.86	0.78	0.77	0.80	0.83	0.78	0.83

[a] In years.

Appendix 50. Survival estimates of female black bears using Downing population reconstruction in West Virginia, 1991–2006.

Age[a]	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[b]	0.80	0.86	0.77	0.78	0.87	0.80	0.86	0.73	0.80	0.75	0.79	0.79	0.69	0.80	0.65	0.45
Subadults[c]	0.88	0.87	0.83	0.78	0.83	0.81	0.79	0.78	0.79	0.80	0.86	0.83	0.73	0.82	0.80	0.77
Adults[d]	0.88	0.83	0.82	0.74	0.85	0.84	0.84	0.81	0.83	0.86	0.78	0.77	0.80	0.83	0.78	0.83

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-years old.

Appendix 51. Survival estimates of female black bears using cohort population reconstruction in West Virginia, 1991–2006.

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.78	0.91	0.79	0.83	0.88	0.81	0.88	0.74	0.73	0.68	0.80	0.80	0.70	0.77	0.61	0.51
2	0.80	0.76	0.72	0.72	0.81	0.76	0.84	0.71	0.75	0.73	0.68	0.66	0.49	0.60	0.47	0.37
3	0.90	0.87	0.79	0.79	0.83	0.81	0.77	0.75	0.78	0.77	0.77	0.75	0.62	0.68	0.64	0.45
4	0.88	0.90	0.86	0.72	0.83	0.81	0.74	0.72	0.82	0.81	0.82	0.74	0.60	0.75	0.62	0.44
≥ 5	0.84	0.80	0.79	0.71	0.83	0.82	0.81	0.78	0.79	0.82	0.73	0.71	0.69	0.72	0.56	0.54

Appendix 52. Survival estimates of female black bears using cohort population reconstruction in West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[a]	0.79	0.85	0.76	0.77	0.85	0.78	0.87	0.72	0.74	0.69	0.74	0.74	0.60	0.69	0.55	0.45
Subadults[b]	0.89	0.88	0.83	0.76	0.83	0.81	0.76	0.74	0.79	0.79	0.79	0.75	0.61	0.71	0.63	0.44
Adults[c]	0.84	0.80	0.79	0.71	0.83	0.82	0.81	0.78	0.79	0.82	0.73	0.71	0.69	0.72	0.56	0.54

[a] 1 and 2-year old.

[b] 3 and 4-year old.

[c] ≥ 5-year old.

Appendix 53. Survival estimates of male black bears using Downing population reconstruction in West Virginia, 1991–2006. Males ≥ 5-years old collapsed into one age class.

Age[a]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.70	0.77	0.55	0.76	0.67	0.65	0.74	0.64	0.60	0.56	0.52	0.66	0.59	0.66	0.49	0.43
2	0.70	0.64	0.60	0.50	0.67	0.58	0.69	0.53	0.49	0.54	0.52	0.55	0.48	0.59	0.48	0.30
3	0.74	0.75	0.62	0.72	0.49	0.80	0.67	0.61	0.52	0.59	0.76	0.56	0.53	0.62	0.57	0.51
4	0.75	0.74	0.68	0.56	0.63	0.45	0.69	0.60	0.80	0.55	0.77	0.68	0.60	0.70	0.61	0.65
≥ 5	0.83	0.79	0.73	0.73	0.75	0.77	0.74	0.64	0.72	0.80	0.81	0.70	0.64	0.74	0.64	0.66

[a] In years.

Appendix 54. Survival estimates of male black bears using Downing population reconstruction in West Virginia, 1991–2006.

Age[a]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Juveniles[b]	0.70	0.72	0.57	0.66	0.67	0.62	0.72	0.60	0.56	0.55	0.52	0.63	0.54	0.63	0.49	0.39
Subadults[c]	0.75	0.74	0.65	0.66	0.56	0.72	0.68	0.60	0.63	0.58	0.77	0.60	0.56	0.64	0.59	0.57
Adults[d]	0.83	0.79	0.73	0.73	0.75	0.77	0.74	0.64	0.72	0.80	0.81	0.70	0.64	0.74	0.64	0.66

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-years old.

Appendix 55. Survival estimates of male black bears using cohort population reconstruction in West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	0.70	0.77	0.58	0.73	0.68	0.61	0.75	0.64	0.60	0.55	0.51	0.63	0.55	0.61	0.49	0.43
2	0.68	0.65	0.61	0.54	0.62	0.59	0.64	0.55	0.50	0.53	0.50	0.54	0.42	0.52	0.36	0.30
3	0.74	0.73	0.62	0.73	0.58	0.75	0.68	0.50	0.55	0.61	0.75	0.53	0.52	0.52	0.42	0.18
4	0.80	0.74	0.64	0.56	0.64	0.61	0.60	0.62	0.70	0.61	0.79	0.66	0.55	0.68	0.42	0.39
≥ 5	0.82	0.79	0.73	0.71	0.74	0.77	0.76	0.61	0.70	0.75	0.77	0.67	0.58	0.67	0.53	0.39

Appendix 56. Survival estimates of male black bears using cohort population reconstruction in West Virginia, 1991–2006.

Age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Juveniles[a]	0.69	0.72	0.59	0.65	0.66	0.60	0.71	0.61	0.56	0.54	0.51	0.61	0.49	0.57	0.44	0.39
Subadults[b]	0.76	0.73	0.63	0.66	0.60	0.70	0.65	0.56	0.59	0.61	0.77	0.57	0.53	0.56	0.42	0.26
Adults[c]	0.82	0.79	0.73	0.71	0.74	0.77	0.76	0.61	0.70	0.75	0.77	0.67	0.58	0.67	0.53	0.39

[a] 1 and 2-year old.

[b] 3 and 4-year old.

[c] ≥ 5-year old.

Appendix 57. Average survival estimates for female and male black bears using Downing and cohort population reconstruction in West Virginia, 1991–2002.

