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EFFECTS OF TRANSLOCATION AND CLIMATIC EVENTS ON THE POPULATION GENETIC STRUCTURE OF BLACK BEARS IN NEW MEXICO

by

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THESIS

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ABSTRACT

Population structure of the American black bear (*Ursus americanus*) in New Mexico has been shaped by anthropogenic and natural forces. Black bears occur in habitat islands throughout New Mexico with natural movement among islands influenced by periodic drought, resource limitations and dispersal. Both natural movement and human mediated translocations primarily involve male black bears because of their tendency to move farther distances and more frequent conflict with human dominated landscapes than females. Using DNA microsatellite analysis to investigate the degree of differentiation between different population segments (F_{st} =0.025 across genetic loci, range = 0.018-0.032) we determined that black bear populations in New Mexico are relatively undifferentiated. Lack of genetic structure is due to bear movement from a combination of distance between population clusters, climatic variation affecting resource availability, anthropogenic-mediated movement of nuisance bears and potentially a population

contraction during the early part of the 1900's. Testing matrilineages through

mitochondrial DNA of this species with high female philopatry would help to

answer the question of how much anthropogenic movement has affected

population structure.

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Introduction

The American black bear (*Ursus americanus*) is primarily found in forested

habitats throughout North America (Stirling and Derocher 1989). Black bears are

large (NM males = 120 kg, NM females 70 kg) forest omnivores that can utilize a

variety of nutritional resources including both hard and soft mast crops such as

acorns (*Quercus spp.*), piñon nuts (*Pinus spp.*), squaw root (*Conophilus spp.*) and

choke cherries (*Prunus spp.*).They also forage on anthropogenic food supplies

such as garbage, orchards, and beehives when they are available: this sets up a

potential conflict with humans.

Black bears range from Nova Scotia to Florida in the east, and from Alaska to

Zacatecas, Mexico in the west. Two lineages of North America black bears

(western and eastern) are recognized and are believed to have diverged from a

common ancestor approximately 1.8 million years ago, (Byun, Koop and

Reimchen 1997; Wooding and Ward 1997; Stone and Cook 2000). The

Pleistocene glaciation is believed to be responsible for this separation and the

lineages appear to be mixing in the northwestern and mid-west (Wooding and

Ward 1997, Stone and Cook 2000, Peacock et al. 2007, Pelletier et al. 2011).

During the 2-3 million years black bears have lived in sympatry with three other

bear species, including the extinct short-faced bear (*Arctodus simus*), the extinct

North American spectacled bear (*Tremarctos floridanus*) and the brown or grizzly

bear (*Ursus arctos*) with which it still occurs in the northern part of its range (Stirling and Derocher 1989,Wooding and Ward 1997, Costello et al. 2001).

Black bear habitat in New Mexico is widely distributed in mid to high elevation (approximately 2000 – 3700 meters) mountainous regions containing coniferous habitat types. Primary habitat types used by black bears include ponderosa pine, piñon-juniper woodland, mixed conifer, oak scrub, riparian, spruce/fir and their associations with only occasional use above tree line (Costello et al. 2001). These habitats are patchily distributed in the basin and range topography of southern and central New Mexico and in the southern Rocky Mountains. Marginal habitats include forest fringes and piñon-juniper woodlands that provide seasonal food resources, but that do not provide refuges and other resources needed by bears.

Pelton and Vanmanen (1994) estimated that black bears still inhabit 62 percent of their historic range and now occur sympatrically with the brown bear in the northern part of the species' range. While both species occurred in the Southwest in modern times, the brown bear was extirpated from New Mexico within the last 100 years. It thought that brown bears occupied more open habitats such as the Great Plains and valleys (Costello et al. 2001) and it is likely that black bears have expanded their range into more open habitats in the Southwest in the absence of competition from grizzly bears. Most of the state is not suitable black bear habitat, so most bears are found in habitat "islands" that are often separated by large expanses of unsuitable habitat (Figure 1. Costello et al. 2001). Low lying basins

between mountain islands do not provide adequate resources for year-round existence for black bears, but they do travel through these areas and may use riparian corridors extensively.

In the 1800s and early 1900s widespread persecution and hunting, which included the use of poisons greatly reduced New Mexico's black bear populations (NMDGF 1926, Bailey 1932, Brown 1985). During this period, black bears, grizzly bears (*Ursus arctos horribilis*), jaguars (*Panthera onca*) and cougars (*Puma concolor*) were actively pursued to eliminate the threat to cattle and sheep production. By the 1920s, the black bear was considered rare in most regions of the state and was confined to back country and wilderness areas (NMDGF 1926). At the time, the game and fish department estimated that the state population was fewer than 660 animals (NMDGF 1926). In some mountain ranges, such as the Sandias, black bears were nearly extirpated during the early 1900s (Hayes 1990) due to conflicts with domestic shepherds. In 1924, over the region which included New Mexico, Arizona, Utah and southern Colorado, the US Forest Service estimated the population at no more than 1,500 black bears (Brown 1985). In 1926 the black bear was protected as a game species and the state mammal.

Since they were protected they have recolonized available habitat statewide. Four decades later, the black bear population in New Mexico was estimated at 3,000 animals based on harvest results and hunter surveys (Lee 1967). Current population estimates places the population at 5,500-7,000 animals (Costello et al. 2001, NMDGF 2012).

Population estimates do, however, vary greatly and all of the estimates discussed above are highly speculative and not based on a validated population estimation tool. Black bears and other large secretive carnivores are very difficult to census and population estimates are often based on the quantity of suitable habitat that is are subject to variations in habitat quality, natural population cycles and environmental variability. Current population estimates are based on density estimates or extrapolations of density estimates determined through mark/recapture studies of radio tagged bears in two different study areas in New Mexico which attempted capture of all bears on each study area (Costello et al. 2001).

The NMDGF is tasked with responding to incidences of nuisance bear activity or depredation and has translocated and recorded the movements of numerous bears across New Mexico as a result of management actions (NMDGF unpublished data, Appendix B). The public reacts to increased bear activity and demands management action on the part of the NMDGF (NMDGF SGC Meeting Transcripts 2001-2011). Management action can take the form of trapping and translocation, education, citation for illegal wildlife feeding, or no action at all. Translocation of nuisance bears complicates the integrity of their genetic structure by moving bears into areas or populations where they may not have moved naturally. Translocations records for New Mexico, where bears were moved and then encountered at some later date, show that translocated animals sometimes move long distances (male max 515 kilometers, female max 208 kilometers)

(NMDGF unpublished data). Because black bears are naturally highly vagile and capable of making large movements in pursuit of nutritional resources or mating opportunities (Costello et al. 2001) a combination of induced and natural movements suggest the potential for a high amount of gene flow and reduced population structure in the black bear population of New Mexico (Hellgren et al. 2005; Peacock et al. 2007). However, the fragmented distribution of suitable habitat and the often long distances between habitat islands might predict the opposite - low gene flow between disjunct population segments across the region.

The goal of this study was to examine the population structure of black bears in New Mexico as it currently exists and relates to available habitat. Our working hypothesis was that the desert basins and human dominated valleys isolate black bear populations on mountain islands creating genetically distinct population segments. Other studies looking at movement of black bears across similar landscapes have determined that while separated populations can be considered meta-populations some structure still exists (Atwood et al. 2011, Onorato et al. 2007, Varas-Nelson 2010), more than seems to occur in New Mexico populations. The main reason for these differences may be shorter distances between population clusters and a higher degree of anthropogenic movement. Our secondary goals included exploring whether a population bottleneck occurred in the state during the period of active predator control and persistent hunting during the early part of the 1900's. To accomplish these goals, we collected tissue

samples for genetic analysis from black bears across the state (Figure 1) and used these samples to analyze population structure throughout New Mexico.

Materials and Methods

The NMGDF requires that human-caused black bear mortalities be reported by the hunter or a Conservation Officer reporting the kill. The pelt of a harvest must be tagged within 5 days of reporting the kill, a tooth is removed for aging, a genetic sample is taken and the location of the kill is recorded. This information is used by the NMGDF to regulate the harvest of bears statewide across bear management zones (BMZs). There may be some discrepancies with hunter reported kill locations as they may try to manipulate closure times of BMZs. This may cause some error in reported kill location but the amount of error is unknown and believed to be small.

DNA Extraction and microsatellite typing - We extracted DNA from 143 muscle and ear plug samples using DNeasy nucleic acid isolation kit (Qiagen Inc., Valencia, California). Samples were selected to cover the existing range of black bears in New Mexico, limited by sample availability (Figure 1). A total of 13 microsatellite DNA loci (CXX20, CXX110, G1A, G1D, G10B, G10C, G10J, G10L, G10M, G10O, G10P, UarMU50, and UarMU59) were selected (Paetkau et al 1998, Table 1). For preliminary screening, each locus was amplified individually to test for variability in New Mexico bears. A total of 8 individuals

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across the state were selected at random. Thermal cycler conditions were obtained from a previous study (Robinson et al. 2007). Reactions were performed in a total volume of 10uL, 3.51μL ddH20, 2.4μL Applied Biosystems (AB) BufferII, 0.96μL AB $MgCl_2$ Solution, 1.2μL dNTP mix (2mM), 0.3μL Primer Forward (20uM), 0.3μL Primer Reverse (20uM), 0.13μL AB AmpliTaq and 1.0μL of 50ng/μL extraction. From the original 13 loci, 12 showed variability. For the 10 most variable loci a modified multiplexing scheme was applied (Robinson et al. 2007). Multiplexing was split into 5 marker sets: set1- (G1A, G10B, G10C), set2- (Gxx20, G10J), set3- (G10L, G1D), set4- (Mu50, G10M), and set5- (G10P). PCR was performed in 96 well plates. In each plate reaction both a positive and a negative control were included. PCR conditions were optimized for chemistry and cycling conditions. PCR products were combined with Genescan 400HD [ROX] Size Standard, and sent for fragment analysis at the University of New Mexico Molecular Biology Facility. PCR products were sized using fluorescence fragment analysis technology (ABI Prism 3130, Applied Biosystems, Foster City, CA). Microsatellite fragment sizes were collected and scored using Genotyper 1.0 (Applied Biosystems) software.

We used 12 of the loci (Cxx110, Cxx20, G1A, G10B, G10C, G10D, G10J, G10L, G10M, G10P, Mu50, UarMU59) (Table 1) for all individuals with complete genotypes.

Analysis of microsatellite data – Data input files were created using Microsatellite Toolkit 3.1 (Park 2001) and CONVERT 1.31 (Glaubitz 2004). Microsatellite Toolkit, FSTAT (Goudet 2001) and GENEPOP Version 4.1.10 (Raymond and

Rousset 1995, Rousset 2008) were used to calculate expected and observed heterozygosity (H_E and H_O respectively), allele frequencies and diversity statistics (Table 2).

