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9th Western States & Provinces Deer & Elk Workshop

Santa Ana Pueblo, New Mexico
May 16-19, 2011

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Eric M. Rominger, New Mexico Department of Game and Fish.

Bottom-Up, Top-Down, And Abiotic Factors Affecting Elk Recruitment

BRUCE JOHNSON, Oregon Department of Fish and Wildlife
*PRISCILLA COE, Oregon Department of Fish and Wildlife

Invited speaker no abstract was provided.

*Presenter

Effect Of Enhanced Nutrition On Mule Deer Population Rate Of Change

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Abstract: Concerns over declining mule deer (*Odocoileus hemionus*) populations during the 1990s prompted research efforts to identify and understand key limiting factors of deer. Similar to past deer declines, a top priority of state wildlife agencies was to evaluate the relative importance of habitat and predation. We therefore evaluated the effect of enhanced nutrition of deer during winter and spring on fecundity and survival rates on the Uncompahgre Plateau in SW Colorado. The treatment represented an instantaneous increase in nutritional carrying capacity of a pinyon (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma)* winter range and was intended to simulate optimum habitat quality. By manipulating nutrition and leaving natural predation unaltered, we determined whether habitat quality was ultimately a critical factor limiting the deer population. We measured annual survival and fecundity of adult females and survival of fawns, then estimated population rate of change as a function of enhanced nutrition. Pregnancy and fetal rates of adult females were high and did not vary in response to treatment. Fetal, neonatal, overwinter fawn, and adult female survival rates increased in response to treatment, although the treatment effect on overwinter survival was most pronounced. Overwinter rates of fawn survival averaged 0.905 (SE = 0.026) for treatment deer and 0.684 (SE = 0.044) for control deer. Our estimate of the population rate of change was 1.165 (SE = 0.036) for treatment deer and 1.033 (SE = 0.038) for control deer. We found strong evidence that enhanced nutrition of deer reduced coyote (*Canis latrans*) and mountain lion (*Puma concolor*) predation rates of ≥6-month- old fawns and adult females. Winter-range habitat quality was a limiting factor of the Uncompahgre Plateau mule deer population. Therefore, we recommend evaluating habitat treatments for deer that are designed to set-back succession and increase productivity of late-seral pinyon-juniper habitats that presently dominate the winter range.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:7

Evaluation Of Winter Range Habitat Treatments On Over-Winter Survival And Body Condition Of Mule Deer

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Abstract: During the winter of 2004–2005, the Colorado Division of Wildlife initiated a 5-year study designed to assess the impacts of landscape level winter range habitat improvement efforts on mule deer population performance. Conducted on the Uncompahgre Plateau and in adjacent valleys in SW Colorado, we repeatedly measured over-winter fawn survival and total deer density on 4 study areas as well as on a fifth, variable area, each winter of the study. Additionally, on 2 of the study areas we estimated late- winter body condition of does. Compared to results from other research throughout the west, a well as on the Uncompahgre Plateau, survival estimates for 6-month-old mule deer fawns were highly variable between areas, but tended to be above published long term averages. Preliminary evidence suggests that areas that have received habitat treatments have higher fawn survival. Point estimates of deer density on the 5 study areas across winters have varied but in general, the variance surrounding deer density estimates have followed a consistent trend between all winters of the study with no major annual change observed. Estimates of total body fat for adult female deer showed no apparent distinction between treatment and reference study areas. Preliminary conclusions from this study lend support to habitat management efforts as a means to mitigate mule deer habitat loss or to improve mule deer population performance.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:8

Condition Dynamics, Reproduction, And Survival Of Winter-Fed And Free-Wintering Female Elk In Southcentral Washington

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Abstract: We collected condition and reproductive data from live-handled elk in the Yakima Herd at the beginning and end of each winter. We maintained ≥70 radiocollared females and attempted to recapture each twice per winter; we also sampled non-radioed elk, but few were recaptured subsequently. We also estimated fall condition from organs collected from hunter-killed elk and weighed elk at one feedsite where this was feasible. We handled 371 different females during 782 captures. Analyses accounted for repeated measures. Overall pregnancy rate was 83.9%. Samples were small for yearlings and old females, but yearlings were less fecund, and reproductive senescence was apparent after age 17–18. Winter feeding did not affect fertility. Using multi-state modeling for animals we resampled, we estimated the transition probability for pregnant in year t to year t+1 was 0.82 (95% CI = 0.76–0.87) and for not pregnant in year t to pregnant in year t+1 was 0.69 (95% CI = 0.53–0.83) in the best model. Lactating elk entered winter in poorer condition (ingesta-free body fat [IFBF] = 6.3% than nonlactaters (IFBF = 9.2%); lactaters were also leaner at the end of winter (IFBF = 4.2% vs. 5.8%). Controlling for other effects, overwinter fat loss was marginally dependent on lactation status; the effect was more apparent in moderate-to-severe winters. Elk entering winter in better condition tended to lose more condition (IFBF) overwinter. Lactaters and nonlactaters were in substantially better condition in early fall (13.9% and 14.8% IFBF). We similarly report

results for mass dynamics. Adult condition data and mid-winter calf scale weights suggested these elk were on a moderate to good level of nutrition, based on reference values from controlled nutrition experiments.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:9-10

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Effects Of Predator Removal On Mule Deer Populations In Elk County, Nevada

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Abstract: Large herbivores exhibit strong density dependence in population growth. Depending upon the relationship to ecological carrying capacity, those populations may be regulated by top-down processes or through changes in nutritional condition and be driven by bottom-up processes. We tested the hypothesis that mule deer in the Ruby Mountains and in the Granite Range, Nevada were regulated by top-down processes and that productivity of those populations would be improved by removal of predators, coyotes (*Canis latrans*) and mountain lions (*Puma concolor*). We compared areas where predators were removed to control areas where predators were not manipulated. We used aerial surveys of mule deer in treatment and control units to look at fawn to doe ratios during winter or fawn to adult ratios during spring to examine changes in productivity and recruitment of mule deer populations. We examined harvest statistics for males including hunter success and percent of harvest >4 antler points. We also compared pre- and post-treatment in units where predator control was implemented to determine changes in productivity or recruitment. We observed no difference in fawn to doe, fawn to adult ratios, hunter success, or percent harvest of >4 antler points pre- and post-treatment or between treatment and controls. Mule deer in the Ruby Mountains and Granite Range do not appear to be regulated by top-down processes. We recommend collecting additional data on mule deer, such as body condition, before and during predator control to determine if limitation is predominately top down or bottom up.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:11

Effects Of Spike 20P On Vegetation And Mule Deer In Trans-Pecos, Texas

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Abstract: Grasslands throughout North America have been lost to a variety of factors, including brush encroachment. In Texas, many economically and ecologically important species are obligates of desert grasslands including desert mule deer (*Odocoileus hemionus*). At Boracho Peak Ranch, west of Kent, Texas approximately 21,652 ha has been aerially treated with Spike 20P herbicide at 0.34 kg/ha of active ingredient tebuthiuron. Vegetation was sampled in June of 2009 and 2010 and November of 2010 to help determine the effects of Spike 20P on vegetation. Treatments were based on the year of herbicide application. Results of grass biomass show an increasing trend that correlates to increasing years post treatment of Spike. Forb richness was reduced to less than half the level of controls. Based on our results it is evident that Spike 20P herbicide is effective in increasing grass production. Control of the woody species creosote and tarbush was effective. Spike 20P may provide higher levels of grass biomass for livestock, while additionally increasing grass cover for various desert grassland species of wildlife, however the loss of forb diversity may outweigh these benefits. To determine how Spike 20P affects wildlife we monitored 42 radio collared desert mule deer to determine habitat use in response to Spike applications. Additionally, road surveys were conducted to monitor other important species of wildlife. The results of this study should help land managers make better decisions about the use of Spike 20P.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:12

Is There A Home Advantage For Non-Migrating Elk On Sympatric Winter Ranges Under Wolf Predation Risk?