	Statewide				North				South			
	Female		Male		Female		Male		Female		Male	
Age[a]	Downing	Cohort	Downing	Cohort	Downing	Cohort	Downing	Cohort	Downing	Cohort	Downing	Cohort
1	0.82	0.80	0.65	0.65	0.79	0.79	0.64	0.63	0.86	0.84	0.66	0.64
2	0.77	0.75	0.58	0.58	0.67	0.66	0.53	0.52	0.81	0.81	0.69	0.67
3	0.82	0.80	0.65	0.65	0.73	0.72	0.64	0.62	0.85	0.88	0.72	0.73
4	0.82	0.80	0.66	0.66	0.76	0.76	0.61	0.62	0.74	0.83	0.81	0.80
5+	0.82	0.79	0.75	0.73	0.80	0.75	0.69	0.72	0.85	0.82	0.81	0.80
Juveniles	0.80	0.78	0.63	0.62	0.74	0.73	0.60	0.59	0.84	0.83	0.68	0.66
Subadults	0.82	0.80	0.66	0.65	0.75	0.74	0.62	0.62	0.84	0.85	0.75	0.77
Adults	0.82	0.79	0.75	0.73	0.80	0.75	0.69	0.72	0.85	0.82	0.81	0.80

[a] In years.

[b] 1 and 2-year old.

[c] 3 and 4-year old.

[d] ≥ 5-years old.

Appendix 58. Survival estimates from straight tag returns for black bears in northern West Virginia, USA, 1991–2007.

Sex	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
Female	0.79	0.79	0.83	0.76	0.90	0.95	0.88	0.86	0.92	0.94	0.83	0.96	1.00	0.91	0.87	0.89	0.93	0.88
Male	0.55	0.65	0.57	0.61	0.62	0.60	0.81	0.66	0.63	0.63	NA[a]	0.79	0.88	0.75	0.65	0.41	0.78	0.66

[a] There were 0 male black bears tagged and available for harvest on the northern study area in 2001. Females available for harvest during that year were collared black bears from previous years.

Appendix 59. Survival estimates from straight tag returns for black bears in southern West Virginia, USA, 1999–2007.

Sex	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
Female	0.86	0.96	0.72	0.86	0.80	0.89	0.83	0.82	0.71	0.83
Male	0.94	0.35	0.68	0.48	0.25	0.71	0.71	0.50	0.60	0.58

Appendix 60. West Virginia black bear management survey questionnaire developed by West Virginia Division of Natural Resources and Responsive Management and conducted by Responsive Management.

1. WVBEAR

START

PRESS ENTER WHEN INTERVIEW BEGINS.

2. TIME WHEN PROGRAM WAS OPENED.

TIME1 1:1-5

|__|__|__|__|__|

3. SURVEY NAME

SNAME 1:6

(CHECK ONLY ONE ANSWER)

|__| 1. WVBEAR

4. Hello, my name is __________. I'm calling on behalf of the West Virginia Division of Natural Resources to ask you some questions about black bear management in West Virginia. Do you have a few minutes to answer some questions? (MUST BE AT LEAST 18)

CONPER1 1:7-8

(CHECK ONLY ONE ANSWER)

|__| 1. Correct person, good time to do survey (GO TO QUESTION 6)
|__| 2. Bad time/schedule recall (CB - do not save) (GO TO QUESTION 5)
|__| 3. AM, NA, BZ (do not save)
|__| 4. TM (GO TO QUESTION 98)
|__| 5. RF
|__| 6. NE (GO TO QUESTION 99)
|__| 7. DS
|__| 8. BG
|__| 9. DL
|__| 10. Bad Number (missing digit, begins with zero, etc.)

SKIP TO QUESTION 102

==

5. When would be a more convenient time to call you back?
Thank you for your time.

WHENCALL

ENTER DAY AND TIME ON CALLSHEET (CB)

SKIP TO QUESTION 102

==

6. TIME WHEN INTERVIEW BEGAN.

TIME2 1:9-13

|__|__|__|__|__|

7. First, I'd like to ask you several questions about your knowledge of and opinions on black bears in West Virginia.

BEARINT

PRESS ENTER TO CONTINUE.

8. First, how much would you say you know about black bears in West Virginia? Would you say you know a great deal, a moderate amount, a little, or nothing?

KNOWBEAR 1:14

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 8)
|__| 2. A great deal
|__| 3. A moderate amount
|__| 4. A little
|__| 5. Nothing
|__| 6. DNR: Can't say how much he/she knows

9. TIME CHECK.

TIME3 1:15-19

|__|__|__|__|__|

10. Overall, would you say the black bear population in West Virginia is too high, about right, or too low?

WVLEV 1:20

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 10)
|__| 2. Too high
|__| 3. About right
|__| 4. Too low
|__| 5. Don't know

11. In your opinion, should the black bear population in West Virginia be increased, remain the same, or be decreased?

WVPOP 1:21

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 11)
|__| 2. Increased
|__| 3. Remain the same
|__| 4. Decreased
|__| 5. Don't know

12. Overall, would you say the black bear population IN YOUR COUNTY is too high, about right, or too low?

CNTYLEV 1:22

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 12)
|__| 2. Too high
|__| 3. About right
|__| 4. Too low
|__| 5. Don't know

13. In your opinion, should the black bear population IN YOUR COUNTY be increased, remain the same, or be decreased?

CNTYPOP 1:23

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 13)
|__| 2. Increased
|__| 3. Remain the same
|__| 4. Decreased
|__| 5. Don't know

14. Would you support or oppose having black bears within 1 mile of your home?

ONEMILE 1:24

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 14)
|__| 2. Strongly support (GO TO QUESTION 16)
|__| 3. Moderately support (GO TO QUESTION 16)
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

15. Would you support or oppose having black bears within 5 miles of your home?

FIVEMILE 1:25

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 15)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

16. Sometimes people have problems with wildlife in their neighborhoods or around their homes. Have you personally had any problems or property damage resulting from BLACK BEARS within the past 2 years?