HWE and linkage disequilibrium analysis – We conducted tests for Hardy-Weinberg expectations and linkage disequilibrium globally and for each locus using GENEPOP (version 4.1.10; Raymond and Rousset 1995 and Rousset 2008).

Genetic structure analysis– Clusters of genetically related individuals were defined using the software GENELAND (Guillot et al. 2005a, 2005b, and 2009) in R version 2.13.1 (R 2011), a Bayesian modeling package utilizing geographic locations but creating populations based upon genetic relatedness and geographic location as *a priori* information. GENELAND was used to describe related groups and reveal population connectivity across the state. The default settings and the spatial model (200,000 iterations using 40 for thinning for 5000 retained iterations) in GENELAND was used due to the expected close relationships and migration/movement between the potential population clusters. Ten independent runs of the model using K = 1-6 (where K equals the putative number of populations) were made to assess consistency of results. We chose the K that best fit the data and fit the posterior probability analysis of population assignments by the model. A final run used the same parameters but set K to the inferred number of subpopulations determined by the runs with variable K. The posterior probability of subpopulation membership was determined using a burn-in of 1000

iterations and individuals with a posterior probability of population membership
of greater than 0.75 were unambiguously assigned to that subpopulation.
The software STRUCTURE version 2.1 (Pritchard et al. 2000) was also used to
test assumptions arising from other model usage. STRUCTURE is a Bayesian
clustering algorithm that uses multilocus genotype data to estimate the probability
of the data (X) given the number of genetically distinct clusters (K), and classifies
individuals into the most likely cluster (Pritchard et al. 2000). STRUCTURE
does not assume *a priori* information on geographic location or gene frequencies,
individuals are assigned to clusters that best reflect HWE and linkage equilibrium
across loci (Pritchard et al. 2000, Evanno et al. 2005). STRUCTURE Harvester
(Evanno et al. 2005, Dent and vonHoldt 2012) was used to perform the ΔK
method to estimate the most likely number of genetically distinct clusters (K).

Translocation Data – Data from bears translocated by the NMDGF in the
Northwest area of New Mexico were compiled from the original records
(NMDGF unpublished data) after the bear, identified by an ear tag, had been
killed. Much of these data were recorded inconsistently and incompletely over
the years, so we assembled only the highest quality records from one quarter of
the state. Data were recorded on individual bears as they were relocated in the
course of nuisance activities, basic information recorded included: location of
capture (physical and UTM grid location), activity, location moved to, dates of
capture and release, and ear tag number and color. We added calculated distance
moved and determined reason for mortality (Appendix B).

La Niña weather pattern analysis – We compared years with high levels of bear

nuisance activity and road kill, and to a lesser extent harvest with La Niña years.

During La Nina periods the precipitation is generally lower and bear nuisance

levels and road kills rise as bears search for nutrients outside of their normal home

ranges (Costello et al. 2001). Statewide precipitation data and ENSO data were

plotted with bear mortality and the relationship was explored

(http://www.ncdc.noaa.gov/temp-and-precip/time-series.html,

http://www.elnino.noaa.gov/lanina.html).

Results

Characteristics of microsatellite loci – All 12 loci were polymorphic with an

average of 4.8 alleles/locus (range: 2-13 alleles/locus). H_O (0.559, SD=0.14),

determined using Nei's estimation of heterozygosity (Nei 1988), was within the

range reported for black bears (0.36-0.81 – Clarke et al. 2001, Paetkau et al. 1998,

Paetkau and Strobeck 1994, Brown et al. 2009), and did not differ significantly

from H_E (0.601, SD=0.14, p > 0.069 at 95%). Using Weir and Cockerham's

(1984) estimation of F_{st} for all loci (0.025, range = 0.018-0.032) and jackknifing

over all loci (0.026, SE = 0.010), we found that the bears sampled from New

Mexico show low overall genetic differentiation.

HWE and linkage disequilibrium analysis – Global tests for the pooled dataset

revealed Hardy-Weinberg equilibrium was significantly different across loci but

was not significantly different (P = 0.1625, S.E.= 0.003) overall (Table 5) . This

is not unexpected due to underlying population subdivisions. Linkage

disequilibrium was not observed with no P < 0.05 across all loci comparisons.

Analysis of population structure - Using the program GENELAND (Guillot et al.)

to create posterior probability analysis of genetic clusters and population

assignments, resulted in 5 populations being assigned. Ten independent runs were

performed with an additional run performed at the inferred number of

populations. GENELAND assigned 5 population clusters (pop. 1: 11 individuals,

pop. 2: 2 individuals, pop.3: 85 individuals and pop. 5: 29 individuals, no

individuals were assigned to pop. 4).   Probability of population membership

assignments was very low, with the range of probability of assignment ranging

from 10.0% to 43.0%. No individuals were unambiguously assigned indicating a

high degree of admixture. The maps of K = 1-5 clusters that GENELAND

produced are informative in that they are all very similar indicating low

probability of specific cluster assignment and further indicating a lack of genetic

differentiation between clusters (Figure 2).

Five independent runs were performed in STRUCTURE (Pritchard et al. 2000)

for K = 1-6 (to account for putative population origin based upon biogeographic

regions within New Mexico) and the final K was determined by the best fit for the

data using STRUCTURE Harvester (Dent and vonHoldt 2012, Figure 2). The

runs were performed with 100,000 Markov Chain Monte Carlo repetitions after a

burn-in period of 30,000 using the admixture model with correlated allele

frequencies allowed between subpopulations to account for the expectation of

high gene flow. Individuals were assigned to subpopulations during a final run

using a burn-in of 100,000 and 500,000 iterations at the inferred K = 3. Inferred

ancestry assignment values for K = 3 ran from 0.08 to 0.80. Only 9 individuals

were unambiguously assigned to any given population cluster (assignment value

> 0.75, 3 individuals to C1, 5 individuals to C2 and 1 individual to C3), indicating

a high amount of movement between subpopulations. Two bar plot

representations, one for K = 3 and one for K = 6, of each individual's ancestry

have little discernible pattern of population assignment other than a high level of

admixture (Figure 3).

Translocation results – Of 105 tagged-bear mortalities from the Northwest Area

of New Mexico, the NMGDF moved bears an average of 68 km (standard

deviation = 55.7 km, range 8-280 km) between 2000 and 2011 (Appendix B).

Discussion

Investigation of the degree of relatedness of a sample of New Mexico's black

bears using DNA microsatellites illustrates that bears in New Mexico show a

higher degree of admixture and lower overall differentiation than bears studied

nearby in Arizona, Mexico and Texas (Atwood et al. 2011, Hellgren et al. 2005,

Onorato et al. 2007, Varas-Nelson 2010). The high degree of admixture in New

Mexico's black bear populations are likely to be explained by: 1) migration (eruptive bear activity) from small habitat islands due to density dependent factors in search of nutritional resources, or, in the case of males, dispersal and mating opportunities (Rogers 1987, Onorato et al 2004, Costello 2010); and 2) anthropogenic translocations based on management activities aimed at lessening human-bear conflict, and 3) the potential for a population bottleneck to have occurred before black bears were protected in 1926 and the founder effects and out-breeding depression that would have occurred with it. We discuss each of these potential effects on black bear genetic population differentiation in the following discussion.

Natural movements of black bears and population genetics

Black bears move for a variety of reasons and long distance movements between habitat fragments is frequent and likely varies with both age and sex. These movements may be prompted by several drivers that are both density dependent and density independent and include: resource limitation due to climate or specific weather events, dispersal by young males, and rare dispersal by older aged animals or females.

Other researchers have had some results that varied somewhat from New Mexico's regarding the structural relationship between different habitat segments. In general while the bear populations studied elsewhere in the Southwest were

related; they showed higher amounts of differentiation than we have ($F_{st} = 0.025$, 95% CI: 0.018-0.032). Atwood et al. (2011) found significant differentiation between two sub-populations in Arizona, one in the east-central highlands (Mogollon Rim and White Mountains) and one in the border region ($F_{st} = 0.111$; 95% CI: 0.056-0.156; Patagonia, Huachuca, Whetstone, Rincon, Galiuro and Chiricahua Mountains). The potential corridors between these various population segments are compromised by human development and lack of black bear habitat. Varas-Nelson (2010) found that black bears from isolated sky islands, including the Huachuca, Peloncillo, Pinaleno, Chiricahua, Catalina, and Rincon Mountains, the Mogollon Rim Mountains (Four Peaks and Mount Ord, the Nutrioso Mountains and the Apache National Forest) in Arizona and the Sierra Los Ajos, Sierra San Luis and Sierra El Nido in México could be considered the same population ($F_{st} = 0.07$ between populations) but that distance between each population affected the degree of differentiation and that little exchange occurs between Mexican and United States populations except on the border, and that exchange could be compromised by border security activities. Onorato et al. (2007) found differences between black bears from isolated mountain ranges in West Texas (Black Gap, Big Bend National Park and the Trans-Pecos) and México (Sierra del Carmen and Serranias del Burro Mountains), including $\phi_{st} = 0.63$ values between sampling localities, but these populations did show some connectivity (ϕ_{st} is an index of mitochondrial DNA structuring). Higher levels of genetic structuring observed in those studies, relative to New Mexico may be a consequence of at least two factors.

First, New Mexico populations are closer together (30-60 kilometers vs. 100-120 kilometers in Arizona/Mexico and 40-300 kilometers in Texas/Mexico, Table 4); second, they are also separated by areas that provide less navigable habitat for black bears than that in New Mexico. Arizona and the border region with Mexico have a rapidly growing human population and related infrastructure. Texas bear distributions are characterized by long distances of non-habitat between potential habitat segments and intervening human development.

The second is that there has not been as much anthropogenic movement in these populations, although managers in Arizona historically moved bears (Varas-Nelson et al. 2010). The character and quality of the habitat in between the mountain ranges, and the ability of bears to move through it, is also important. In New Mexico, there are still relatively clear movement corridors between most of the sub-populations with some exceptions (e.g. Tijeras Canyon between the Sandia and Manzano Mountains has continuous human development and Interstate 40, Interstate 25 through Raton Pass near the Colorado border is a significant barrier accounting for numerous road kills annually). The Rio Grande Bosque also provides a movement corridor in New Mexico running straight through the middle of the state and passing close to numerous habitat islands. In Arizona, Mexico and Texas, habitat between the ranges is human dominated, extremely arid, and dangerous for bears to cross, as it is in New Mexico, but more

so. Most human mediated bear translocations occur between habitat patches in relatively close proximity.