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Abstract: Previous research on the partially migratory Ya Ha Tinda elk herd found demographic balancing of migration strategies. Migrant elk were exposed to higher forage quality resulting in higher pregnancy and calf weights, while resident elk traded-off forage quality by selecting areas close to humans and living in large group sizes that resulted in reduced predation risk and increased survival. Despite equal estimated fitness between migration strategies, the migrant to resident ratio of this population has declined over the last decade. We studied whether behavioral differences in (1) space use and (2) vigilance between each strategy influenced forage intake providing evidence for a home advantage for resident elk under wolf predation when on the sympatric winter range with migrants. We found high home range overlap between migratory strategies, but resident elk were exposed to higher overall predation risk than migrants because of fine-scale differences in use relative to wolf avoidance of humans at night but not during the day. Vigilance levels of migrant elk were similar regardless of their proximity to humans or timber while vigilance increased in resident elk only when far from human activity, indicating habituation. Both groups of elk experienced foraging costs due to vigilance, but resident elk were better at synchronizing vigilance with periods of chewing using "spare time" to alleviate foraging costs. We discuss implication of a growing resident elk population on these top-down vs. bottom-up dynamics.

*Presenting/corresponding author

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:13

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Investigating The Effects Of Top-Down Regulation On Life-History Strategy Of A Partially Migratory Elk Herd

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Abstract: Partial migration occurs when a portion of the population migrates, and results from density-dependence in the relative costs and benefits of migrating or remaining a resident. For elk (*Cervus elaphus*), migration is an adaptive strategy for maximizing optimum forage quality while reducing predation risk, thus begging the question of what maintains resident elk in partially migratory populations. I will test competing hypotheses about the effects of top-down versus bottom-up regulation of a partially migratory elk herd in west-central Alberta, Canada. First, to test my top-down hypothesis, I will use a time-series analysis of cause-specific mortality rates in a competing risks framework to test for density dependence in predator caused-mortality for migrant and resident elk using VHF and GPS survival data collected from >300 adult female elk since 2001 to present. I will test my competing hypothesis that this elk herd is regulated by bottom-up processes using a time-series analysis of pregnancy rates and mean adult female weights for migrant and resident elk. Finally, I will test the hypothesis that this elk herd has reached a low-density equilibrium below food based carrying capacity. For this I will use seasonal migrant and resident survival and reproductive rates to construct a Leslie matrix model to estimate population growth rates as a function of population density. Preliminary results of Kaplan Meier survival estimates regressed against migratory status and density show evidence for density dependence affecting resident, not migrant, adult female elk in this population.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:14

Metrics Of Predation: Perils Of Predator-Prey Ratios

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Abstract: We delineated potential problems with predator-prey ratios. These included determining where and when to sample, the double-variable nature of ratios, interpretation of point estimates, a potential lack of equilibrium, including time lags of predators to changing prey density. Further complications include presence of alternative prey, and the nearness of the prey population to carrying capacity (K). We also present a new technique for calculating confidence intervals for predator-prey ratios. We modeled population dynamics under changing predator and prey numbers to assess whether predator-prey ratios could be used to interpret if forcing was bottom-up or top down. We concluded ratios were impossible to interpret. We offer an alternative model using life-history characteristics of large herbivores to assess effects of predation on the prey population.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:15

Cause Specific Mortality Of Neonatal Elk On Valles Caldera National Preserve

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Abstract: For the Jemez Mountains elk (*Cervus elaphus*) herd, the Valles Caldera National Preserve (VCNP) is a major parturition area. Elk remain on the Preserve the remainder of the summer and fall, leaving the when snow levels prevent foraging. Fall ground surveys conducted by the Valles Caldera Trust (VCT) biology staff and aerial surveys conducted by New Mexico Department of Game and Fish (NMDGF) revealed elk calf/cow ratios were in the low 20s within the VCNP. The data presented here are from the first two years of a three year study. In May 2009, VCT and NMDGF implemented a cause-specific mortality study of neonatal elk within VCNP. In the first year, crews were able to capture and radio tag 36 new born elk calves from May 22–June 22. Black bears (*Ursus americana*), Mountain lions (*Puma concolor*), and coyotes (*Canis latrans*) were the greatest source of mortality accounting for 31.3% (n = 5), 31.3% (n = 5), 25% (n = 4), respectively, of known caused mortalities (n = 16). Unknown fates (loss of tag, cause of death unknown, tag found with no signs of predation) was 13.9% (n=5) for animals tagged in 2009. Other causes of death included infection (n = 1, 6.3%) and blunt force trauma (n = 1, 6.3%). A minimum of fifty two percent (16 of 31) of the marked individuals died before being recruited into the adult population. Because the fate of the 5 marked individuals were unknown, they were censured when calculating, mortality rates, most likely some proportion of the unknown fate calves died leading to a mortality rate higher than 52%. In 2010, 53 newborn elk calves were tagged from May 26–June 23. Black bears and coyotes were the major causes of mortality, accounting for 47.6% (n = 10) and 38.1% (n = 8) respectively, of the known caused mortalities (n = 21), respectively. One mountain lion mortality (4.8%) and one case of abandonment (4.8%) also occurred. Unknown fates were higher in 2010 tagged calves (18.9% n=10) than 2009 (13.9%). A minimum of 48% of the marked individuals died in 2010. Because the fate of the 11 marked individuals were unknown they were censored from the mortality rate calculation, most likely some of the unknown fate calves died leading to a mortality rate between 47.6 and 58.5%. Predation mortality for the two years combined accounted for 91.9% (n = 34) of the total known caused mortalities (n = 37). Unknown fates for the two years was 16.8% (n = 15). VCT plans on marking an additional 40+ calves during the calving season in 2011. These calves will be monitored for cause of death, which will be determined as in previous study years. Once the third year of observations is completed, VCT will make management decisions on how to possibly increase the calf survival on VCNP.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:16

Demographic Response Of Mule Deer To Experimental Reduction Of Coyotes And Mountain Lions

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Abstract: We tested the efficacy of removing coyotes and mountain lions on mule deer population dynamics in southeastern Idaho, 1997–2006. We monitored aspects of mule deer ecology while experimentally manipulating predator populations within 10 Game Management Units. To determine survival and causes of mortality, 250 neonates, 284 6-month-old fawns, and 254 (521 deer years) adult females were monitored with radio telemetry in 2 study sites, one with coyote and mountain lion removal and one without 1998–2002. Survival of neonates was related to alternate prey abundance, coyote removal rates, and weather conditions. Winter fawn survival was influenced by summer precipitation, winter precipitation, and fawn mass. Adult female winter survival increased with mountain lion removal. December fawn-to-adult female ratios (fawn ratios) increased significantly at maximum rates of mountain lion removal. Coyote removal had no significant effect on fawn ratios, except after a weather-related population reduction. Coyote or mountain lion removal alone did not influence mule deer population trend, although the top model, including previous year's mountain lion removal and winter severity, explained 27% of the variance in population rate of increase. The lack of fawn ratio or population response to coyote reduction indicates that decreased neonate mortality due to coyote removal is partially compensatory. Coyote removal programs targeted when mule deer fawn mortality is additive and coyote removal conditions are optimal may influence mule deer population vital rates, but likely will not change direction of population trend. Mountain lion removal increased mule deer survival and fawn ratios, but not population trend.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:17