BEARPROB 1:26

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 16)
|__| 2. Yes (GO TO QUESTION 19)
|__| 3. No
|__| 4. Don't know

SKIP TO QUESTION 27

==

17. YOU HAVE SELECTED INCONSISTENT ANSWERS.

INCONS3

PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 19

==

18. YOU DID NOT USE SPACE BAR.
NOSPAC3
PRESS ENTER TO TRY AGAIN.

19. What kind of problems did the black bear(s) cause?
(DNR LIST; CHECK ALL THAT APPLY)
WTBRPB 1:27-44
(CHECK ALL THAT APPLY)

|__| 1. Garbage
|__| 2. Birdfeeder
|__| 3. Porch / house
|__| 4. Camping equipment (tent, food containers, etc.)
|__| 5. Pets
|__| 6. Livestock
|__| 7. Threat, injury, or illness to humans
|__| 8. Annoyance to humans
|__| 9. Landscaping or yard (excluding gardens)
|__| 10. Agricultural damage (crops)
|__| 11. Agricultural damage (orchard)
|__| 12. Garden (personal)
|__| 13. Structural damage (such as fencing)
|__| 14. Vehicle collisions as driver
|__| 15. Vehicle collisions as passenger
|__| 16. Damage to vehicle while it was parked
|__| 17. Other
|__| 18. Don't know

IF (#19 = 0) GO TO #18
IF (#19 @ 18 AND NOT (#19 = 131072)) GO TO #17
IF (#19 @ 17) GO TO #20

SKIP TO QUESTION 21

==

20. ENTER OTHER PROBLEMS.
WTBRPBST 2:1-240

____

21. Did you contact anyone as a result of the problem
with black bear(s)?

BEARCONT 2:241

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 21)
|__| 2. Yes (GO TO QUESTION 24)
|__| 3. No
|__| 4. Don't know

SKIP TO QUESTION 27

==

22. YOU HAVE SELECTED INCONSISTENT ANSWERS.

INCONS4

PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 24

==

23. YOU DID NOT USE SPACE BAR.

NOSPAC4

PRESS ENTER TO TRY AGAIN.

24. Whom did you contact about the problem with black bear(s)?
(DNR LIST; CHECK ALL THAT APPLY)

WHBRCT 3:1-14

(CHECK ALL THAT APPLY)

|__| 1. Local Police
|__| 2. State Police
|__| 3. 911
|__| 4. Animal Control
|__| 5. Fire Department
|__| 6. WV DNR Law Enforcement Officer/ Conservation Officer
|__| 7. WV DNR's Wildlife Resources Section
|__| 8. WV DNR (NON SPECIFIC)
|__| 9. U.S. Department of Agriculture

|__| 10. U.S. Fish and Wildlife Service
|__| 11. SPCA/Humane Society
|__| 12. Insurance Company
|__| 13. Other
|__| 14. Don't know

IF (#24 = 0) GO TO #23
IF (#24 @ 14 AND NOT (#24 = 8192)) GO TO #22
IF (#24 @ 13) GO TO #25
IF (#24 @ 6 OR #24 @ 7 OR #24 @ 8) GO TO #26

SKIP TO QUESTION 27

==

25. ENTER OTHER RESPONSE.
WHBRCTST 4:1-240

____

____

____

IF (#24 @ 6 OR #24 @ 7 OR #24 @ 8) GO TO #26

SKIP TO QUESTION 27

==

26. How satisfied or dissatisfied were you with the service you received from the West Virginia Division of Natural Resources regarding the problem with black bear(s)?
WVDNR 4:241
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 26)
|__| 2. Very satisfied
|__| 3. Somewhat satisfied
|__| 4. Neither satisfied nor dissatisfied
|__| 5. Somewhat dissatisfied
|__| 6. Very dissatisfied
|__| 7. Don't know

27. Overall, do you think the West Virginia Division of Natural

Resources has done an excellent, good, fair, or poor job of managing black bears in West Virginia?

MNGBEAR 4:242

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 27)
|__| 2. Excellent
|__| 3. Good
|__| 4. Fair
|__| 5. Poor
|__| 6. Don't know

28. Do you support or oppose the regulated hunting of black bears in West Virginia?

HUNTING 4:243

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 28)
|__| 2. Strongly support (GO TO QUESTION 31)
|__| 3. Moderately support (GO TO QUESTION 31)
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose (GO TO QUESTION 35)
|__| 6. Strongly oppose (GO TO QUESTION 35)
|__| 7. Don't know

SKIP TO QUESTION 37

==

29. YOU HAVE SELECTED INCONSISTENT ANSWERS.

INCONS9

PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 31

==

30. YOU DID NOT USE SPACE BAR

NOSPAC9

PRESS ENTER TO TRY AGAIN

31. Why do you support the regulated hunting of black

bears in West Virginia?
(DNR LIST; CHECK ALL THAT APPLY)
WHYHNT 5:1-10
(CHECK ALL THAT APPLY)

|__| 1. Population control
|__| 2. Black bears threaten human safety
|__| 3. Black bears cause damage to crops
|__| 4. Black bears cause damage to property
|__| 5. Black bears cause damage to livestock
|__| 6. Hunting is a HUMANE METHOD of controlling black bear population
|__| 7. Want the opportunity to hunt bears
|__| 8. Hunting black bears is a tradition
|__| 9. Other
|__| 10. Don't know

IF (#31 = 0) GO TO #30
IF (#31 @ 10 AND NOT (#31 = 512)) GO TO #29
IF (#31 @ 9) GO TO #32

SKIP TO QUESTION 37

==

32. ENTER OTHER REASON FOR SUPPORTING BLACK BEAR HUNTING.
WHYHNTST 5:11-250

____

____

____

SKIP TO QUESTION 37

==

33. YOU HAVE SELECTED INCONSISTENT ANSWERS.
INCONS10
PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 35

===

34. YOU DID NOT USE SPACE BAR
NOSPAC10
PRESS ENTER TO TRY AGAIN

35. Why do you oppose the regulated hunting of black bears in West Virginia?
(DNR LIST; CHECK ALL THAT APPLY)
NOHNT 6:1-7
(CHECK ALL THAT APPLY)

|__| 1. Opposed to all hunting / Animal rights
|__| 2. Opposed to TROPHY hunting
|__| 3. Black bear population is too low
|__| 4. Black bears are not a threat to human safety
|__| 5. Prefer OTHER METHODS to control population
|__| 6. Other
|__| 7. Don't know