Migration pulses that accompany precipitation/drought cycles in the arid southwest (Southern Oscillation Index, Zack et al. 2003) appear to have large effects on localized population movement and structure, leading to the observed patterns (Figure 5, A., B. and C.). The NMDGF has anecdotal records of increased levels of bear movement and activity related to droughts going back 8 decades. These records continue through the present with much more accurate data collected regarding type of mortality and locational information. In 2011 alone, a very strong La Nina year with accompanying late frosts that killed oak buds, there were 479 sport harvested bears, 223 depredation/nuisance related mortalities and 58 road kills for a total of 777 total bear kills by the end of November. These are the highest numbers ever recorded for depredation/nuisance kills and road kill. Additionally, the 12-year average total mortality (since 2000 at the beginning of the last La Nina cycle and the highest recorded mortality preceding 2011's) has been 439 and 2011's harvest alone exceeds that, and the total mortality exceeds it by 43% (NMDGF bear harvest records 2011). Records are somewhat scattered, still during the 2011 season over 200 bears were translocated. Some of these were later euthanized, but others may have contributed to the gene pool in a new location.

Zack et al. (2003) theorized that eruptive black bear activity could be predicted using the Southern Oscillation Index (ENSO). This pattern is consistent for La Niña years, when precipitation is lower than average (Avg. = 14.49" from 1979-2011), bear-human interactions increase with a weak relationship ($r^2 = 0.1414$) between bear mortality and precipitation (Figure 4c). Human-caused bear mortality levels (hunter harvest, road kill and departmental/landowner removals) have been reasonably accurately tracked since the late 1980s in New Mexico (Figure 5). Discernible peaks in mortality and nuisance activity, including translocations, road kill and euthanasia of problem bears; follow La Niña years although other fluctuations (e.g. mast crop failures due to late freezes that destroy oak flowers and/or do not allow fruit set) occur. Other factors are obviously confounding the accuracy of ENSO prediction. Wet periods occurring for 2 or more years may allow local populations to expand, leading to eruptive patterns despite climatic variation. This pattern may have a stronger effect overall than the La Niña related pattern. Localized populations that do not suffer resource limitations grow in between periodic droughts leading to density dependent dispersal by males, and potential anthropogenic movement of nuisance animals.

Some local populations of black bears that are surrounded by more urbanized portions of the state or are directly adjacent to high quality bear habitat, such as the Sandia Mountains, Albuquerque and its bedroom communities, Raton, and Ruidoso have consistently higher levels of bear human interactions (Figure 1). Bear human interactions increase near human population centers and include

incidents involving a bear utilizing human provided food, intentionally or not. In this system, the number of bears that a habitat segment can support fluctuates based upon precipitation/drought cycles. The implication is that the habitat islands in the Basin and Range system, and the mountainous portions of New Mexico, can only support a certain number of bears. Density estimates used by the NMGDF to estimate bear populations which derive from Costello et al. (2001) may be accurate some years and descriptive of the ability of the habitat to support bears, but inaccurate in others when precipitation is either lower or higher than normal or other climatic factors such as late frosts occur.

The potential effects of human translocations on black bear genetics

The above mentioned climatic effects are coupled with the movement of individual nuisance animals by departmental actions, leading to the observed pattern of diminished population structure in individual habitat islands. In the past, state agencies such as the NMGDF or the Arizona Department of Game and Fish generally took the pragmatic approach of moving a nuisance bear to a nearby mountain range or habitat segment. In New Mexico this generally meant moving the bear 80-100 kilometers (straight-line distance). Similar transplant distances occurred in Arizona (Ron Thompson, AZDGF ret., pers. com; Varas-Nelson 2010), but current policies forbid translocation of nuisance animals as a regular course of action (Ron Day, AZDGF, pers. com). Occasionally, nuisance bears are moved short distances, generally to the nearest available habitat patch and then

aversely conditioned. These movement distances may be <10 kilometers, but bears are moved as far as 250 kilometers. Longer distance translocations occurred when convenient, or in particular cases, such as a female bear with young cubs. Management direction has changed with most agencies moving fewer animals and either euthanizing or subjecting them to aversive conditioning (Western Black Bear Workshop, MT, 2012). Bears that are "multiple offenders" are generally euthanized.

Between 2000 and 2011, a minimum of 964 bears were translocated in New Mexico, some of them multiple times, only 28% of those bears were female. Eighty percent or more of these bears were moved 80-100 kilometers from their place of capture. The remainder were either moved shorter distances as opportunity presented itself, for aversive conditioning, or longer distances if the potential to rehabilitate the individual bear seemed valuable. Unfortunately records of bear translocations throughout the state have been of poor quality, negating the possibility of rigorous analysis. During this same period (2000-2011), 346 bears (36%) that had been handled previously died from either 1) being hit by vehicles, 2) were euthanized because of repeated nuisance activity or 3) were harvested by hunters. Fifty percent of the subset of 346 bears was translocated during the same time period.

Records for bears moved prior to 2000 were inconsistent making it impossible to determine the origin of many ear tagged bears. Records since 2000 are better, but

remain incomplete. I used the highest quality subset of the records, from the

Northwest Area, to assess movement. Substantial anthropogenic movement

significantly confuses our ability to characterize the genetic structure of bear

populations statewide, particularly when females and/or females with cubs are

moved. Females are generally philopatric, while males disperse further distances

(Elowe and Dodge 1989, Beck 1991, Costello et al. 2008, Costello 2010, Pelletier

et al. 2011). Costello (2010) found that female black bears in New Mexico

(n=99) only dispersed 0-7 kilometers, while males (n=53) dispersed 22 to 67

kilometers from their natal ranges. Average translocation distances for the

Northwest Area of the state from 2000-2011 were slightly larger than natural

dispersal distances at 68 km, yet we still see little structure between population

centers. Uncontrolled and/or planned translocations by humans of female bears to

areas where they were unlikely to disperse naturally may have a major effect on

overall genetic variability.

Do we see the effects of a population bottleneck on black bear genetics?

During the early history of New Mexico, black bears and grizzly bears, along with

cougar, jaguar, gray wolves (*Canis lupus*) and virtually all other carnivores, were

persecuted. Many of these species had federal or local bounties due to their

predation on ungulate resources, both wild and domestic. Since the black bear was

protected in 1926, harvest has varied, possibly stabilizing only within the last

several decades (NMDGF 2012 unpublished data). During the early portion of

this protection from persecution, black bear numbers in New Mexico were increasing in suitable habitats in mountainous, conifer-dominated ecosystems statewide.

By the mid-1920's the population of black bears in New Mexico was estimated at around 660 animals. Estimation techniques used were not well explained, but were probably a combination of sightings, animals trapped for cattle/sheep killing, sport harvested animals, etc. With a current estimate of 5,500 – 7,000, the New Mexico population has potentially expanded by at least ten-fold in the last 80-90 years.

This rapid expansion raises the question, have there been population genetic effects of this rapid expansion? Founder effects and/or out-breeding depression could account for and explain some of the low level of differentiation between population segments which was found. A small starting population of 660, spread across the state, with the somewhat slow growth potential of black bears (Stirling 1990a, Costello et al. 2001) may have led to a fairly limited gene pool for the expanding population. Mitochondrial DNA can be used to determine whether or not a bottleneck may have occurred through the analysis of parentage and matrilineal lines which can explain population substructure more completely than nuclear DNA techniques such as microsatellite analysis which determines the effect of bi-parentally inherited genes (Pelletier et al. 2011).

Some of the lack of differentiation found could be due to recent recolonization of unoccupied habitat segments and founder effects in those recolonizing populations. Allelic diversity is somewhat low in New Mexico compared to other areas and studies (Table 5) which supports a bottleneck in recent history despite a robust bear population currently. Before the 1980s, nuisance bear activity was generally a local problem in New Mexico tied to town dumps or other easily available sources of nutrients. Only since the mid-1980s or so, have habitat islands become saturated to the point that bears have had to make long distance movements out of individual mountain ranges to disperse or in search of nutritional resources or breeding opportunities in the case of males (Costello 2010).

Conclusions

Matrilineages should be analyzed using mtDNA to determine whether or not females and males show a different pattern due to female philopatry and the effects of anthropogenic movements. The result of these movements is that local black bear populations in New Mexico, and potentially Arizona, Mexico, and Texas are very difficult to quantify and describe the population genetics of accurately without long-term monitoring of the bear populations and in-depth analysis of the population genetics. An ideal regional assessment of population connectivity, size, genetic differentiation and viability would be large in scale and cooperation but would be expensive. To set the stage for future management and

such a large-scale study, an emphasis should be placed on building extensive archives of bear samples that are rigorously preserved and that have associated accurate geo-referenced locality information.

While the above stated issues make management decisions more difficult in the short term, it also means that the genetic integrity of the statewide meta-population does not appear to be in jeopardy of losing isolated and divergent genotypes in the near future. It also emphasizes the need to maintain corridors for dispersing animals. Potentially, management of the regional population, including adjacent portions of Arizona and Colorado may be more appropriate than current management based on political or biogeographic boundaries. Based on the current existence of a meta-population, managing most of New Mexico as one population rather than the current 14 bear management zones seems appropriate.

Translocations are generally ineffective at relieving the problem of nuisance bears and a significant portion of translocated animals are destroyed soon after removal. Long range translocations may complicate efforts to use genetic methods to monitor population dynamics. Humane euthanasia of offending animals before they become habitual offenders (Hopkins et al. 2012) and development of long-term, spatially extensive collections should be implemented.

Table 1. Twelve variable microsatellite loci selected and amplified.

Locus	5' Primer	3' Primer	Label
CXX20[a]	AGCAACCCCTCCCATTTACT	TTGTCTGAATAGTCCTCTGCG	FAM
CXX110[a]	TGCTTTGGGTTAAATCTAAGCC	CCCCAGAGATGTGGCATC	HEX
G1A[b]	ACCCTGCATACTCTCCTCTGATG	GCACTGTCCTTGCGTAGAAGTGAC	HEX
G1D[b]	ACAGATCTGTGGGTTTATAGGTTACA	CTACTCTTCCTACTCTTTAAGAG	FAM
G10B[b]	GCCTTTTAATGTTCTGTTGAATTTG	GACAAATCACAGAAACCTCCATCC	FAM
G10C[c]	AAAGCAGAAGGCCTTGATTTCCTG	GGGGACATAAACACCGAGACAGC	FAM
G10J	GATCAGATATTTTCAGCTTT	AACCCCTCACACTCCACTTC	FAM
G10L[b]	GTACTGATTTAATTCACATTTCCC	GAAGATACAGAAACCTACCCATGC	TET
G10M[b]	TTCCCCTCATCGTAGGTTGTA	AATAATTTAAGTGCATCCCAGG	TET
G10P[b]	ATCATAGTTTTACATAGGAGGAAGAAA	TCATGTGGGGAAATACTCTGAA	FAM
UarMU50[c]	GGAGGCGTTCTTTCAGTTGGT	TGGAACAAAACTTAACACAAATG	TET
UarMU59[c]	GCTGCTTTGGGACATTGTAA	CAATCAGGCATGGGGAAGAA	TET

[a]Ostrander et al. 1993; [b]Paetkau et al. 1995; [c]Taberlet et al. 1997

Table 2. Population statistics of the 11 separate discrete habitat units sampled.