RMEF Collaboration With Partners To Make Habitat For Elk

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Abstract: The Rocky Mountain Elk Foundation was founded in 1984 with a mission to ensure the future of elk, other wildlife and their habitat. Several core values were developed; Funds raised were to be used to enhance habitat, protect habitat or fund research that would add to the body of science for elk and habitat management. RMEF wanted to work with state and federal agencies not try to direct their efforts in their elk conservation efforts. RMEF wants to be a good partner which starts with relationships at all levels in the agencies and organization. It is important that conservation groups are keenly aware of the agencies' priorities and at the same time that agencies know enough about the conservation groups that their project proposals are consistent with funding goals and levels. RMEF has utilized a Project Advisory Committee (PAC) in each state to evaluate and select proposals for funding. The PAC is made up of a biologist from the state wildlife agency, a biologist from the U.S. Forest Service, a biologist from the Bureau of Land Management, a wildlife professor from a state university, the lead RMEF volunteer (State Chair), and the RMEF Regional Director in each state with wild free-ranging elk. RMEF wants to fund projects that are consistent with the state elk management plan and consistent with the federal agencies' land management plans. The membership of the PAC utilizes each agency's expertise to help select the best projects to fund and gives more ownership to the process. It is imperative that all of the available funds from NGOs be used for direct project costs and not be directed to administrative costs of the agency. The RMEF funds help the agencies expand their elk conservation budget and are not intended to replace them for use in other programs. The leverage brought about by combining funds often encourages other organizations to contribute. In some state elk tag/permits are made available to the NGOs to sell and use the funds for elk conservation work. In some states the NGOs help select the projects funded by the tag funds at the PAC meeting or some other collaborative meeting. RMEF commits all of the tag funds available each year in order to achieve the much needed conservation work. However, some NGOs seem to commit to far less funding than they have available. It is critical for the agencies and NGOs to put all these tag funds to work instead of building up a large balance to avoid legislative challenges about the use or lack of use of the funds for their intended purpose. Many legislative sessions this year tried to move the tag funds from the wildlife agency to the general funding category to make up for state budget shortfalls. Agencies and NGOs need to consistently show that the funds are being fully utilized toward effective conservation work to avoid losing them.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:18

Elk Demographic Characteristics And Home Range Size In The Glass Mountains, Texas

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Abstract: Following the extinction of Merriam elk (*Cervus elaphus merriami*) in the early 20th century, Rocky Mountain elk (*C. e. nelsoni*) were reintroduced into the Trans-Pecos region of Texas beginning in 1927. Most research on elk has been collected in moderately moist, forested areas; therefore minimal data exists on elk in arid lands. We determined elk home range and movements in the Glass Mountains, Texas. A total of 9,357 locations was collected. Average home range size for bulls was 252±84 km^2 and cows averaged 154±23 km^2. Mean core area (50% kernel polygon) was 59±23 km^2 for bulls and 35±6 km^2 for cows. On average, GPS-collared bull elk moved 2.9 km/day (range = 0.46 km/day–13.35 km/day). Home ranges and movements in the Glass Mountains are comparable to previous studies in arid environments suggesting that home ranges increase with decreasing food availability. Due to the large home ranges, it is not possible to effectively manage elk within each individual property. Because elk in Texas do not have a regulated harvest, we suggest forming a wildlife cooperative management program in efforts to successfully manage elk herds in the Trans-Pecos.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:19-27

Along with the extirpation of most elk populations in North America in the early 20th century, a native population of Merriam's elk (*Cervus elaphus merriami*) inhabiting the southern Guadalupe Mountains of Texas was driven to extirpation (Schmidly 2004) through excessive hunting and degradation of habitat by overgrazing (Toweill and Thomas 2002). Since 1928, landowners and state agencies have reintroduced Rocky Mountain elk (*C. e. nelsoni*) into the Trans-Pecos region of Texas where many populations have been established (Schmidly 2004). The Texas Game and Fish Commission listed elk as a game species in 1959. Around that time, the Trans-Pecos population was estimated to be approximately 300 (Schmidly 2004). In 1997 the 75th Texas Legislature changed elk status from native to exotic.

Home range estimates of elk in North America have been based mostly on information collected on elk in moderately moist, mountainous habitats or coastal forests. Much of this research was documented in the Pacific Northwest or Rocky Mountain regions; therefore minimal data exists for elk in arid lands (McCorquodale et al. 1989, Strohmeyer and Peek 1996). Additionally, most estimates of home range and movements for elk have been derived from populations that are exclusively or predominantly on public lands.

To manage a population effectively, knowledge of home range and movements is a vital prerequisite. In addition to 2 related studies in the Trans-Pecos region focusing on habitat selection (Witt 2008) and landowner attitudes on elk (Guevara 2009), this study provides necessary information for managing elk herds within the Glass Mountains. Specifically, our objectives were to estimate elk annual home range and movement patterns in the private lands matrix of the Glass Mountains, Texas.

Study Area

The Trans-Pecos region of Texas lies in the northeastern Chihuahuan Desert and has several mountain ranges including our study area, the Glass Mountains. The Glass Mountains are located in northeastern Brewster County and extend into the southwestern portion of Pecos County, between the towns of Marathon and Fort Stockton (Grace 1983). Approximately 48–64 km northeast from Altuda pass, the Glass Mountains exhibit rugged sheer limestone cliffs in the southwest to moderately rolling hills in the northeast (Warnock 1977). Elevation ranges from 1,200 to 1,980 m (Grace 1983). The Glass Mountains are comprised of many private ranches; therefore utilization of land varies which might affect movement and population growth of elk.

West of the Pecos River, the Trans-Pecos region is described as arid with an average rainfall of 35.6 cm per year, mostly occurring in late summer. Rainfalls supply water to dirt tanks, and rock and road depressions. These ephemeral water sources are available to wildlife for short periods of time. Cattle ranching has provided additional water sources throughout the landscape.

Vegetation of the Glass Mountains is very diverse and includes beargrass (*Nolina texana*), catclaw acacia (*Mimosa biuncifera*), sotol (*Dasylirion leiphyllum*), grey oak (*Quearcus grisea*), junipers (*Juniperus* sp.), pinyon pine (*Pinus cembroides*), tobosa (*Hilaria mutica*), mesquite (*Prosopis glandulosa*), tarbush (*Flourensia cernua*), creosote (*Larrea tridentata*), mariola (*Parthenuem incanum*), lechuguilla (*Agave lechuguilla*), skeletonleaf goldeneye (*Viguiera stenoloba*), brickellbush (*Brickella coulteri*), and little leaf sumac (*Rhus microphylla*).

Habitat communities in the Glass Mountains included riparian, tobosa grassland, juniper (*Juniperus pinchotii*) woodland, mesquite-tarbush scrubland, creosote-mariola shrubland, desert grassland, desert scrubland, and evergreen woodland (Witt 2008). According to Witt (2008), elk favored the eastern portion of the range and preferred juniper, riparian, and evergreen woodland areas.

Methods

Capture—We captured (Scientific Permit Number 0592-525) and collared 6 bull elk from September-November 2009 in addition to the 14 cows and 2 bulls collared in 2006–2007 (Witt 2008) in the Glass Mountains, Texas. Before the capture, we determined common areas utilized by elk. We used the darting method, immobilizing elk on foot from ground blinds and helicopter. We used a mixture of 600 mg xylazine and 200 mg telazol (Kreeger 1996).

Upon immobilization, personnel hobbled and blindfolded elk. Lotek GPS 3300 (Newmarket, Ontario, Canada) model collars were attached as per instructed by Lotek Wireless, Inc. During collar fitting, neck condition and swelling during the rut was considered. Tooth replacement and wear (Heffelfinger 1997) was used to determine age. The reversal drug, 1,000 mg of Tolazine, was then injected into a muscle (Kreeger 1996).

Data Collection—Weekly locations of up to 14 elk (12 F, 2 M), wearing Lotek VHF collars were collected via aerial telemetry since November 2006 (Witt 2008). The 6 GPS collared bull elk were located as well following the 2009 capture. Weekly aerial locations were determined using aerial telemetry flown at 600 m above ground. Location data gathered via aerial telemetry was entered into a spreadsheet where it was converted to UTM coordinates and then imported into ArcGIS 9.3.

The 6 GPS collars were affixed to bull elk and were programmed to record a location at 4-hour intervals. A "fix" consisted of date, time, location, elevation, dimension, and number of satellites. The beacon was initialized to be active from 0800–1700, corresponding with attempted ground and aerial telemetry locations. Collars were retrieved beginning in August 2010 through September 2010 (Table 1). Typical retrieval consisted of gathering a location via aerial telemetry followed by tracking through ground telemetry with a Lotek remote release mechanism. Remote release efforts required the remote controller to be within 100 m of the collared bull.