IF (#35 = 0) GO TO #34
IF (#35 @ 7 AND NOT (#35 = 64)) GO TO #33
IF (#35 @ 6) GO TO #36

SKIP TO QUESTION 37

===

36. ENTER OTHER REASON FOR OPPOSITION TO BLACK BEAR HUNTING.
NOHNTST 6:8-247

____

____

____

37. Do you support or oppose the regulated hunting of black bears IN YOUR COUNTY?

HUNTCNTY 6:248

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 37)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

38. Would you support or oppose regulated black bear hunting in West Virginia if you knew that the West Virginia Division of Natural Resources carefully monitors the black bear population?

WITHCARE 6:249

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 38)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

39. Would you support or oppose regulated black bear hunting in West Virginia if you knew that the black bear population, as a whole, is stable?

STABLE 6:250

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 39)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

40. Next, I'm going to read some different methods of black bear hunting, and I'd like to know if you would support or oppose each.

TYPINT

PRESS ENTER TO CONTINUE.

41. Would you support or oppose regulated black bear hunting with a gun?

(IF ASKED: Without bait)
(IF ASKED: Without dogs)

GUNTYP 7:1

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 41)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

42. Would you support or oppose regulated black bear hunting with a bow?

(IF ASKED: Without bait)
(IF ASKED: Without dogs)

BOWTYP 7:2

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 42)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

43. Would you support or oppose regulated black bear hunting with the use of dogs?

(IF ASKED: Hunting with dogs is currently allowed during the bear firearms season in some counties.)

(IF ASKED: Without bait)

GDOGTYP 7:3

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 43)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

44. Currently, black bear hunting with the use of bait is NOT legal.

BAITINT

PRESS ENTER TO CONTINUE.

45. Would you support or oppose regulated black bear hunting with a gun and the use of bait?

(IF ASKED: Baiting is the placement of food with the intent of attracting a game animal.)

GBAIT 7:4

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 45)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

46. Would you support or oppose regulated black bear hunting with a bow and the use of bait?

(IF ASKED: Baiting is the placement of food with the intent of attracting a game animal.)

BBAIT 7:5

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 46)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose

|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

47. Would you support or oppose allowing bear hunters to train dogs, WITHOUT harvesting animals, YEAR-ROUND?

(IF ASKED: Currently, West Virginia residents with the required bear hunting licenses may train dogs year-round on bear on private land with the landowner's written permission and on public lands.)

TRAIN 7:6

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 47)
|__| 2. Strongly support (GO TO QUESTION 50)
|__| 3. Moderately support (GO TO QUESTION 50)
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose (GO TO QUESTION 54)
|__| 6. Strongly oppose (GO TO QUESTION 54)
|__| 7. Don't know

SKIP TO QUESTION 56

==

48. YOU HAVE SELECTED INCONSISTENT ANSWERS.

INCONS98

PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 50

==

49. YOU DID NOT USE SPACE BAR.

NOSPAC98

PRESS ENTER TO TRY AGAIN.

50. Why do you support allowing bear hunters to train dogs, without harvesting animals, year-round?
(DNR LIST; CHECK ALL THAT APPLY)

WHYYR 7:7-12

(CHECK ALL THAT APPLY)

|__| 1. There's no reason to oppose it
|__| 2. It should be a right / should be personal choice / should NOT be a
|__| 3. government decision (GO TO QUESTION 50)
|__| 4. It increases hunting success
|__| 5. Other
|__| 6. Don't know

IF (#50 = 0) GO TO #49
IF (#50 @ 6 AND NOT (#50 = 32)) GO TO #48
IF (#50 @ 5) GO TO #51

SKIP TO QUESTION 56

===

51. ENTER OTHER RESPONSE.

WHYYRST 8:1-240

____

____

____

SKIP TO QUESTION 56

===

52. YOU HAVE SELECTED INCONSISTENT ANSWERS.

INCONS99

PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 54

===

53. YOU DID NOT USE SPACE BAR.

NOSPAC99

PRESS ENTER TO TRY AGAIN.

54. Why do you oppose allowing bear hunters to train dogs, without harvesting animals, year-round?
(DNR LIST; CHECK ALL THAT APPLY)
NOTYR 8:241-249
(CHECK ALL THAT APPLY)

|__| 1. Opposed to training dogs for ANY hunting purpose
|__| 2. It disturbs black bears
|__| 3. It disturbs game or wildlife (in general)
|__| 4. It disturbs YOUNG game or wildlife / shouldn't be allowed when
|__| 5. young are being reared (GO TO QUESTION 54)
|__| 6. It disturbs people
|__| 7. Concerns about trespassing
|__| 8. Other
|__| 9. Don't know

IF (#54 = 0) GO TO #53
IF (#54 @ 9 AND NOT (#54 = 256)) GO TO #52
IF (#54 @ 8) GO TO #55

SKIP TO QUESTION 56

===

55. ENTER OTHER RESPONSE.
NOTYRST 9:1-240

____

____

____

56. Have you personally ever had any problems resulting from the training of hunting dogs for any species?
TRAINPRB 9:241
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 56)
|__| 2. Yes (GO TO QUESTION 57)
|__| 3. No
|__| 4. Don't know

SKIP TO QUESTION 62

==

57. What was the problem you experienced?
(ENTER ? FOR DON'T KNOW)
DOGPRB 10:1-240

____

____

____

LOWEST VALUE = "A"