Population Statistics

Population	Samp. size	Loci typed	Exp. Hz	Exp. Hz SD	Obs H	Obs H SD	No Alleles	No Alleles SD
Black Range	7	12	0.6337	0.0474	0.6310	0.0527	3.58	1.24
Burros&North	8	12	0.6184	0.0449	0.6012	0.0505	4.42	1.24
GMU 17	9	12	0.6055	0.0516	0.5061	0.0510	3.92	1.38
JemezMtns	19	12	0.5879	0.0590	0.5659	0.0350	4.92	1.51
MtTaylor	8	12	0.5417	0.0659	0.5863	0.0513	3.67	1.61
NGila	15	12	0.5974	0.0464	0.4642	0.0380	4.67	1.67
SSanJuans	12	12	0.6439	0.0417	0.5335	0.0419	5.33	1.61
Sacramentos	9	12	0.6131	0.0527	0.5939	0.0479	4.00	1.48
SandiasManza	21	12	0.6227	0.0452	0.5664	0.0321	5.08	1.56
Sangres	14	12	0.5773	0.0481	0.5543	0.0395	5.08	1.24
Zunis	5	12	0.5426	0.0724	0.5500	0.0642	3.42	1.38

Table 3. Hardy-Weinberg Exact test results across all loci from GENEPOP showing an overall P-value of 0.1625 which is not significant at the 95% level. HWE tests between loci show significant differences.

Locus	P-Val	S.E.	Switches (ave.)
G10C	0.1402	0.0048	9332.22
G10D	0.0945	0.0066	14938.40
G10L	0.0027	0.0008	10547.55
G1A	0.0602	0.0041	9644.45
G10B	0.0000	0.0000	14977.91
Gxx20	0.0072	0.0013	10362.18
G10J	0.0330	0.0034	12193.09
Mu50	0.0000	0.0000	21741.09
G10M	0.0002	0.0001	17325.45
G10P	0.0021	0.0005	12143.50
UarMu59	0.6100	0.0155	6086.73
Cxx110	1.0000	0.0000	21337.91
All:	0.1625	0.0030	13385.87 (ave.)

Table 4. Distances in kilometers between centralized sub-populations of black bears in
New Mexico, Arizona (Atwood et al. 2011, Varas-Nelson et al. 2010) and Texas
(Onorato et al. 2007).

State	Central Sub-population	Other Sub-population	Distance in Kilometers
New Mexico	Sandias/Manzanos	Southern San Juans	30 km
New Mexico	Sandias/Manzanos	Sangre de Cristos	40 km
New Mexico	Sandias/Manzanos	Zunis/Mt. Taylor	60 km
New Mexico	Sandias/Manzanos	Gila Region	60 km
New Mexico	Sandias/Manzanos	Sacramentos	60-90 km
Arizona	Chiricahuas	Mogollon Rim	120 km
Arizona	Chiricahuas	Sierra el Nido	100 km
Arizona	Chiricahuas	Catalinas	100 km
Texas	Big Bend	Fort Davis Mts.	140 km
Texas	Big Bend	Sierra del Carmen	40 km
Texas	Big Bend	Guadalupe Mts.	300 km

Table 5. Mean population study statistics from across North American black bear range

Population	Sample size	Loci typed	HE	HO	Avg. No. Alleles
New Mexico	127	12	0.601	0.559	4.8
Arizona*	155.36	11	0.534	.0508	6.27
Arizona/Mexico*	173	10	0.79	0.78	13.9
California*	574	13	0.58	0.53	8.3
Colorado*	512	7	0.73	0.70	8.6
Quebec*	141	10	0.842	0.829	11.5
Alaska*			0.54-0.80		
Wisconsin*		6	0.77	0.84	8
Across Range*			0.36 – 0.81		

*Arizona (Atwood et al. 2011), Arizona/Mexico (Varas-Nelson et al. 2010), California (Brown et al. 2009), Colorado (Apker et al. 2009, pers. com), Texas (Onorato et al. 2004), Quebec (Bernatchez et al.), Alaska (Peacock et al. 2007) across range **(**Paetkau & Strobeck 1994, Paetkau 1998, Clarke et al. 2001, Brown et al. 2009)

Figure 1. New Mexico bear habitat model (Costello et al. 2001) including, areas of high bear nuisance activity and road kill locations in New Mexico from 2000-2011.

New Mexico Black Bear Habitat Model
with Sample Locations, Roadkill Locations,
and Nuisance Communities

Sample Locations
Roadkill Locations
Nuisance Communities

Bear Model 2001
Primary Habitat
Secondary Habitat
Edge Use

0   25   50   100 Miles
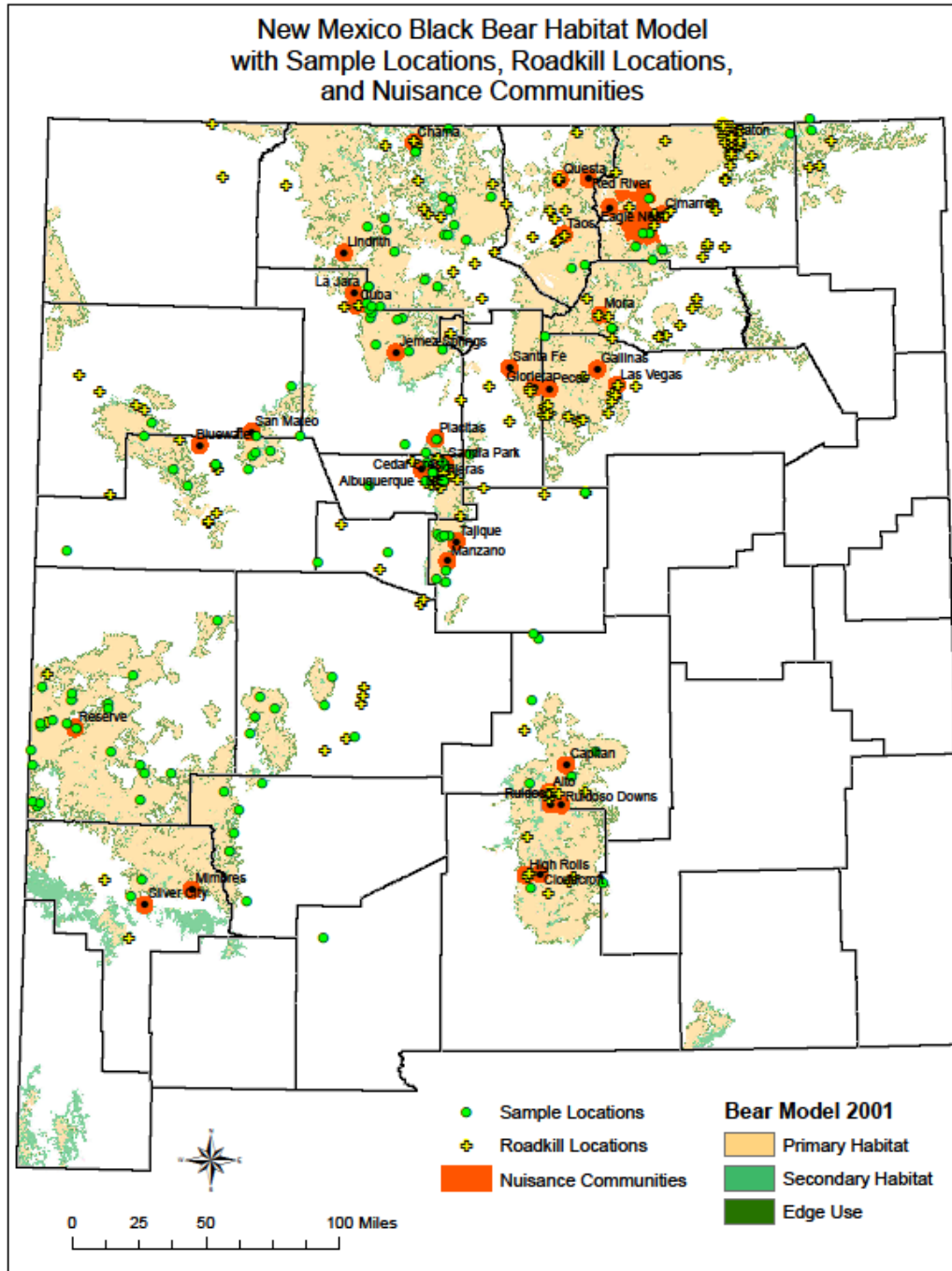
Figure 2. Maps of posterior probability clusters K=1-5 showing very little differentiation between genetic and geographic *a priori* information. The lighter the color, the higher the probability of belonging to the indicated cluster, each individual is a black circle. Interestingly the highest probability of assignment for all individuals appears to be cluster 4, to which no individuals were assigned.

A.

Map of posterior probability to belong to cluster 1

B.

Map of posterior probability to belong to cluster 2

C.

Map of posterior probability to belong to cluster 3

D.

Map of posterior probability to belong to cluster 4

E.