		Total Range Size (km^2)[a]	
Elk	*n*	50%	95%
M1	178	59	230
M2	165	58	257
M3[b]	1,984	28	152
M23[b]	1,936	88	364
M24[bc]	---	---	---
M25[b]	1,800	26	127
M26[b]	1,572	93	380
M27[bc]	---	---	---
$\bar{X}$	1,273	59 (23)	252 (8)

[a] Percent kernel
[b] GPS collared elk
[c] Unable to gather sufficient amount of

TABLE 1. Total kernels (% isopleths) as determined from radio telemetry locations for bull (M) elk in the Glass Mountains, Texas, USA, 2006–2010.

Once a collar was retrieved, Lotek host hardware was then used to gather fix records and data were imported into ArcGIS 9.3. Data were projected to North American Datum 1983, Universal Transverse Mercator Zone 13 North.

Data Analysis—Kernel methods estimate the probability of occurrence at each point in space (Harris et al. 1990; Worton 1987, 1989). Three-dimensional Kernel methods are also advantageous as they do not require making any assumptions (Worton 1987, 1989) and have been proposed as a more accurate means of estimating home range size (Kie et al. 1996; Seaman and Powell 1996; Seaman et al. 1999; Worton 1987, 1989, 1995) when compared to earlier methods such as the 2-dimensional Minimum Convex Polygon (Boulanger and White 1990, White and Garrot 1990, Worton 1987). Home Range Tools (Rogers et al. 2007) was downloaded as an extension for ArcGIS to determine annual and collective home ranges for each elk. To produce home range kernel polygons, we used the Kernel Density Estimation. Within Kernel Density Estimation we used Gaussian (bivariate normal) fixed kernel estimators, a least squares cross validation smoothing parameter, grid size of 30 x 30, and scaling factor of 2 x 10^9. Isopleths were drawn to include all locations for each elk at 95% and 50%. Annual dates for calculated kernels for year 2007 included November 2006 to December 2007. After testing for normality in PASW-SPSS (2009), df used an independent samples t-test with unequal variances to compare and report *P*-values for average home range between males and females. Calculation of movements was restricted to GPS collared elk. Movement of elk was determined through the Calculate Travel Times and Distances option in Home Range Tools. Output data included distance from last observation, time (m/s) from last observation, and distance (km/hr) from last observation. Output data was copied from the attribute table and pasted into a spreadsheet where units were converted to metric; monthly and collective km/24-hr averages were calculated.

Results

Capture—We successfully captured 6 mature bull elk from September - November 2009. Four elk were trapped via free range darting and 2 elk were trapped by darting from the helicopter. Witt (2008) captured 14 elk (3 M, 11 F) via free range darting and net guns by helicopter in October 2006 and March 2007. We were only able to gather sufficient data for analysis from 4 of them due to one hunter harvested mortality and one collar malfunction caused by being torn off in a barbed wire fence.

Home Range and Movements—We recorded a total of 2,076 aerial telemetry locations from November 2006–August 2010. Average aerial telemetry location error was 1.13 km (SE = 0.16) and ranged from 0.79 - 1.71 km. Collectively, we were able to gather 7,281 (96.0%) locations out of a total 7,587 attempts; 6,348 (87.2%) locations in 3D and 933 (12.8%) locations in 2D from GPS collars for the months of September 2009–August 2010.

		Total Range Size (km^2)[a]	
Elk	*n*	50%	95%
F4	166	18	96
F6	165	17	127
F7	161	29	160
F8	157	34	173
F9	161	43	183
F10	164	58	217
F11	157	34	138
F12	159	33	120
F14	153	32	112
F15	102	41	199
F21	95	39	166
F22	93	46	157
$\bar{X}$ (SE)	144	35 (6)	154 (21)

[a] Percent kernel

TABLE 2. Total kernels (% isopleths) as determined from radio telemetry locations for cow (F) elk in the Glass Mountains, Texas, USA, 2006–2010.

Annual 95% home ranges were recorded for each elk since 2006 (Tables 1–2, Figures 1–3). An average of 148 VHF locations and 1,823 GPS locations per corresponding individual was used to determine home range size through kernel polygons. Average home range size for bulls (252 km^2 [SE = 84 km^2]) and cows (154 km^2 [SE = 23 km^2]) was not different (P = 0.07). Mean core area (50% kernel polygon) was not different in size (P = 0.10) for bulls (59 km^2 [SE = 23 km^2]) than for cows (35 km^2 [SE = 6 km^2]). We estimated average monthly movements (km/day) of GPS collared elk, but were limited because data was absent for some elk for the months of September 2009, October 2009, November 2009, and August 2010 due to collar deployment and retrieval (Fig. 3). The average maximum movement of GPS collared bulls was 13.35 km/day (SE = 1.83 km/day) and minimum average was 0.46 km/day (SE = 0.10 km/day). Movements for elk averaged 2.09 km/day (SE = 0.08 km/day), 3.40 km/day (SE = 0.12 km/day), 1.75 km/day (SE = 0.08 km/day), and 4.36 km/day (SE = 0.18 km/day).

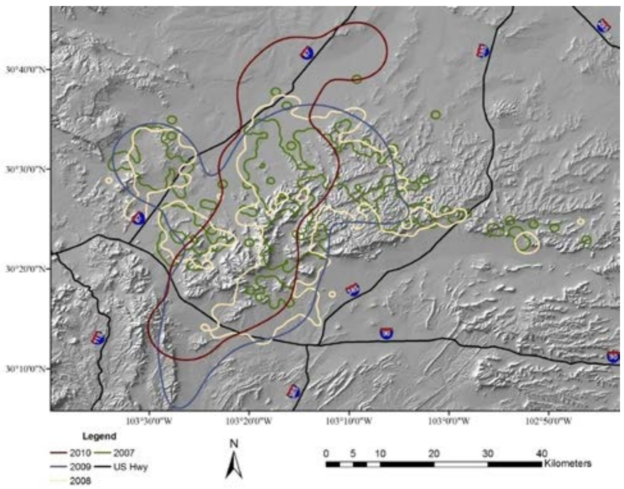

FIGURE 1. Composite kernels (95% isopleths) for all collared elk in the Glass Mountains, Brewster and Pecos Counties, Texas, USA, November 2009–August 2010.

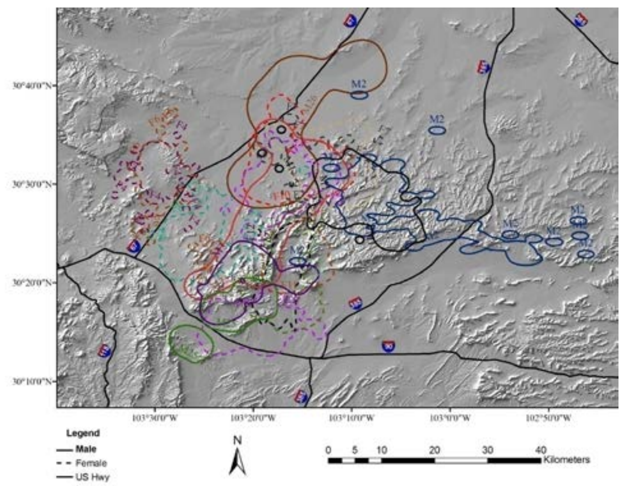

FIGURE. 2. Individual composite kernels (95% isopleths) for all male and female collared elk in the Glass Mountains, Brewster and Pecos Counties, Texas, USA,. November 2009–August 2010

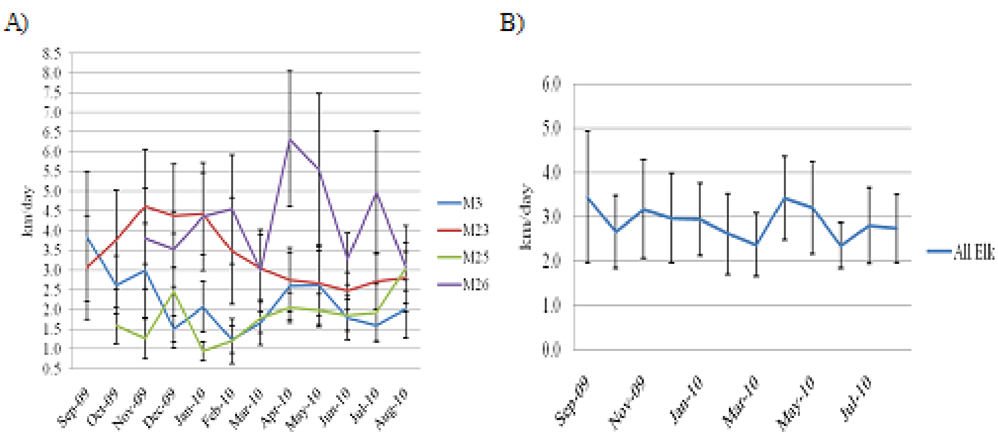

FIG. 3. Monthly movements for individual (A) and all (B) GPS collared bull elk in the Glass Mountains, Brewster and Pecos counties, Texas, USA, September 2009 - August 2010.