SKIP TO QUESTION 60

==

58. YOU HAVE SELECTED INCONSISTENT ANSWERS.
INCONS1
PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 60

==

59. YOU DID NOT USE SPACE BAR
NOSPAC1
PRESS ENTER TO TRY AGAIN

60. What species were the dogs being trained to hunt?
(READ LIST AS NECESSARY; CHECK ALL THAT APPLY)
TRSPC 10:241-247
(CHECK ALL THAT APPLY)

|__| 1. Black bear
|__| 2. Raccoon
|__| 3. Fox
|__| 4. Game birds (e.g., quail, doves, pigeons)
|__| 5. Rabbit
|__| 6. Other
|__| 7. Don't know

IF (#60 = 0) GO TO #59
IF (#60 @ 7 AND NOT (#60 = 64)) GO TO #58
IF (#60 @ 6) GO TO #61

SKIP TO QUESTION 62

===

61. ENTER OTHER SPECIES.
TRSPCST 11:1-240

____

____

____

62. Currently, black bear hunting in West Virginia is only allowed in the fall. Would you support or oppose adding a spring black bear hunting season?
SPRING 11:241
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 62)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

63. Do you agree or disagree that it is okay to feed WILDLIFE or to leave food out for WILDLIFE?
FEEDWILD 11:242
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 63)
|__| 2. Strongly agree
|__| 3. Moderately agree
|__| 4. Neither agree nor disagree
|__| 5. Moderately disagree
|__| 6. Strongly disagree
|__| 7. Don't know

64. Do you agree or disagree that it is okay to feed WHITE-TAILED DEER or to leave food out for WHITE-TAILED DEER?

FEEDDEER 11:243

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 64)
|__| 2. Strongly agree
|__| 3. Moderately agree
|__| 4. Neither agree nor disagree
|__| 5. Moderately disagree
|__| 6. Strongly disagree
|__| 7. Don't know

65. Would you support or oppose WHITE-TAILED DEER hunting with the use of bait?

(IF ASKED: Baiting is the placement of food with the intent of attracting a game animal.)

(IF ASKED: It's currently legal to bait deer EXCEPT in a Containment Area. A Containment Area is an area designated by the Director of the Division of Natural Resources where deer have been found to be infected with Chronic Wasting Disease. The purpose of a Containment Area is to manage, control, eradicate and/or prevent the spread of the disease. There is a Containment Area North of U.S. Route 50 in Hampshire County.)

DEERBAIT 11:244

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 65)
|__| 2. Strongly support
|__| 3. Moderately support
|__| 4. Neither support nor oppose
|__| 5. Moderately oppose
|__| 6. Strongly oppose
|__| 7. Don't know

66. Great! We're just about through. The final questions are for background information and help us analyze the results.

DEMO

PRESS ENTER TO CONTINUE.

67. Have you hunted in West Virginia in the past 12 months?

HUNTED 11:245

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 67)
|__| 2. Yes (GO TO QUESTION 70)
|__| 3. No
|__| 4. Don't know
|__| 5. Refused

SKIP TO QUESTION 72

===

68. YOU HAVE SELECTED INCONSISTENT ANSWERS.

INCONS2

PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 70

===

69. YOU DID NOT USE SPACE BAR

NOSPAC2

PRESS ENTER TO TRY AGAIN

70. Which species have you hunted in West Virginia in the past 2 years? (DNR LIST; CHECK ALL THAT APPLY)

HTSPEC 12:1-18

(CHECK ALL THAT APPLY)

|__| 1. White-tailed deer
|__| 2. Wild turkey
|__| 3. Wild boar
|__| 4. Black bear
|__| 5. Waterfowl (e.g., ducks, geese)
|__| 6. Squirrel
|__| 7. Raccoon
|__| 8. Cottontail rabbit
|__| 9. Snowshoe hare
|__| 10. Ruffed grouse
|__| 11. Pheasant
|__| 12. Bobwhite quail
|__| 13. Crow
|__| 14. Woodchuck

|__| 15. Fox
|__| 16. Coyote
|__| 17. Other
|__| 18. Don't know

IF (#70 = 0) GO TO #69
IF (#70 @ 18 AND NOT (#70 = 131072)) GO TO #68
IF (#70 @ 17) GO TO #71

SKIP TO QUESTION 72

==

71. ENTER OTHER SPECIES.
HTSPECST 13:1-240

____

____

____

72. Do you own land in West Virginia?
OWNLAND 13:241
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 72)
|__| 2. Yes (GO TO QUESTION 73)
|__| 3. No
|__| 4. Don't know
|__| 5. Refused

SKIP TO QUESTION 76

==

73. About how many acres of land do you own in West Virginia?

(ROUND TO NEAREST ACRE; ANYTHING LESS THAN 0.5 ROUNDS TO 0)
(ENTER 8,888 FOR REFUSED; ENTER ? FOR DON'T KNOW)
ACRES 13:242-245
|__|,|__|__|__| acres

LOWEST VALUE = 0

IF (#73 = 8888) GO TO #76
IF (#73 = 888 OR #73 = 88) GO TO #75
IF (#73 = 0 OR #73 > 80) GO TO #74

SKIP TO QUESTION 76

===

74. DID YOU MEAN TO ENTER #73?

ACRESCHK 13:246

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 74)
|__| 2. Yes
|__| 3. No (RETURN TO PREVIOUS QUESTION) (GO TO QUESTION 73)

SKIP TO QUESTION 76

===

75. YOU ENTERED #73. DID YOU MEAN TO ENTER #73 OR DID YOU MEAN TO ENTER 8888 FOR REFUSED?

ACRECHK2 13:247

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 75)
|__| 2. Actual number of acres
|__| 3. Respondent refused (RETURN TO PREVIOUS QUESTION AND ENTER 8888) (GO TO QUESTION 73)

76. Do you consider your place of residence to be a larger city or urban area, a suburban area, a small city or town, a rural area on a farm, or a rural area not on a farm?