Map of posterior probability to belong to cluster 5
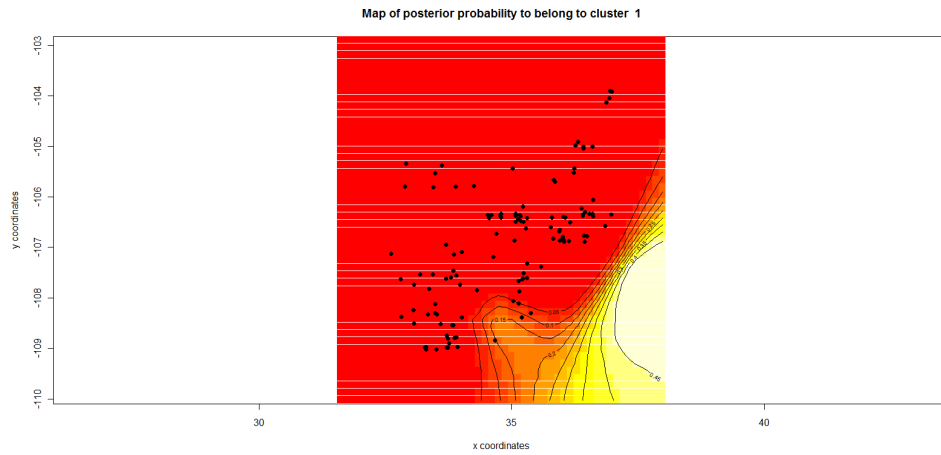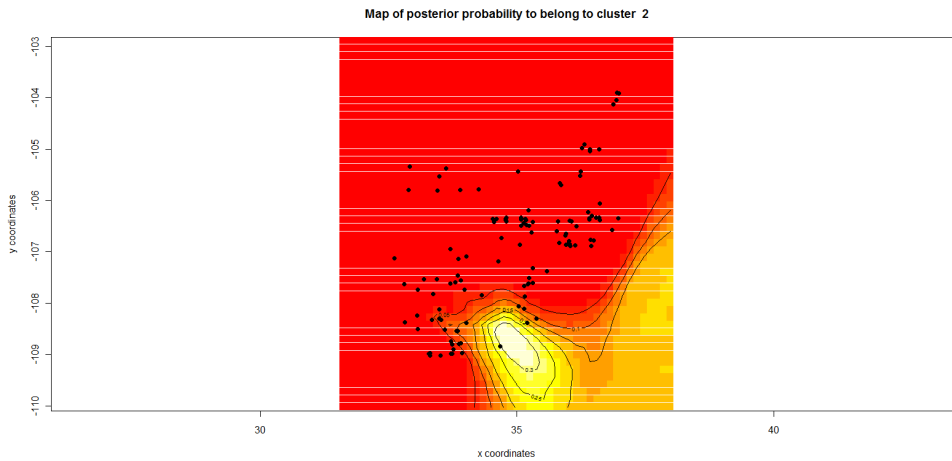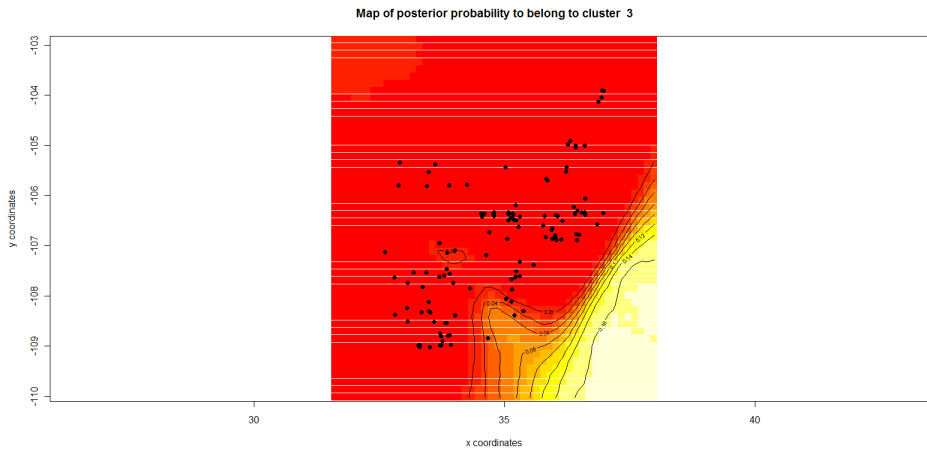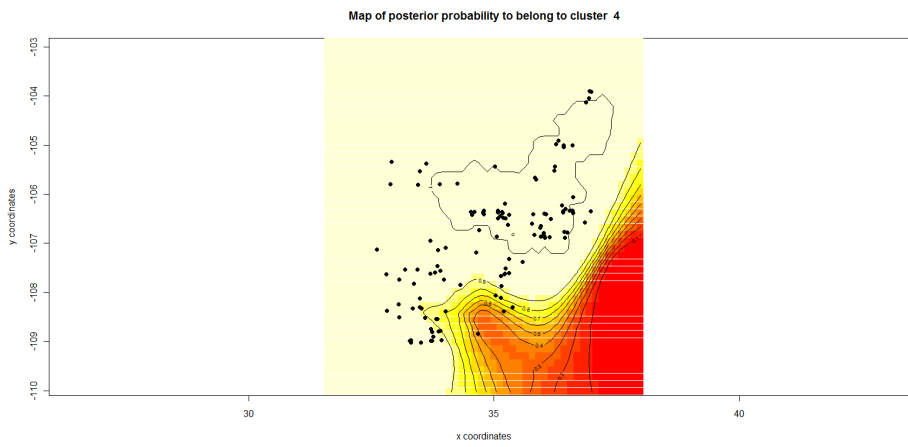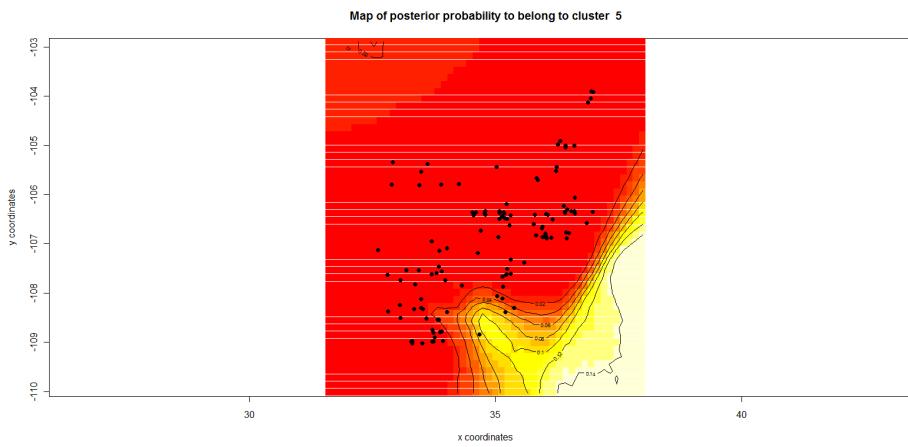
Figure 3. STRUCTURE Harvester output showing the ΔK indicating best fit using the Evanno Technique and an inferred most likely cluster of 3 populations.

$$DeltaK = mean(|L''(K)|) / sd(L(K))$$
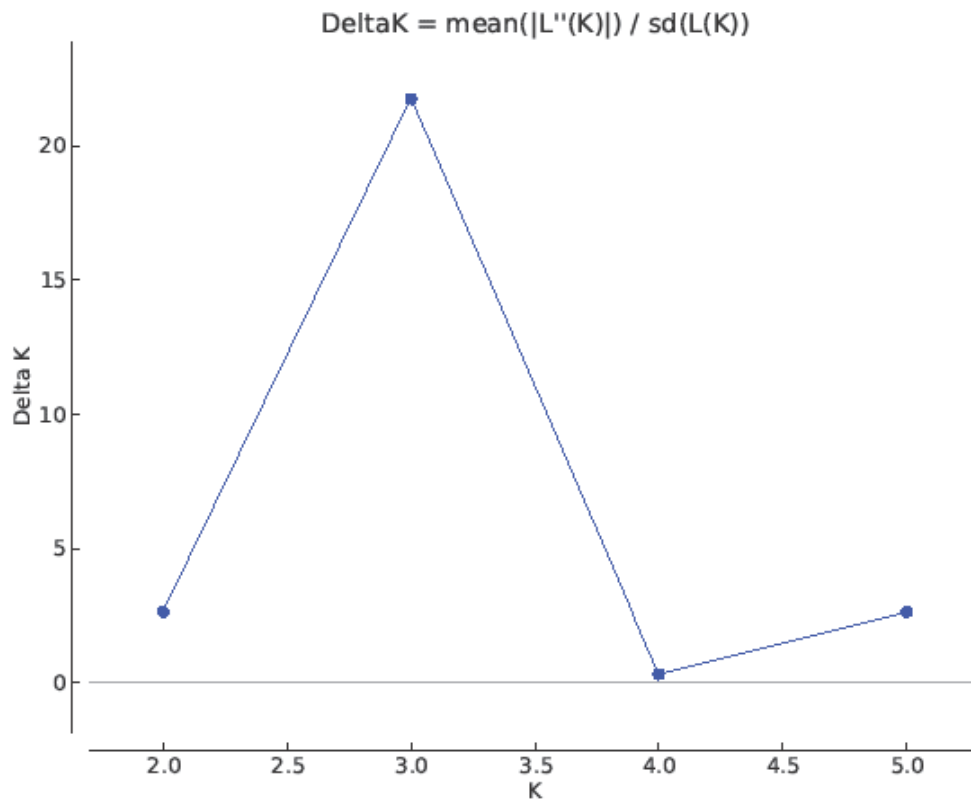
Figure 4. Genetic assignment results from program STRUCTURE for N=3 and N=6 using the admixture model with correlated alleles option. Individuals are grouped according to putative population assignments (1 = NWNM, 2 = NENM, 3 = WCNM, 4 = ECNM, 5 = SWNM and 6 = SENM). Genetic population clusters are coded with different colors, and the percentage of any color for an individual represents the probability of assignment to a specific cluster. For both N=3 and N=6 the assignments to specific clusters are very low, indicating low a low quantity of differentiation between population segments and a high degree of admixture.

(A)
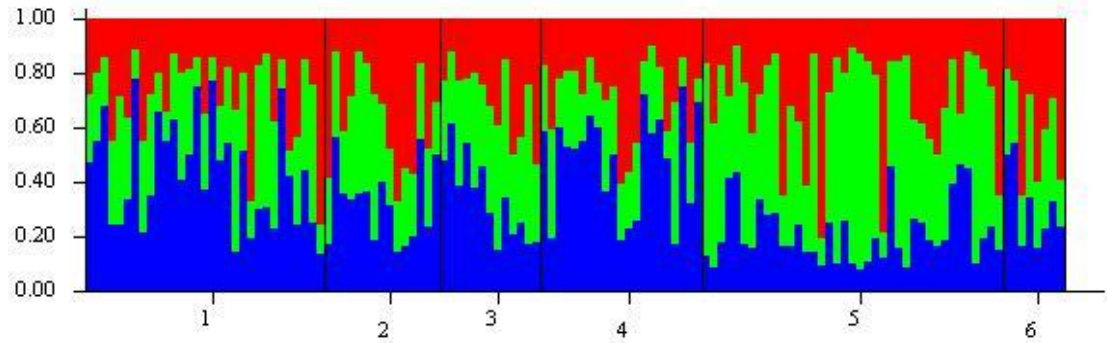
(B)
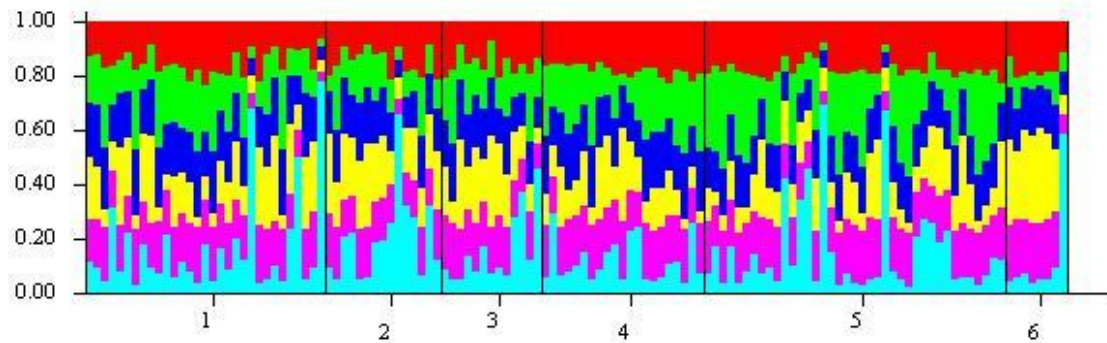
(C)
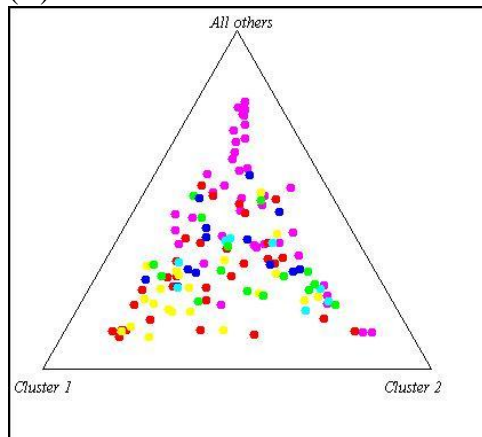
Figure 5. Black bear harvest and mortality across 3 decades. La Nina years correspond to periods of low precipitation statewide. Total harvest includes all known mortality and tends to be high, with a lag after identified low precipitation years (NOAA.GOV and NMDGF). High mortality occurs when bears are moving about more seeking resources during drought periods when they are more visible to humans, and therefore more subject to both hunter harvest and more likely to engage in nuisance activity and/or become road kill.