Discussion

Home range sizes have been studied extensively throughout the Rocky Mountains (Bear 1989, Craighead et al. 1973, Edge and Marcum 1985, Irwin and Peek 1983, Toweill and Thomas 2002, Van Dyke et al. 1998) but there is a lack of data for arid environments. McCorquodale et al. (1989) also studied elk in an arid environment and determined annual range for cows to be 161.4 km^2 (SE = 8.5 km^2) and bulls to be 163.1 km^2 (SE = 17.4 km^2). Our results in the Glass Mountains were similar for cow elk (154 km^2, SE = 21 km^2), but larger for bulls (252 km^2 [SE = 8 km^2]). A reason behind this might be that cow elk ranges are influenced by the availability of food, whereas bull ranges are influences by the availability of food and cows. Protein feeders might also have influenced cow elk movements resulting in smaller home ranges than bull elk. Although bull elk use feeders, their movements can be governed more by availability of cows and territories during the rut (Noyes et al. 1996).

Our results support McNab (1963) who stated that home range size is larger where food density is greater. Home ranges of elk in the Glass Mountains are likely larger due to the arid environment. For example, within the forested environment of the Garnet Mountains of Montana, Edge et al. (1985) recorded annual cow elk mean home range as 44.18 km^2. Craighead et al. (1973) conducted a study on a nonmigratory herd in Yellowstone National Park and determined annual elk home ranges to be 15.54 km^2 and 30.56 km^2.

Although we found that home ranges for male and female elk were not significantly different, this might have been influenced by the use of GPS collars. Because 6 bulls were equipped with GPS collars that acquired locations every 4 hours, their ranges better represent the range and movements of elk. For VHF elk, telemetry sampling was only on average every 14 days. This underrepresents range and movements estimates (White and Garrot 1990, Seaman and Powell 1996).

Bull elk in the Glass Mountains moved the most during September 2009 and April 2010. Movements in September might be explained by correspondence with the rut season. April movements might be explained by the fact that it is one of the driest times of the year therefore elk maybe going to water more frequently. Our movement data is similar to McCorquodale (2003) who determined herd movements in an arid shrub-steppe environment to average 2.2 km/day (SE = 0.2 km/day) in the summer, 3.0 km/day (SE = 0.4 km/day) in the fall, and 3.5 km/day (SE = 0.6 km/day) in the spring.

Management Implications

The distribution of elk in the Trans-Pecos is probably due to forage and water availability. Although metabolically produced, surface water is needed by elk (Thomas and Toweill 2002); most elk prefer to stay ≤0.8 km of water depending on the season and presence of cattle (Thomas and Toweill 2002). Limiting factors such as forage and water should be addressed when developing management plans.

When considering management actions and their potential effects on elk management, it is important to note range boundaries across seasons and years (Van Dyke et al. 1998). Because elk are exotic in Texas, they are not necessarily managed the same from property to property as they are in public land states, where elk harvest is restricted by game laws. A few elk traveled through ≥9 properties. Within each property, there are no limits on elk harvest. Landowners may choose not to harvest or to harvest unlimited cows and bulls of any size. Due to the large home ranges of elk in the Glass Mountains, strategies to manage elk for each individual property would not be effective; therefore management across properties, specifically mountain ranges in the Trans-Pecos are recommended.

Acknowledgements

We would like to thank the Sul Ross State University volunteers who assisted collecting field data and the landowners of the Glass Mountains for access to their property. Thank you to our pilots, G. Vose and C. L. Woodward for the numerous safe flights. Funding was provided by the Rocky Mountain Elk Foundation, San Antonio Livestock Exposition, and Borderlands Research Institute.

Literature Cited

Bear, G. D. 1989. Seasonal distribution and population characteristics of elk in Estes Valley, Colorado. Colorado Division of Wildlife Special Report 65. Denver, Colorado.

Boulanger, J. G., and G. C. White. 1990. A comparison of home range estimators using Monte Carlo simulation. Journal of Wildlife Management 54:310–315.

Craighead, J. J., F. C. Craighead, Jr., R. L. Ruff, and B. W. O'Gara. 1973. Home ranges and activity patterns of nonmigratory elk of the Madison drainage herd as determined by biotelemetry. Wildlife Monographs 33:3–50.

Edge, W. D., C. L. Marcum, and S. L. Olson. 1985. Effects of logging activities on home range fidelity of elk. Journal of Wildlife Management 49:741–744.

Grace, K. T. 1983. A preliminary ecological study of elk in the Glass Mountains, Brewster County, Texas. M.S. thesis, Sul Ross State University, Alpine, Texas.

Graves, T. A. and J. S. Waller. 2006. Understanding the causes of missed global position system telemetry fixes. Journal of Wildlife Management 70:844–851.

Guevara, A. 2009. Assessing landowner attitudes toward elk and elk management in Trans-Pecos, Texas. M.S. thesis, Sul Ross State University, Alpine, Texas.

Harris S., W. J. Cresswell, P.G. Forge, W. J. Trewhella, T. Woollard, and S. Wray. 1990. Home-range analysis using radio-tracking data - a review of problems and techniques particularly as applied to the study of mammals. Mammal Review 20:97–123.

Heffelfinger, J. 1997. Age criteria for Arizona game species. Arizona Game and Fish Department Special Report 19. Tucson, Arizona.

Irwin, L. L., and J. M. Peek. 1983. Elk habitat use relative to forest succession in Idaho. Journal of Wildlife Management 47:664–672.

Kie J. G., J. A. Baldwin, and C. J. Evans. 1996. CALHOME: a program for estimating animal home ranges. Wildlife Society Bulletin 24:342–344.

Kreeger, T. J. 1996. Handbook of wildlife chemical immobilization. International Wildlife Veterinary Services, Laramie, Wyoming.

McCorquodale, S. M. 2003. Sex-specific movements and habitat use by elk in the Cascade Range of Washington. Journal of Wildlife Management 67:729–741.

McCorquodale, S. M., K. J. Raedeke, and R. D. Taber. 1989. Home ranges of elk in an arid environment. Northwest Science 63:29–34.

McNab, B. K. 1963. Bioenergetics and the determination of home range size. American Naturalist 97:133–140.

Noyes J. H., B. K. Johnson, L. D. Bryant, S. L. Findholt, J. W. Thomas. 1996. Effects of bull age on conception dates and pregnancy rates of cow elk. Journal of Wildlife Management 60:508–517.

PASW for Windows. 2009. Release 18.0.0. Polar Engineering and Consulting: PASW Inc., Chicago, Illinois.

Rodgers, A. R., A. P. Carr, H. L. Beyer, L. Smith, and J. G. Kie. 2007. HRT: Home Range Tools for ArcGIS. Version 1.1. Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada.

Schmidly, D. J. 2004. The mammals of Texas. Revised edition. University of Texas Press, Austin, Texas.

Seaman, D. E., and R. A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075–2085.