RESIDE 13:248

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 76)
|__| 2. Larger city or urban area
|__| 3. Suburban area
|__| 4. Small city or town

|__| 5. Rural area on a farm
|__| 6. Rural area not on a farm
|__| 7. Don't know
|__| 8. Refused

77. What is your county of residence?
(ENTER COUNTY NUMBER FROM CALL STATION SHEET)
(ENTER 88 FOR REFUSED; ? FOR DON'T KNOW)
COUNTY 13:249-250
|__|__|

LOWEST VALUE = 1
HIGHEST VALUE = 88

IF (#77 > 55 AND #77 < 88) GO TO #77

78. What is the highest level of education you have completed?
(READ LIST IF NECESSARY)
EDUCATE 14:1-2
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 78)
|__| 2. Not a high school graduate
|__| 3. High school graduate or equivalent
|__| 4. Some college or trade school, no degree
|__| 5. Associate's degree or trade school degree
|__| 6. Bachelor's degree
|__| 7. Master's degree
|__| 8. Professional or doctorate degree (e.g., M.D. or Ph.D.)
|__| 9. Don't know
|__| 10. Refused

79. Which of these categories best describes your total household income before taxes last year?
(READ LIST)
INCOME 14:3-4
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 79)
|__| 2. Under $20,000
|__| 3. $20,000-$39,999
|__| 4. $40,000-$59,999
|__| 5. $60,000-$79,999

|__| 6. $80,000-$99,999
|__| 7. $100,000-$119,999
|__| 8. $120,000 or more
|__| 9. Don't know
|__| 10. Refused

SKIP TO QUESTION 82

==

80. YOU HAVE SELECTED INCONSISTENT ANSWERS.
INCONS11
PRESS ENTER TO TRY AGAIN.

SKIP TO QUESTION 82

==

81. YOU DID NOT USE SPACE BAR.
NOSPAC11
PRESS ENTER TO TRY AGAIN.

82. What races or ethnic backgrounds do you consider yourself?
Please name all that you think apply.

(READ LIST IF NECESSARY; CHECK ALL THAT APPLY)
RACES 14:5-20
(CHECK ALL THAT APPLY)

|__| 1. White or Caucasian
|__| 2. Black or African-American
|__| 3. Hispanic or Latino (includes Mexican, Central American, etc.)
|__| 4. Native American or Alaskan native or Aleutian
|__| 5. Korean
|__| 6. Japanese
|__| 7. Chinese
|__| 8. Filipino
|__| 9. Native Hawaiian or other Pacific Islander
|__| 10. Vietnamese
|__| 11. Middle Eastern
|__| 12. African (NOT African-American)
|__| 13. South Asian (from India, Pakistan, Bangladesh, etc.)
|__| 14. Other
|__| 15. Don't know

|__| 16. Refused

IF (#82 = 0) GO TO #81
IF (#82 @ 15 AND NOT (#82 = 16384)) GO TO #80
IF (#82 @ 16 AND NOT (#82 = 32768)) GO TO #80
IF (#82 @ 14) GO TO #83

SKIP TO QUESTION 84

==

83. ENTER OTHER RACE.

RACESST 15:1-240

____

____

____

84. May I ask your age?
(ENTER 888 FOR REFUSED; ? FOR DON'T KNOW)

AGE 15:241-243

|__|__|__| years old

LOWEST VALUE = 18

IF (#84 = 888) GO TO #87
IF (#84 > 105) GO TO #84
IF (#84 = 88) GO TO #85
IF (#84 > 79 OR #84 < 16) GO TO #86

SKIP TO QUESTION 87

==

85. YOU ENTERED 88 YEARS. IS THE RESPONDENT 88 YEARS OLD OR DID YOU MEAN TO ENTER 888 FOR REFUSED?

AGECHEK1 15:244

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 85)
|__| 2. 88 years old

|__| 3. Respondent refused (RETURN TO AGE QUESTION AND ENTER 888) (GO TO QUESTION 84)

SKIP TO QUESTION 87

==

86. DID YOU MEAN TO ENTER #84?

AGECHEK2 15:245

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 86)
|__| 2. Yes
|__| 3. No (RETURN TO PREVIOUS QUESTION) (GO TO QUESTION 84)

87. TIME INTERVIEW WAS COMPLETED.

ENDTIME 15:246-250

|__|__|__|__|__|

88. That's the end of the survey. Thanks for your time and cooperation. If you have any additional comments, I can record them here.
(ENTER IN FIRST PERSON; ONLY ENTER RESPONDENT COMMENTS!)

END 16:1-240

____

____

____

89. ENTER ANY IMPORTANT NOTES ABOUT THE SURVEY.
(e.g., explanation of abnormal data, inability to enter response to a question correctly)

NOTE 17:1-240

____

____

____

90. OBSERVE AND RECORD RESPONDENT'S GENDER.

GENDER 17:241

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 90)
|__| 2. Male
|__| 3. Female
|__| 4. Don't know

91. ENTER YOUR INITIALS.

INTVRINT 17:242-244

|__|__|__|

LOWEST VALUE = "A"

92. ENTER THE AREA CODE AND TELEPHONE NUMBER OF NUMBER DIALED.

TELEPHON 18:1-10

|__|__|__|-|__|__|__|-|__|__|__|__|

LOWEST VALUE = 1

93. ENTER RM CASE NUMBER.

CASENO 18:11-16

|__|__|__|__|__|__|

LOWEST VALUE = 1

94. SAVE OR ERASE INTERVIEW.
ONLY ERASE IF THIS IS A PRACTICE INTERVIEW!

FINISH1 18:17

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 94)
|__| 2. Save answers
|__| 3. Erase answers (GO TO QUESTION 101)
|__| 4. Terminate (TM) (GO TO QUESTION 98)
|__| 5. Person was not eligible (NE) (GO TO QUESTION 99)
|__| 6. Review answers (GO TO QUESTION 4)