A. Total Statewide precipitation and Total Bear Mortality, 1979-2011.
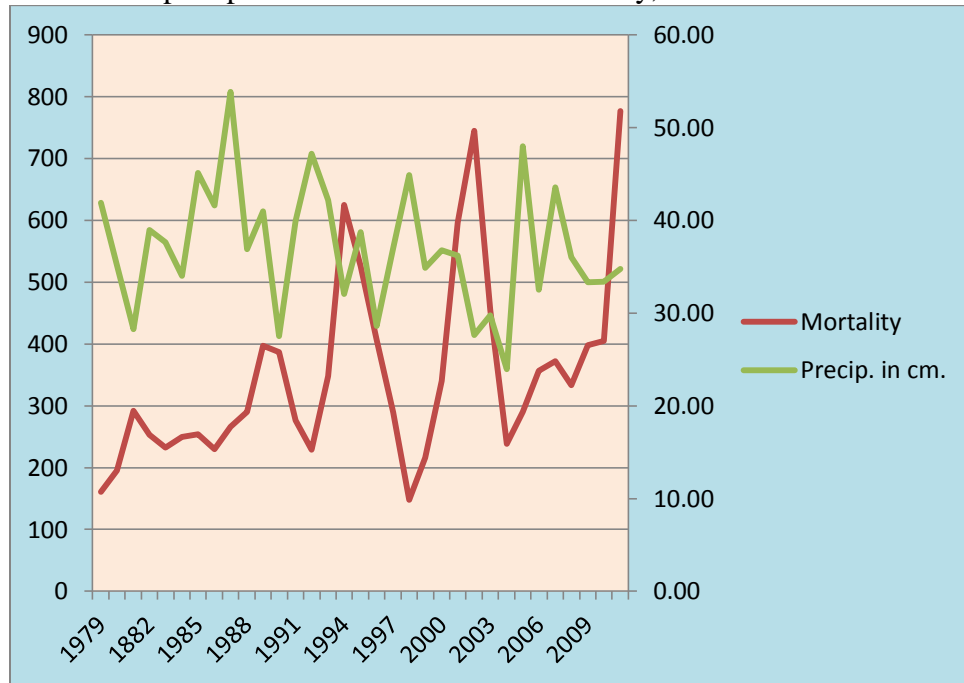
B. Total Statewide Precipitation and Non-harvest Bear Mortality, 1983-2011.
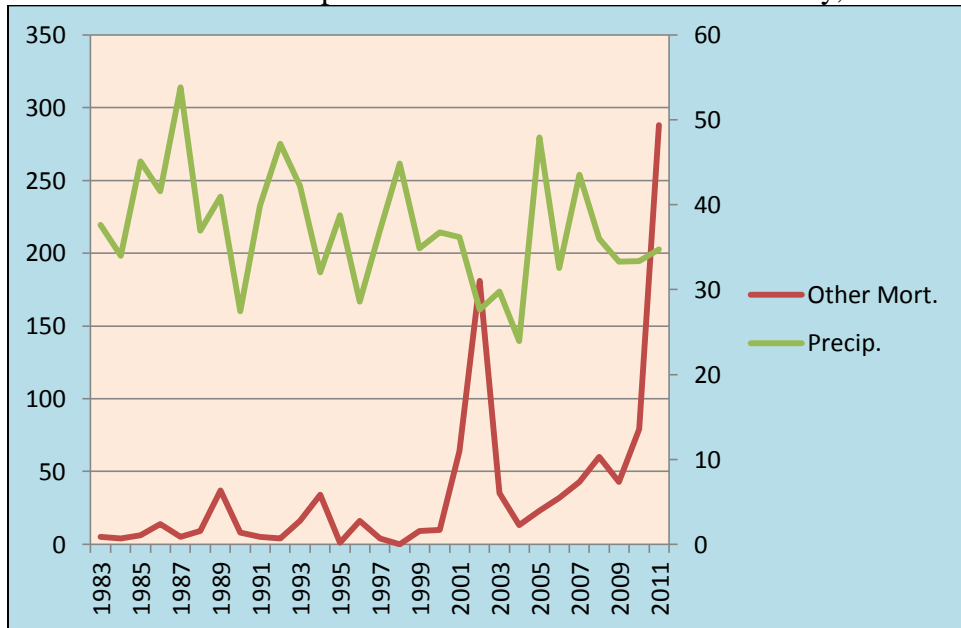
C. Total mortality from 1983 – 2011 plotted with total statewide precipitation from the same period shows a weak relationship r² = 0.1414.

$$y = -22.031x + 672.25$$
$$r^2 = 0.1414$$
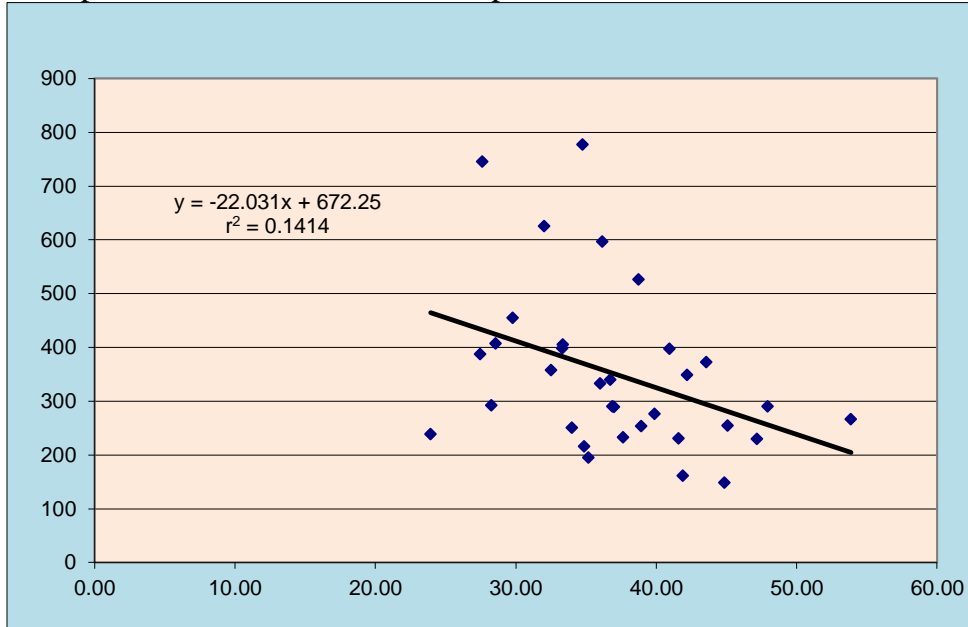
APPENDICES

Appendix A. Museum of Southwestern Biology catalog of samples

Appendix B. Bear mortality, capture and release table and statistics for management bears from 2000-11 in the Northwest Supervisory Area, New Mexico Game and Fish Department.

Appendix A. Museum of Southwestern Biology catalog of samples

MSWB #	Sample Location	Pelt Tag #	Sex	Date	GMU	Location	Zone	Easting	Northing	Type
212706	S. San Juans	17084	m	8/30/2002	51	N of El Rito	13	390000	4027000	SP
212708	Black Range	17118	m	7/25/2002	21	Decker Canyon	13	254000	3632000	Depredation
212709	S. San Juans	17406	m	10/3/2002	51	Canjilon	13	377000	4030000	SP
212763	Sacramentos	17567	m	8/29/2003	54	Urraca Mesa	13	500000	4030000	
212713	N. Gila	20144	m	9/7/2008	16	Collin's Park	12	746233	3633566	
212714	Sangres	20276	m	7/31/2008	55	Ponil Camp	13	500000	4050000	dep
212716	Zuni Mts	20437	m	10/25/2008	10	Paxton Spgs.	12	768200	3880300	sp
212764	Sacramentos	21373	m	8/29/2009	37	Arroyo de Macho Cnyn	13	450000	3705000	
212765	N. Gila	21529	m	8/29/2009	16	Below John Kerr	12	730000	3720000	
212807	Sandias/Manzanos	22039	m	??	8	NE Heights	13	365200	3894000	dep
212718	Zuni Mts	22046	m	10/3/2008	10	Zuni Canyon	12	697600	3838800	sp
212719	Mt. Taylor	22047	m	10/4/2008	9	San Mateo Canyon	13	262500	3910600	sp
212720	Mt. Taylor	22050	m	5/13/2008	9	Grants, Cibola Co., NM	13	238000	3894000	road
212808	Sandias/Manzanos	22103	m	7/2/2008	8	Rio Puerco W. of Burque	13	330000	3880000	road
212721	Sangres	22105	m	9/28/2008	45	Rita de la Cueva Cny.	13	335000	3965000	sp
212723	Jemez Mtns	22115	m	9/19/2008	6	Pedro Spgs.	13	351000	3980000	sport
212809	Mt. Taylor	22161	f	8/1/2008	9	Marquez Canyon, Marquez WMA	13	289000	3910000	sport
212726	Sandias/Manzanos	22162	m	8/10/2008	14	Mountainaire	13	375500	3822000	Dep.
212727	N. Gila	22163	f	8/17/2008	16	Cordoroy Cny.	12	767000	3708000	sport