Seaman, D. E., J. J. Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. Journal of Wildlife Management 63:739–747.

Strohmeyer, D. C., and J. M. Peek. 1996. Wapiti home range and movement patterns in a sagebrush desert. Northwest Science 70:79–87.

Toweill, D. E., and J. W. Thomas. 2002. North American elk: ecology and management. Wildlife Management Institute, Washington, D.C.

Van Dyke, F. G., W. C. Klein, and S. T. Stewart. 1998. Long-term range fidelity in Rocky Mountain elk. Journal of Wildlife Management 62:1020–1035.

Warnock, B. H. 1977. Wildflowers of the Davis Mountains and the Marathon Basin, Texas. Sul Ross State University, Alpine, Texas.

White, G. C., and R. A. Garrot. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California.

Witt, B. R. 2008. Range size and habitat use of elk in the Glass Mountains, Texas. M.S. thesis, Sul Ross State University, Alpine, Texas.

Worton B. J. 1987. A review of models of home range for animal movement. Ecological Modelling 38:277–298.

Worton B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:16

Worton B. J. 1995. Using Monte Carlo simulation to evaluate kernel-based home range estimators. Journal of Wildlife Management 59:794–800.

Factors Affecting The Survival Of Black-Tailed Deer Fawns On The Northwestern Olympic Peninsula, Washington

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Abstract: Black-tailed deer (*Odocoileus heminonus columbianus*) populations of Washington State have suffered declines in some areas over the past 20 years. We suspected low recruitment of fawns, in part, due to recent (1996) infestation of an exotic louse, *Damalinia (Cervicola)*, causing hair loss syndrome (HLS). We looked at the effects of HLS and other factors, such as predation and nutritional stress, on individual fawns by estimating survival rates over four years. A total of 228 fawns were captured between 2006 and 2009. The model selected provided evidence that survival differed between years and was age dependent with fawns being vulnerable during the first 9 weeks and again during the winter timeframe. The average annual survival rate was 0.33, with early survival (from capture date through 9 weeks) at 0.65 and winter survival (1 Dec through 28 Feb) at 0.71. Survival rates were lower for fawns with HLS compared to those without HLS. Predation was the primary source of mortality (74.4%), with cougars (*Puma concolor*) and bobcats (*Lynx rufus*) being the most significant predators (49% and 21%, respectively). Poor nutritional condition over the winter likely influenced mortality as 77% of fawns that died from predation were moderately to severely nutritionally stressed. Fawns with HLS altered their behavior feeding less and scratching more than fawns without HLS, resulting in reduced condition and increased risk of mortality. Long term average annual doe survival and average annual fawn survival indicate the deer population within our study area is stable to declining at $\lambda = 0.995$.

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WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:28

Mule Deer And Elk Management On The Pueblo Of Santa Ana, Sandoval County, New Mexico

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Abstract: The Pueblo of Santa Ana (Pueblo) is a federally-recognized Indian Tribe located in north central New Mexico. Five years of aerial surveys from 2001 to 2005 confirmed very low numbers of mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus*) on the Pueblo. Like many other tribes in the Southwest, the Pueblo has a strong connection to the natural world that involves the use of traditionally-important wildlife species and, thus, ensuring viable deer and elk populations on the Pueblo is a priority. Therefore, the Pueblo embarked upon a multi-year process aimed at increasing populations of these two species on its land. The Pueblo exercised its legitimate right to self governance by establishing rules and standards relating to conservation, regulation, control, and management of wildlife on its lands. The Pueblo developed strong partnerships to initiate landscape-scale habitat enhancement projects, adopted a Wildlife Conservation Code and Regulations to protect wildlife, and initiated projects to better understand the population dynamics and habitat preferences of these two species on its land. While the first two actions have likely contributed to the notable increases in the numbers of deer and elk on the Pueblo, success will be measured by the Pueblo's ability to maintain viable long-term populations while being faced with the expected challenges of climate change, increased urbanization, and different jurisdictional wildlife management philosophies. Perhaps a collaborative approach to wildlife management between neighboring Tribes that blends traditional and contemporary wildlife management philosophies will increase the land base enough to help overcome the expected management challenges.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:29

Mule Deer & Energy: Federal Policy And Planning In The Greater Green River Basin

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Abstract: In an attempt to understand the federal government policy approach to promoting and protecting the West's populations of mule deer, the Theodore Roosevelt Conservation Partnership (TRCP) analyzed the extent of collaboration between the federal land management agencies and the state wildlife agencies on how mule deer management was being addressed during land use planning and major energy development projects. We were specifically concerned with the region known as the Greater Green River Basin (GRB), a geographic area home to some of the most significant mule deer herds in North America. The region is also home to the some of the United States' largest energy reserves, creating the opportunity for substantial conflict. We reviewed and analyzed federal land use planning documents and major energy project documents completed by federal agencies (BLM, Forest Service) within the GRB to find out how the federal agencies treated mule deer habitat in analyses, intended to manage mule deer habitats, incorporated state mule deer planning or objectives, and general collaboration with states in addressing potential mule deer issues. Overall we found that there are inconsistencies across all jurisdictions on how state agency mule deer management plans are incorporated into federal plans and energy projects. We also found that energy development has become the dominant priority for BLM policy and planning within the GRB, that mule deer science is often ignored or misinterpreted, and that protections for mule deer for seasonal restrictions are often waived when relief is requested from energy companies.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:30-32

Executive Summary

In an attempt to understand the federal government policy approach to promoting and protecting the West's populations of mule deer, this project analyzed the extent of collaboration between the federal land agencies and the state wildlife agencies. The overreaching goal was to construct a basic policy assessment that describes the approaches used by agencies to conserve mule deer and their habitat in the face of energy development. It is specifically concerned with the region known as the Greater Green River Basin (GRB), a geographic area home to some of the most significant mule deer herds in North America. The region is also home to the some of the United States' largest energy reserves, creating the opportunity for substantial conflict.

The three states (WY, CO, UT) in which the GRB resides each have some level of state-wide or regional mule deer planning or initiative that outlines how mule deer management and objectives should be met. We reviewed and analyzed land use planning documents and major energy project documents completed federal agencies (BLM, FS) within the GRB to find out how the federal agencies treated mule deer habitat in analyses, intended to manage mule deer habitats, incorporated state mule deer planning or objectives, and general collaboration with states in addressing potential mule deer issues. We also conducted interviews with key agency personnel and other managers who are instrumental in managing mule deer populations and habitats.

Watershed Map of the Greater Green River Basin (GRB) project area.

General Summary

• Federal agencies recognize the importance of mule deer habitats within plans and projects but there is an
inconsistent approach to analysis and future management.
• Crucial winter habitats are identified as the primary concern in most plans and analyses with increased awareness and concern for continued impacts on crucial winter range with no apparent specific plans to avoid or mitigate on-going or future impacts.
• Habitat Management Planning (HMP) is used very sporadically and it is unclear if the proposed HMP's in planning were ever completed or exist today.
• Seasonal and timing stipulations and restrictions are the most common approach to mule deer habitat management on federal lands.
• No reference to existing mule deer initiatives were found in plans or projects, nor were there specific references to how habitat would be managed to meet state set population objectives.
• Management analysis and actions differed between states and offices based on same literature, information and science.
• Management across geo-political boundaries in both cultures (state and federal) was basically non-existent

- Energy development has become the dominant land use priority on the public lands managed by the BLM in the Green River Basin.
- Federal agencies have not embraced the recommendations for implementing state mule deer planning and the North American Mule Deer Conservation plan developed by Western Association of Fish and Wildlife Agencies.