95. CHECK THE LENGTH OF THE INTERVIEW.

TIMECHEK 18:18

(CHECK ONLY ONE ANSWER)

|__| 1. Check (GO TO QUESTION 96)
|__| 2. Real

COMPUTE IF ((#4 = 1) AND (#87 - #6) < 300) 1
COMPUTE IF ((#4 = 1) AND (#87 - #6) > 1500) 1
COMPUTE 2

SKIP TO QUESTION 100

==

96. IS THIS A REAL COMPLETED INTERVIEW?
PRACTICE 18:19
(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 96)
|__| 2. Real completed interview
|__| 3. Practice interview (Select erase answers on next screen) (GO TO QUESTION 94)
|__| 4. Terminate (TM) (GO TO QUESTION 98)
|__| 5. Person was not eligible (NE) (GO TO QUESTION 99)
|__| 6. Review answers (GO TO QUESTION 4)

IF (((#4 = 1) AND (#87 - #6) > 1500) AND #96 = 2) GO TO #97

SKIP TO QUESTION 100

==

97. WAS THIS INTERVIEW COMPLETED IN ONE PHONE CALL OR TWO PHONE CALLS?
STAGES 18:20
(CHECK ONLY ONE ANSWER)

|__| 1. One call
|__| 2. Two calls

SKIP TO QUESTION 100

==

98. SAVE AS TERMINATE OR REVIEW ANSWERS.

SURETM 18:21

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 98)
|__| 2. Save as TM
|__| 3. Review answers (GO TO QUESTION 4)

SKIP TO QUESTION 100

==

99. SAVE AS "NOT ELIGIBLE" OR REVIEW ANSWERS.

SURENE 18:22

(CHECK ONLY ONE ANSWER)

|__| 1. Invalid answer. Select another. (GO TO QUESTION 99)
|__| 2. Save as NE
|__| 3. Review answers (GO TO QUESTION 4)

100. DETERMINES FINAL CALL STATUS.

CONPER 18:23-24

(CHECK ONLY ONE ANSWER)

|__| 1. Correct person, good time to do survey
|__| 2. Bad time/schedule recall
|__| 3. AM, NA, BZ
|__| 4. TM
|__| 5. RF
|__| 6. NE
|__| 7. DS
|__| 8. BG
|__| 9. DL
|__| 10. Bad Number (missing digit, begins with zero, etc.)

COMPUTE IF (#98 = 2) 4
COMPUTE IF (#99 = 2) 6
COMPUTE IF (#4 = 1) 1
COMPUTE IF (#4 = 2) 2
COMPUTE IF (#4 = 3) 3
COMPUTE IF (#4 = 4) 4
COMPUTE IF (#4 = 5) 5
COMPUTE IF (#4 = 6) 6
COMPUTE IF (#4 = 7) 7
COMPUTE IF (#4 = 8) 8

COMPUTE IF (#4 = 9) 9
COMPUTE IF (#4 = 10) 10

SKIP TO QUESTION 102

==

101. ARE YOU SURE YOU WANT TO ERASE THIS INTERVIEW?
ONLY ERASE IF THIS IS A PRACTICE INTERVIEW.
MAKESURE 18:25
(CHECK ONLY ONE ANSWER)

|__| 1. No, do not erase the answers (GO TO QUESTION 94)
|__| 2. Yes, erase this interview

102. SAVE OR ERASE INTERVIEW.
FINISH 18:26
(CHECK ONLY ONE ANSWER)

|__| 1. Save
|__| 2. Erase

COMPUTE IF (#101 = 2) 2
COMPUTE IF (#4 = 2) 2
COMPUTE IF (#4 = 3) 2
COMPUTE 1

103. DATE CALL WAS MADE.
INTVDAT 18:27-34
|__|__|__|__|-|__|__|-|__|__|
Year Month Day

104. DAY OF THE WEEK CALL WAS MADE.
DAY 18:35
(CHECK ONLY ONE ANSWER)

|__| 1. Sunday
|__| 2. Monday
|__| 3. Tuesday
|__| 4. Wednesday
|__| 5. Thursday
|__| 6. Friday

|__| 7. Saturday

COMPUTE (JDAYOFWEEK (TOJUL #103))

SAVE IF (#102 = 1)

Appendix 61. West Virginia black bear hunter survey conducted by the West Virginia Division of Natural Resources, 2007.

West Virginia Bear Hunter Survey For 2006 Hunting and Training Season

1. How do you **<u>primarily</u>** hunt for bears (pick only one)?

   A. Archery B. Gun without dogs C. Dogs

2. Do you also hunt using one of the other two methods not picked in question 1?

   No Yes If yes, which one(s) ______________________

3. In what **one** county do you **primarily** bear hunt in the December season for hunters using dogs, or October-November for hunters not using dogs?
   ____

4. Did you harvest a bear in **2006**? Yes No

5. Did you pass up a legal bear (weighing more than 100 pounds or bear not accompanied by cub) in **2006**? Yes No

6. **While bear hunting**, how many bears did you see during the 2006 bear hunting season? ________

Questions 7 – 15 for hunters that own bear hounds:

7. How many bear hunting dogs do you own? ____

8. How many days did you train your dogs during the **2006** training season? ______

9. How many bears did you tree in the **2006** training season? _____

10. What **one** county do you primarily train your dogs? _______________________

11. How many days did you hunt during the kill season in **2006**? _____

12. How many bears did your group tree in the kill season in **2006**? _____

13. How many bears did your group harvest in **2006**? ______

14. How many hunters typically participate in your hunting group? _______

15. How much money do you spend total on bear hunting each year at **home** (dog maintenance, veterinary bills, purchase dogs, etc.) keeping your dogs not on individual trips? ______

For ALL HUNTERS

16. For your **primary method of bear hunting**, (answer to question 1), do you specifically target bears while hunting or do you just do it concurrently with deer archery or firearms season?
 A. Specifically target bears   B. Hunt concurrent with deer seasons

17. For hunters that **specifically target bears (answered A in 16)**, how much do you spend each year on hunting supplies (Clothes, arrows, ammunition, etc.) for bears?   Please list item and amount:

Item	Amount
__________	______
__________	______
__________	______
Other	______

18. On average, how much do you spend on a **ONE DAY** hunting or training trip (gas, supplies, etc.)? A trip is defined as one day not if you camp while hunting.
Please list:
Gas ___________
Food ___________
Water, Pop, etc.___________
Other ___________

19. What is your age? _______

20. What is your home county of residence? ___________

21. How long have you been bear hunting? ______________

The West Virginia DNR has conducted special bear hunting seasons in Kanawha, Fayette, Boone, and Raleigh counties the last 5 years. The special seasons were an early hunting season with the use of dogs during the first week of November and a bear season concurrent with the first week of bucks firearms season.