212766	Sandias/Manzanos	22168	m	9/7/2009	14	4th of July Cnyn	13	378000	3850000	sport
212728	N. Gila	22292	f	8/17/2008	16	Reserve	12	708500	3732200	sport
212729	N. Gila	22293	m	8/18/2008	15	Potato Patch	12	693850	3737030	sport
212810	Burros and North	22298	m	9/3/2008	23	Frieborn Canyon	12	687200	3732400	sport
212730	Black Range	22339	m	9/23/2008	21	Jaralosa Mt.	13	264000	3703000	
212811	Sangres	22475	m	8/31/2008	48	Ortega Mesa	13	496000	4030000	sport
212734	Sangres	22479	m	9/4/2008	57	Trinchera Pass	13	585000	4088000	
212812	Sangres	22592	m	10/9/2008	57	Paloma Ranch, Indian Head	13	598000	4090000	sport
212767	Sacramentos	22631	f	8/22/2009	34	Alamo Pk.	13	425000	3638500	
212770	Sacramentos	22718	f	8/16/2009	36	Nogal Cny.	13	426555	3750555	
212736	Sangres	23244	m	9/30/2008	48	Heck Cnyn.	13	508000	4019000	sp
212771	Jemez Mtns	23253	f	10/7/2009	6	Rio de Vacas	13	347000	4020000	
212813	Sangres	23309	f	8/25/2008	57	WO Doherty Ranch	13	597000	4097000	sport
212772	GMU 13	23341	f	8/29/2009	13	Datil Mts.	13	238000	3800000	
212739	Sandias/Manzanos	23345	F	8/20/2008	14	Sandia Mts.	13	368588	3888095	road
212740	N. Gila	23401	f	8/18/2008	16	John Kerr Area	12	727000	3748000	sport
212741	Sangres	23402	m	8/19/2008	49	US Hill of FR 439	13	453000	4009000	sport
212742	N. Gila	23404	m	8/17/2008	16	Sand Canyon	12	727000	3745000	sport
212743	Mt. Taylor	23406	m	8/23/2008	9	L-Bar Rch	13	284000	3940000	sport
212802	N. Gila	23408	m	9/1/2008	15	Mangas Mt.	12	741000	3766000	
212746	Jemez Mtns	23409	?	9/3/2008	6	Jemez Mts.	13	332000	3980000	sport
212748	Sangres	23420	F	8/18/2008	49	Frijoles Cnyn., FR 49	13	461000	4011000	sport
212749	Zuni Mts	23491	f	9/8/2008	10	PO Flats	13	738000	3898000	sport
212750	Sangres	23492	m	9/8/2008	48	Ortega Mesa	13	502000	4013800	sport
212751	Sacramentos	23493	m	9/9/2008	38	Gallina Pk	13	431000	3788000	sport

ID	Region	No.	Sex	Date	No.	Location	Zone	Easting	Northing	Type
212752	Jemez Mtns	23494	m	9/29/2008	6	Cuba area	13	333000	3984000	sport
212753	Jemez Mtsn	23495	f	9/10/2008	5	Gallina Pk	13	341000	4040000	sport
212754	Jemez Mtns	23496	m	9/15/2008	6	Pinos Negras	13	331000	3985000	sport
212755	Jemez Mtns	23497	f	9/15/2008	6	Colvares Canyon	13	348000	3979000	sport
212758	Jemez Mtns	23500	f	9/22/2008	6	Jemez Mts.	13	330000	3990000	sport
212773	GMU 17	23540	m	8/23/2009	20	Valle Verde	13	320000	3730000	
212759	N. Gila	23564	m	9/29/2008	16	E. Elk Mt.	12	748000	3712000	
212760	Black Range	23566	m	11/7/2008	21	S. Palomas Cnyn	13	247000	3673000	sp
212774	Sacramentos	23644	f	9/26/2009	34	Agua Chiquita	13	468433	3641348	
212775	S. San Juans	23704	f	10/3/2009	51	S. Mogote Rdg.	13	383000	4036000	
212776	S. San Juans	23705	m	10/8/2009	51	Yeso Tank	13	379000	4030000	
212777	S. San Juans	23706	f	10/11/2009	52	Cruces Basin	13	380000	4093000	
212780	N. Gila	23728	m	8/16/2009	15	Starkweather Cny	12	702771	3735415	
212612	Sacramentos	23767	m	10/14/2008	38	Gallinas Mts., Corona Rinconda Canyon, Cibola Co.	13	428000	3790000	sp
212613	Mt. Taylor	23768	m	10/16/2008			13	257500	3891000	sp
212619	Zuni Mts	23802	m	11/13/2008	12	Zuni Mts.	12	477000	3905000	sp
212628	S. San Juans	23820	f	9/22/2008	51	Trout Lakes	13	376600	4052157	sp
212632	S. San Juans	23826	m	9/23/2009	4	Chama	13	360000	4080000	
212633	S. San Juans	23827	m	9/23/2009	4	Chama	13	360000	4080000	
212630	Sangres	23831	m	9/24/2008	45	Windsor Crk.	13	437000	3968000	sp
212634	Sandias/Manzanos	23848	m	4/21/2008	8	Sandias	13	375000	3883000	road
212635	Sangres	23851	m	6/10/2009	43	Clines Corners, 10 m. east	13	460000	3875000	road
212637	GMU 17	23856	m	8/17/2009	17	San Mateo Mts.	13	263000	3754000	
212638	GMU 17	23857	m	8/18/2009	17	Tubucka Rch.	13	302000	3748550	
212642	S. San Juans	23901	m	9/22/2008	51	Hondo Tank #2	13	405000	4052000	sport

212644	Jemez Mtns	23903	m	9/26/2008	6	Jemez Mts.	13	338000	3987000	sport
212645	Sangres	23904	m	9/29/2008	48	Ortega Mesa	13	492000	4022000	sport
212646	Jemez Mtns	23905	m	9/29/2008	6	Jemez Mts., S. of San Pedro Parks	13	333000	3988000	sport
212647	Mt. Taylor	23906	f	10/3/2008	9	Water Canyon WMA	13	271000	3902000	sp
212651	Burros and North	23911	f	10/14/2008	23	Horse Mesa	12	687000	3734000	sp
212654	Burros and North	23914	m	10/19/2008	23	Pueblo Crk.	12	682000	3718000	sp
212657	GMU 13	23917	f	11/13/2008	13	Sierra Lucero	13	299000	3835000	sp
212803	Sangres	23941	m	10/17/2008	46	Mora	13	477000	3973000	road
212658	S. San Juans	23962	m	9/15/2009	4	W. of Chama	13	360000	4080000	
212660	Black Range	26016	m	9/5/2009	21	N. Seco	13	244000	3662000	
212661	GMU 17	26048	f	10/6/2009	17	Bear Trap Cny.	13	257000	3732000	
212662	GMU 17	26049	m	10/7/2009	17	White Water Cny.	13	272000	3747000	
212663	Black Range	26050	m	10/5/2009	21	10 m. E. of Hermosa	13	250000	3687000	
212664	Black Range	26061	m	10/14/2009	21	Las Palomas Cny.	13	300010	3610100	
212667	S. San Juans	26307	f	9/26/2009	51	Trout Lakes	13	380000	4045000	
212668	Jemez Mtns	26312	m	9/29/2009	6	W. of Bandalier Nat'l Mon.	13	355000	3960000	
212669	Jemez Mtns	26313	m	10/5/2009	5	N. of Llaves	13	331000	4035000	
212671	Jemez Mtns	26318	f	9/14/2009	6	Encino LO	13	365000	4003000	
212805	N. Gila	26322	f	8/16/2009	15	Underwood	12	686841	3755880	
212675	Burros and North	26325	f	8/19/2009	23	Big Pine Cny.	12	687308	3684548	
212676	Burros and North	26326	m	8/19/2009	23	Smoothing Iron	12	684331	3687207	
212677	N. Gila	26333	m	8/27/2009	15	Torriette Lakes	12	704523	3749417	
212678	Burros and North	26335	f	9/13/2009	23	White Rocks	12	683631	3709668	
212680	Burros and North	26340	m	10/12/2009	23	Brushy Mt.	12	689278	3686403	
212681	N. Gila	26348	f	9/7/2009	16	Indian Crk.	12	751000	3708000	

212683	Burros and North	26360	m	10/9/2009	24	Sheep Corral	12	683321	7000210
212684	N. Gila	26461	m	10/14/2009	15	Torriette Lakes	12	705000	3753000
212686	Jemez Mtns	26502	m	10/4/2009	6	Between Dome and Tower	13	375000	3961000
212687	Jemez Mtns	26503	m	10/12/2009	6	Chucoma/Polvadera	13	372000	3493000
212688	Sacramentos	26508	m	10/2/2009	37	FS Rd. 483	13	465000	3720000
212689	Jemez Mtns	26517	m	9/29/2009	6	S. of Los Pinos Trhead	13	331000	4000000
212691	Jemez Mtns	26519	f	9/28/2009	6	S. of Los Pinos Trhead	13	331000	4000000
212692	Jemez Mtns	26520	f	10/2/2009	6	S. of Los Pinos Trhead	13	331000	4000000
212693	Sandias/Manzanos	26632	m	9/5/2009	14	FR 275/422	13	370000	3824000
212694	Zuni Mts	26633	m	9/6/2009	10	Rico Rch.	12	745000	3918000
212695	Sandias/Manzanos	26634	m	9/10/2009	14	4th of July Cny.	13	371000	3851000
212696	Jemez Mtns	26635	f	9/13/2009	5	Gallina Pk.	13	342000	4033000
212697	Sacramentos	26637	m	9/15/2009	36	W. of Bonito Lake	13	425000	3701000
212698	Mt. Taylor	26639	m	9/18/2009	9	W. of Ranger Tank	13	260000	3899000
212699	Sandias/Manzanos	26640	f	9/16/2009	14	4th of July Cny.	13	373000	3849000
212700	S. San Juans	26646	m	10/12/2009	51	FR 124	14	381000	4051000
212701	GMU 17	26649	m	10/17/2009	17	SE of Water Cny.	14	307000	3766000
212702	N. Gila	26650	f	10/24/2009	16	SW of Yellow Mt.	12	749000	3692000
212703	GMU 17	26652	f	9/26/2009	17	Beartrap Cnyn.	13	260000	3742000
212704	Black Range	26695	f	10/9/2009	21	S. of Lookout Mt.	13	241000	3698000
212705	Mt. Taylor	26696	m	10/10/2009	9	Horace Mesa	13	262000	3901000
212782	Sandias/Manzanos	37514	m	9/15/2002		M53 rt., large male, Albq., Bern. Co.	13	363926	3882241
212785	Sandias/Manzanos	37803	f	7/1/2003		F198 rt., 170 lb. female, Inlow Babtist	13	375103	3849638

					Camp, Torr. Co.			
212783	Sandias/Manzanos	37816	f	7/14/2003	F191 rt., Inlow Babtist Camp, Torrance Co.	13	375103	3849638
212788	Sandias/Manzanos	37834	m	8/1/2003	M201 grn. Rt., 250#, eating fruit, Sandoval Co.	13	370889	3907754
212790	Sandias/Manzanos	37836	m	8/3/2003	M227, Near Mountainair, Torrance Co.	13	375778	3828857
212794	Sandias/Manzanos	37839	m	8/6/2003	M247, Cedar Crest, Bern. Co.	13	375807	3891219
212795	Sandias/Manzanos	37841	f	8/8/2003	F175/215, Adelino, Valencia Co.	13	341000	3840000
212798	Sandias/Manzanos	37855	f	8/22/2003	F248/193, subad., in backyard, Rio Rancho, Sandoval Co.	13	352000	3905000
212789	Sandias/Manzanos	38055	F	8/2/2003	M226, Sandia Mts.	13	391200	3898270
212799	Sandias/Manzanos	38162	F	6/24/2004	F67/232, Albq., Bern. Co.	13	364559	3899727
233407	Sandias/Manzanos	134.034.1	F	8/25/2008	Sulphur Cnyn., Sandia Mts.	13	374200	3893300
233406	Sandias/Manzanos	R569	m	9/8/2008	Sandia Mts.	13	391200	3898270

Appendix B. Bear mortality, capture and release table and statistics for management bears from 2000-11 in the Northwest Supervisory Area, New Mexico Game and Fish Department.