Recommendations

Based on the analysis and knowledge of policy, planning, and wildlife conservation we can make the following recommendations:

Coordination

1. Revise current agreements between the BLM, Forest Service, and state wildlife agencies to guarantee each agency is represented on all planning and projects that affect mule deer
2. Ensure recommendations from state mule deer initiatives and the Western Association of Fish and Wildlife Agencies North American Mule Deer Conservation plan are implemented
3. Develop regional coordinating groups for the cross boundary coordination of mule deer

Science

1. Complete a thorough review of the state of the science on mule deer and how they are impacted by energy development activities
2. Establish a regular review process for incorporating science into future plans and projects
3. Address gaps in understanding by undertaking coordinated research on those areas

Planning

1. Specifically identify state population objectives for mule deer and how those objectives are going to be met by habitat management actions, land use designations and protections of specific habitats needed to meet long term sustainability of mule deer populations.
2. Develop specific monitoring and reporting requirements on how commitments made in land use plans are being implemented and met - for annual review by stakeholders and public
3. Incorporate state level mule deer planning, WAFWA mule deer recommendations and habitat guidelines, and other specific mule deer information into all plans and energy projects

Management

1. Develop specific habitat management plans or regional mule deer plans that include agreed upon goals and objectives for mule deer based on habitat and population needs.
2. Develop a set of guidelines or best management practices to be implemented during energy development activities within mule deer habitats
3. Develop specific stipulations and actions that address habitat loss, degradation, and fragmentation of mule deer habitat from energy development including addressing impacts to mule deer hunting opportunities

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Using Camera Traps To Quantify Daily And Seasonal Mineral Lick Use

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Abstract: Natural mineral licks are unique habitat features that are essential to the diet of all North American ungulate species. Northern ungulates are required to make a quick transition from their winter diet to lush green spring forage, which is high in potassium, carbohydrates and protein but low in fiber. These chemical properties of spring forage reduce the digestive efficiency of the rumen and impair absorption. Lick soils provide the necessary elements to help stabilize the rumen, as well as supplement demands of lactation and growth. Unlike forage vegetation patterns, which are non-static and vary with natural disturbance patterns over time, mineral licks are a static resource that may be used by many generations of a population. Since these small, localized areas are of significance to the ecology of a variety of ungulate species, their preservation on the landscape is critical. Despite this, rigorous information on the location and use of these resources is often limited to non-existent for much of Alberta. The goal of our project is to provide wildlife managers with an inventory that can be used in ongoing land use planning for an area known for its overlap of forestry, petroleum, and recreation value. As part of our initiative, we will be using remote camera traps to quantify seasonal and daily use of a subset of the known mineral licks. We will discuss our approach to collecting, storing and analyzing this information and will present preliminary results from a pilot project conducted in 2010.

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WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:33

Using Wildlife Underpasses As A Management Tool

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Abstract: Wildlife underpasses are situated in areas where a highly dispersed population converges into a relatively small area along a migration corridor. In addition to reducing wildlife-vehicle collisions and maintaining migration corridor connectivity, use of underpasses by wildlife may provide valuable information for wildlife managers. We used a newly constructed underpass and associated trail cameras to collect data for mule deer in relation to timing of migration, classification of animals by sex and age class, and fawn survival over winter. From October 2009 to December 2010, we documented 12,130 deer using the underpass. We used a negative binomial analysis to test three hypotheses of factors affecting mule deer use of the underpass during fall migration of 2010 (n = 5,354): temperature, precipitation, and both temperature and precipitation. We found that deer use of the underpass was negatively associated with minimum daily air temperature and positively associated with snow depth. We compared underpass classification data with aerial classification data and found that aerial counts resulted in fewer fawns and adult bucks compared to the underpass data. Underpasses may increase the probability of detecting small-bodied (fawns) or solitary (bucks) individuals, and thus improve estimates of fawn and mature buck-to-doe ratios. By comparing the number of fawns per 100 adult deer between fall and spring migration we may be able to determine fawn survival over winter. Wildlife managers that have access to wildlife underpasses should consider their use for collection of important data for management and harvest regulations.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:34

Monitoring Rocky Mountain Elk Response To Hunting In The East Kootenay, British Columbia

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Abstract: Rocky Mountain elk populations in the East Kootenay, British Columbia, increased between the mid 1990s and mid 2000s. Correspondingly, there was a rise in public concern with grassland overgrazing and agricultural crop depredation. Much of the blame was targeted at non-migratory elk, which remain in low elevation habitat year-round. In response, the BC provincial government initiated liberal cow/calf elk hunts. These hunts were restricted to low elevations and closed in early October to focus harvest on non- migratory elk. We radio-collared and monitored 80 cow elk between 2007 and 2009 to update migratory behaviour information, as well as assess the response of the elk population and individual elk to the new hunts. We found that elk migratory behaviour changed dramatically over time. In the late 2000s, roughly 50% of collared cow elk did not migrate, compared to 5% when elk were last monitored in the early 1990s. Furthermore, elk that did migrate in the 2000s left low elevation areas later in the spring and returned earlier in the fall compared to the 1990s, spending at least two additional months in and around heavily grazed grasslands and agricultural areas. Our radio-collar data also pointed to significant cow mortality associated with the new hunts, and a higher harvest on non-migratory elk. We found that elk responded to the new hunts by spending less time in low elevation areas during the hunt. However the response was short term: non-migratory elk did not respond by becoming migratory.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:35

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Patterns And Factors In Migratory Movements Of Nevada Mule Deer

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Abstract: GPS collars were deployed on approximately 70 mule deer does beginning in late 2006 through 2011. Collar deployment objectives were: better describe migration routes and timing to assist in land conservation efforts; focus post-wildfire habitat restoration efforts on critical mule deer use areas; help confirm future highway wildlife crossing locations; and assist in more effective interstate mule deer herd management among adjoining states. Summer and winter range elevations and habitat types and migration distance and timing were identified for each animal in GIS. Snow depth data were compiled and analyzed for influencing migration timing. Migration routes between seasons and years were evaluated for site fidelity and use of certain topographic features. Migration routes were as short as 15 miles and as long as over 120 miles, with the majority having at least 1,000 feet elevation change each season. Migrations involved movements within Nevada and interstate movements with adjoining states of Utah, Idaho, Oregon, and California. A wide range of situations/pertubations existed along migration routes. Some migrations were highly consistent or obligatory based on day length (photoperiod), while others were more facultative with variable start dates likely based on weather events. Current migration routes in northeastern Nevada were compared to those described for the same mule deer herds from a late 1950s mule deer migration study. Several mule deer herds have very complex, multidirectional migration routes that are difficult to describe at certain scales and present challenges for mitigating future impacts. The need exists to have a more complete depiction of mule deer migration corridors and associated data sharing at a regional (interstate) level to better conserve these epic mule deer journeys of survival under increasing and continued threats by large-scale human development projects and catastrophic events.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:36

Utilizing Antler Point Restrictions For Mule Deer To Maximize Hunter Opportunity In Southern British Columbia

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Abstract: A ≥4-antler point restriction (APR) or 4-point season for mule deer (*Odocoileus hemionus*) meant to maximise hunter opportunity was implemented within Region 3 of southern British Columbia. Hunter opportunity was defined as the number of days available to hunt bucks during an annual general open season (GOS), including both any-buck and 4-point buck seasons. Between 1987 and 2009 annual buck hunting regulations were changed from any-buck only seasons, to a combination of any-buck and 4-point buck seasons. An assessment found hunting regulations that included a 4-point buck season reduced hunter kills relative to any-buck seasons, and accounted for 31–37% of the buck harvest whereby the majority of the harvest 63–69% still occurred during the any-buck seasons. Hunter numbers and hunter days remained consistent over most of the study period, although there was an increase in recent years. Regional deer numbers may have declined midway through the study but by 2008 appeared to have increased to slightly above the original estimate. We provide explanations as to why our results appear counter to some findings from other studies and suggest that utilizing a combination of 4-point and any-buck seasons for mule deer for 92 days can maintain maximum hunter opportunity while retaining a sustainable harvest.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:38–46

Key Words: Antler Point Restrictions, British Columbia, hunter opportunity, mule deer

Hunters are an integral component of the North American Model of Wildlife Conservation (Geist et al. 2001), but maintaining or increasing hunter numbers is a current challenge faced by wildlife managers (Prukop and Regan 2005). Increasing hunting opportunities can benefit hunter recruitment and retention, but managing those opportunities sustainably entails considerations of both the biological limitations of the species and their habitat and social values of hunters (Denny 1976). Mule deer are an important species to hunters throughout western North America. Agencies managing mule deer harvest must balance hunter's expectations of maximizing opportunity (e.g. class of animal and days of hunting) with a reasonable chance of harvesting a mature buck (Wakeling and Watkins 2010). Agencies managing high hunter demand normally have to limit hunter opportunity by implementing limited-entry hunting (LEH) systems. While LEH-systems provide some advantages over general open season (GOS) such as reduced hunter crowding and maintenance of more natural age structures of bucks, the disadvantages include fewer licenses sold which equates to reduced hunter opportunity and funds for conservation. Maximizing season length is one tool that can be used to maintain hunter numbers because it allows ample opportunity for hunters to plan and participate in numerous hunts in different habitats (e.g. alpine) and under varying conditions but is difficult to implement in jurisdictions which have high hunter numbers, especially when combined with low security cover and/or high levels of access. For the purposes of this paper we define hunting opportunity as the number of days available to hunt bucks during an annual GOS, including both any-buck and 4-point buck seasons.