22. Did you participate in these special early hunting seasons?   Yes   No

23. If yes, how many years did you participate?   1 2 3 4 5

24. How many bears did you harvest in the last 5 years (2002-2006) during these special seasons in Kanawha, Fayette, Boone, and Raleigh counties?
0 1 2 3 4 5

25. If you hunted bears during these special seasons did you pass up an opportunity to harvest a legal bear (weighing more than 100 pounds or bear not accompanied by a cub)? Yes No

26. If yes to question 25, how many bears did you not shoot that you could have legally harvested during these 5 special seasons? ________

Do you have any other comments:

____
____
____
____
____
____
____
____

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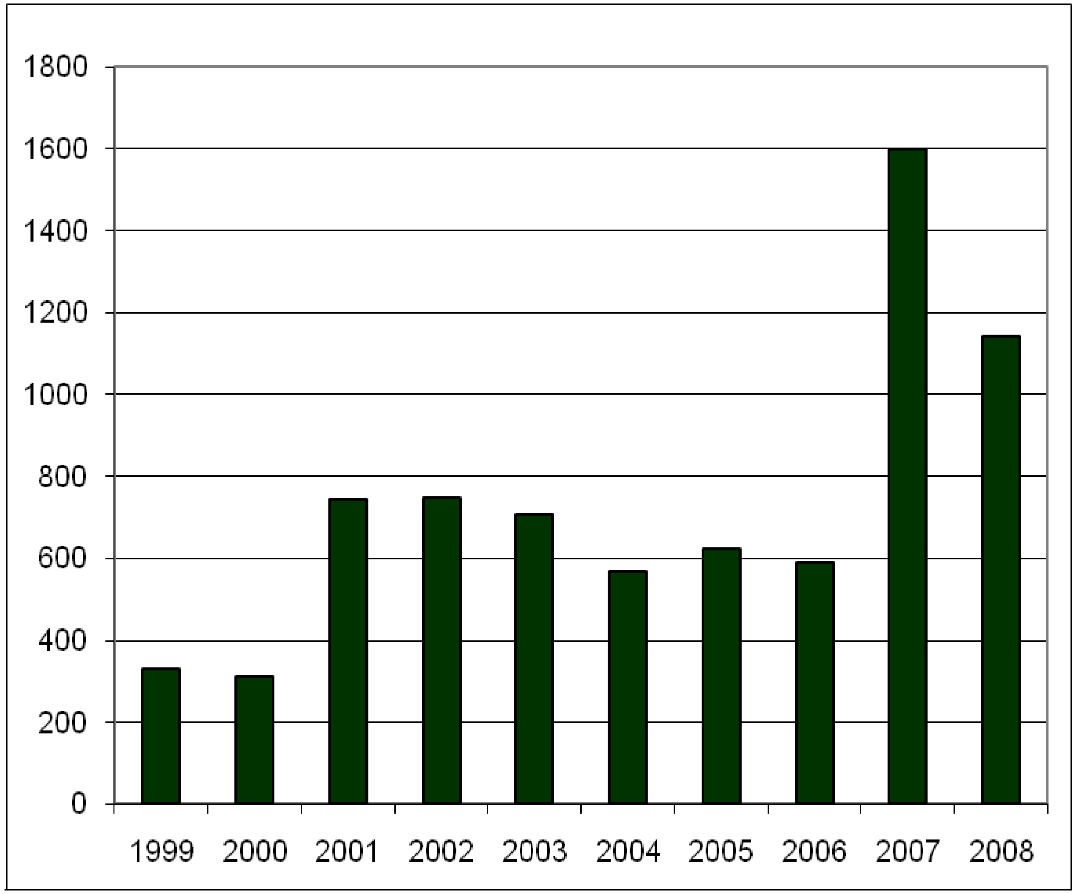
Division of Natural Resources of West Virginia
Wildlife Resources Section – Chris Ryan
State Office Building #3, Room 825
Charleston, WV 25305

(**Tape Here**)

Appendix 62. Number of nuisance black bear complaints received by West Virginia Division of Natural Resources, 1999-2008.



Vitae

Christopher William Ryan was born to William and Carolyn Ryan on December 28, 1972 in Morgantown, West Virginia. He graduated from Morgantown High School in 1991 and attended West Virginia University 1991–1995 earning a B.S in Wildlife Management. After a summer job at Tudor Farms in Maryland, he attended Virginia Tech 1995–1997 earning a M.S. degree in Wildlife Resources. His major advisor was Dr. Mike Vaughan. His thesis project was part of the large Cooperative Allegheny Bear Project and was entitled "Reproduction, Survival, and Denning Ecology of Black Bears in Southwestern Virginia." He worked as a technician for the Virginia Department of Game and Inland Fisheries for a few months before returning to his native West Virginia to work for the West Virginia Division of Natural Resources. He was hired as a nuisance bear trapper and worked out of the Beckley office for 5 months; he then lived at the DNR cabin at Bear Branch in Greenbrier County with his faithful dog "Autumn" for 10 months and was a grouse technician. He was hired permanently in August 1999 as a wildlife manager in Tyler County with the responsibility of Conaway Run Lake and The Jug Wildlife Management Areas. He was promoted to Wildlife Biologist 1 in February 2002 and moved to Charleston. He was promoted to Wildlife Biologist 3 in September 2003 and was placed in charge of the bear project. He met his future wife, Beth, in July 2004 and began his pursuit of his Ph.D. that fall at West Virginia University under the guidance of Dr. John Edwards while not taking time off from work. He was married in August 2006. He was promoted to Supervisor of Game Management Services (Research) in July 2009 and defended his doctoral dissertation on October 29, 2009.