Kill Type	Sex	Age	Kill Date	Release Date	Dif. Mos	Capture	Release	Release Kilometers +/- 2k
dep	F	10	09/22/01	8/16/2001	1	Albq	Monte Largo	41
sp	F	5	10/09/01			La Jara	Largo GMU 2b	90
sp	F	6	09/10/01	9/3/2001	0	La Jara	Largo GMU 2b	70
sp	F	4	10/14/01	8/4/2001	2	Tijeras	GMU 9	66
sp	F	12	09/25/01	8/3/2001	2	Tijeras	Rice Park	71
sp	F	15	09/16/01	9/14/2001	0	Aztec	Cottonwood	85
sp	F	10	8/1/2002	8/21/2001	12	Cuba	2b	21
dep	F	9	9/18/2002	7/19/2002	2	Espanola	dead	62
dep	F	8	9/19/2002			East Mts.	dead	66
sp	F	4	10/12/2002			Ice Caves	GMU 9	112
road	F	9	10/22/2002	10/12/2002	0	Raven Rd.	Ellis Trail	113
sp	F	6	10/5/2002			Espanola	dead	82
dep	F	3	08/27/03	8/22/2003	0	Sandias	dead	82
sp	F	0	08/03/03	7/7/2002	13	Ponderosa	dead	118
sp	F	5	09/25/03	7/14/2003	2	Inlow	Rice Park	72
sp	F	7	09/13/03	7/17/2003	2	Inlow	Rice Park	179
sp	F	0	10/02/03			Santa Fe	dead	185
dep	F		07/25/05	7/25/2004	12	Moriarty	dead	166
dep	F		07/13/05	7/13/2004	12	Gallup	dead	50
sp	F	2	09/27/05	7/30/2005	2	Zunis	San Pedro Parks	8
sp	F	3	10/05/05			Santa Fe	dead	75
dep	F		07/25/05	7/25/2004	12	Tijeras	dead	150
sp	F		09/30/06	8/31/2003	35	El Morro	Marquez	10
sp	F	2	08/26/07	5/22/2007	3	Santa Fe	Monte Largo	57
dep	F		07/28/08	6/14/2008	1	Lindreth	dead	96
sp	F	4	09/28/08	8/30/2003	1	La Cueva	Indian Crk.	14
road	F		06/22/09	7/9/2008	11	Albq.	Capilla Peak	23
sp	F	6	10/06/09	9/9/2006	1	Albq.	Rice Park	85
dep	F		07/12/10	6/18/2010	1	Hyde Park twice	Caracas	100
dep	F	12	09/08/10	8/2/2009	13	Santa Fe	Gallinas Mts.	71
sp	F	2	10/02/10	7/19/2010	3	Santa Fe	GMU 51	103
road	F		12/22/10	10/28/2010	2	Chama	Cabresto Cny.	188
dep.	F		06/24/11	6/19/2011	0	Fenton	San Gregorio	167
dep.	F		07/07/11	6/30/2010	12	Cuba	Mesa Alta	67
dep.	F		08/03/11	10/20/2009	22	Tesuque	GMU 6	56
dep.	F		08/15/11	7/5/2007	49	Cedar Gr.	dead	185

dep.	F		09/14/11	8/29/2011	0	Los Alamos	Bluebird Mesa	185
sp	F		10/01/11	7/5/2010	3	La Cueva	Mud Springs	80
sp	F		10/02/11	8/14/2011	2	San Pedro	GMU 52	80
dep.	F		10/05/11	10/4/2011	0	Santa Fe	Humphries	64
road	F		11/01/11	9/5/2011	2	Santa Fe	Bluebird Mesa	60
sp	M	3	10/16/00	7/26/2000	3	Cuba	Chiquito	21
sp	M	8	11/02/00	8/24/2000	3	Santa Fe	Rio Cebolla	96
sp	M	2	11/14/00	9/28/2000	2	Santa Fe	GMU 6	62
sp	M	7	09/11/01	8/27/2001	1	Cedar Crest	Kayser Tr.	185
sp	M	0	06/23/01	6/7/2001	1	Bluewater	Marquez release	56
road	M	7	09/07/01	8/19/2001	1	Placitas	Marquez release	44
sp	M	9	09/19/01	6/22/2001	3	Kettner	Oso	140
dep	M	3	09/24/01	9/4/2001	1	Cedar Crest	Kayser Tr.	200
sp	M	4	09/29/01	8/22/2000	13	Wingate	Marquez Rio Cebolla	68
sp	M	4	10/14/01	8/23/2001	2	Pecos	GMU 6	215
sp	M	8	09/15/01	8/31/2001	1	Jemez Sprgs.	French Mesa 5b	78
sp	M	3	11/10/01	7/17/2001	4	Inlow	Rice Park	96
sp	M	2	11/17/01	8/7/2001	3	Placitas	Rice Park	56
dep	M	3	7/24/2002	8/18/2001	11	Tramway	10-k	68
sp	M	4	10/2/2002	8/11/2000	26	Tijeras	Marquez	96
sp	M	3	10/19/2002	10/8/2002	0	Cedar Crest	10k	164
dep	M	4	07/01/03	10/10/2002	9	Timberlake	GMU 9	70
sp	M	5	08/25/03	6/24/2002	14	Bluewater	Marquez Rio Cebolla	73
sp	M	5	08/17/03	6/3/2001	26	Canyoncito	GMU 6	100
sp	M	16	09/07/03	8/1/2003	1	Edgewood	Rice Park	51
dep	M	5	09/19/03	8/6/2003	2	Cedar Crest	Monte Largo	130
sp	M	6	09/25/03	9/4/2003	1	Santa Fe Tr.	GMU 6	56
sp	M	7	10/05/03	8/4/2003	2	Manzano	Crest cut	92
sp	M	2	09/29/04	6/30/2001	39	Grants	Rice Park	164
sp	M	9	09/14/04	6/24/2002	27	Kettner	Oso Cnyn.	90
road	M		06/06/04	6/3/2004	0	Hyde Park	Mesa de las Viejas	165
road	M		06/07/04	11/19/2003	7	Jemez Mts.	5b	260
sp	M	3	08/21/04	8/5/2003	12	Paliza	Rice Park	222
sp	M	6	10/23/04	7/18/2003	15	Milan	Marquez	91
road	M					Raven	Monte Largo	60
dep	M		07/02/05	7/12/2004	12	GMU 4	dead	62
road	M		02/28/06	8/18/2001	64	Carnuel	Kayser	45
sp	M	2	09/14/06			Espanola	dead	98
sp	M	5	10/03/06	7/13/2006	3	Raton	Cruces Basin	205
sp	M	6	09/26/06	4/14/2004	29	Los Alamos	French Mesa 5b	48
sp	M	2	09/26/06	8/17/2001	61	Tijeras	GMU 9	160

dep	M	3	06/28/07	6/28/2006	12	Placitas	Ranger Tank	80
road	M		09/15/07	10/9/2002	59	Cedar Crest	Monte Largo	184
sp	M	6	09/06/07	9/8/2001	72	Santa Fe	TWC	71
dep	M	3	08/01/08	7/17/2008	0	Zuzax	Sedgewick	112
road	M	2	08/08/08	7/24/2008	0	Albq.	dead	151
sp	M	6	08/16/08	7/1/2008	1	Albq.	Beaverhead	100
road	M		08/28/08	8/2/2003	1	Santa Fe	Rice Park	40
sp	M	11	09/08/08	8/28/2006	0	Manzano	GMU 6	50
dep	M		07/26/09	7/26/2008	12	Lindreth	dead	120
dep	M	10	07/24/09	7/21/2009	0	Santa Fe	GMU 51	21
sp	M		09/06/09	6/18/2008	15	MacIntosh	Rice Park	50
sp	M	2	09/10/09	6/9/2009	3	Four Hills	Monte Largo	85
dep	M		06/25/10	6/20/2010	0	Cuba	Trout Lakes	20
dep	M		08/02/10	7/2/2010	1	Chama	French Mesa	80
sp	M	3	09/07/10	6/26/2006	51	El Dorado	Gallina Peak	75
sp	M	6	09/21/10	7/21/2010	2	Lindreth	Mud Springs	70
road	M		05/08/11	7/27/2010	10	Sufi	Marquez	280
dep.	M		07/19/11	5/14/2011	2	Albq.	Marquez	75
dep.	M		07/24/11	6/4/2010	13	Los Alamos	Valles Caldera	85
dep.	M		08/02/11	8/11/2010	12	Hyde Park	GMU 6	48
dep.	M		08/16/11	7/23/2010	13	Cedar Hill	Indian Crk.	48
dep.	M		08/25/11	8/26/2001	120	Santa Fe	GMU 6	98
sp	M		08/28/11	7/21/2011	1	Four Hills	Marquez	110
sp	M		09/30/11	8/14/2011	1	Los Alamos	Bluebird Mesa	71
sp	M		10/02/11	7/23/2010	2	Chama	dead	104
sp	M		10/03/11	7/31/2011	2	Santa Fe	Mesa de las Viejas	153
road	M		10/06/11	6/5/2011	4	Edgewood	Tres Piedras	180
sp	U	2	09/30/06	6/12/2005	3	Santa Fe	GMU 51	95

		Tot =	1046	10198
		N =	97	105
41 Females				
		Avg =	2	68
63 Males		StDev =	18.9	55.71626
1 U		Median =	3	82
		Var =	358	3104.302
		Confidence =	3.77	10.65701
		Min. =	0	8
		Max. =	120	280
		Conf. T =	3.81	10.78247

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