Many agencies have used antler point restrictions (APRs) in an attempt to balance expectations of hunters with biological considerations for the deer population. A common perception among hunters is that APRs can lead to both more deer and larger antlered bucks but scientific evidence rarely supports this assertion (Carpenter and Gill 1987; Erickson et al. 2003). For example, Colorado experimented with APRs in 8 game management units for 7 years and found only marginal benefits to buck:doe ratios in some situations and no substantial increase in the proportion of mature bucks (Freddy et al. 1993). Similar findings of little to no improvement in buck/doe ratios using APRs have been determined in Idaho, Montana, Oregon, Wyoming and Utah. An additional problem of using APRs is that illegal kills can increase, such as reported in Montana where illegal kills increased to 18% of legal harvest following implementation of an APR (Erickson et al. 2003).

Southern British Columbia has been using a 4-point buck regulation to maintain high levels of hunter opportunity and a sustainable harvest of bucks for over two decades while providing a reasonable probability of harvesting a mature buck. British Columbia's Wildlife Regulation defines a four-point buck as any mule deer buck having a minimum of four tines on one antler excluding the brow tine. The four-point regulation was first implemented in the Okanagan region of southern BC due to concerns around low buck/doe ratios and declining average age of bucks in the harvest (Harper 1998). We assessed three different harvest structures, of which two contained 4-point seasons, in Region 3 in southern BC over a 23-year time period from 1987–2009. Prior to 1992, a liberal 80–85 day any-buck season was in place but concerns were eventually raised that this season may not sustainable as was suggested in the Okanagan (Harper 1998). From 1992–1997 a 23–40 day 4-point season was implemented during November/December to reduce the buck harvest during the entire rutting period when bucks are most vulnerable to harvest (Erickson et al. 2003). From 1998–2009 the 4-point buck season was extended to also include the month of September in an attempt to further reduce overall harvest of bucks, but maintain high levels of hunting opportunity. Season length during this time was 92 days and consisted of 31 days of any-buck (Oct) and 61 days of 4-point buck (Sept and Nov/Dec). The purpose of this paper is to assess the sustainability of hunting opportunity and harvest of mule deer bucks during the 23-year period when any buck seasons only, and combined any-buck/4-point seasons were in effect.

Methods

The study area is situated near Kamloops BC and consisted of 20 Wildlife Management Units (3-12, 3-13; 3-17 to 3-20; 3-26-3-31, 3-34 to 3-41) (Figure 1). There were three season structures over a 23-year time that consisted of: any-buck regulation (September through December) from 1987–1991; an any-buck (September and October), followed by a 4-point buck (November and December) regulation from 1992–1997; and a 4-point (September) followed by any-buck (October), followed by another 4-point buck (November and December) regulation from 1993–2009 (Table 1).

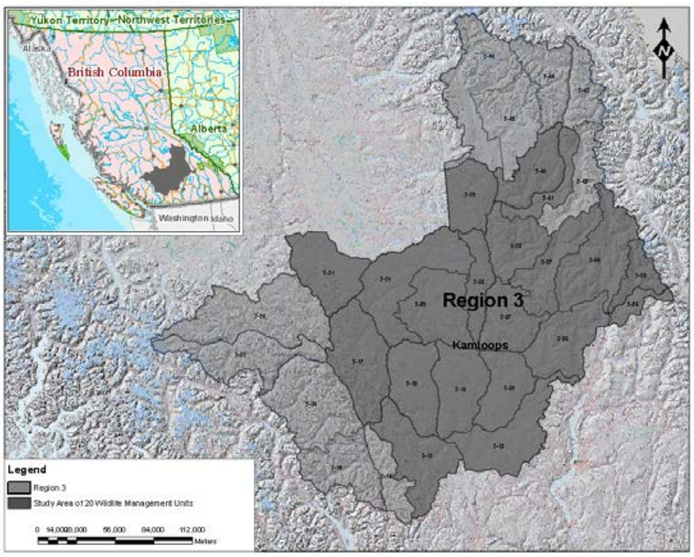

Figure 1. Study area in southern British Columbia. The light and dark shading depicts Region 3, the area regional mule deer population estimates were generated for while the dark shading shows the 20 Wildlife Management Units where three harvest structures were assessed.

Total reported resident hunter harvest, sex-age composition (male, female, juvenile), hunter numbers, and hunter days for mule deer were gathered and estimated from a hunter harvest questionnaire which is mailed to a random sample of hunters following the hunting season in December with a second notice to non-responders in March. The questionnaire was sent to approximately 27% of the estimated mule deer hunters with an initial response rate of 45% with a follow-up response rate of 30% on the second mailing.

Season Structure	Sep 10-19	Sep 20-30	Oct 1-10	Oct 11-20	Oct 21-31	Nov 1-10	Nov 11-20	Nov 21-30	Dec 1-13	Total Kills	% Any Buck	% 4Pt
1998–2009 ≥4Pt/Any Buck/≥4Pt	3	3	25	18	21	7	12	8	4	526	63	37
1992–1997 Any Buck/≥4Pt	13	13	11	15	17	9	11	8	4	386	69	31
1987–1991 Any Buck	1	14	8	12	17	15	14	11	9	445	100	0

Table 1. Percent reported harvest of mule deer bucks in 10–13 day time intervals for three hunting season structures in 20 Wildlife Management Units (3-12, 3-13; 3-17 to 3-20; 3-26 to 3-31, 3-34 to 3-41) from 1987–2009 in southern British Columbia. Shading denotes a 4-point antler point regulation.

Reported kills were binned in 10 to 13-day intervals from September 10 to December 13 which encompassed all season dates and enabled an assessment of reported kills within and among each of the three hunting structures. Regional population estimates of pre-hunt mule deer numbers were based on expert judgment every 3–5 years as part of a provincial ungulate reporting system. Data on mule deer ages and antler points were collected from 1983–1987 through a provincial program where deer hunters were encouraged to submit a front incisor tooth along with antler point information through the mail in return for a wildlife management participation crest. This program was in place when there were any-buck seasons but no comparable data exists during 4-point seasons (Table 2).

Age	%n	Number of Antler Points									n
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	
1	33	23	65	10	2	<1	0	0	0	0	435
2	17	1	44	31	22	2	<1	0	0	0	232
3	11	0	10	28	49	10	3	0	0	0	146
4	11	0	5	21	47	19	6	1	1	0	151
5	8	0	2	16	61	17	2	1	1	<1	103
6	6	0	6	11	50	23	5	5	<1	<1	84
7	5	1	4	10	44	26	10	4	<1	0	70
8	4	0	6	13	35	23	11	6	6	0	47
9	2	0	12	24	31	30	1	1	1	0	33
10	1	0	8	23	46	23	0	0	0	0	13
11	1	0	0	14	50	21	14	<1	0	0	14
12+	<1	0	0	20	0	40	40	0	0	0	5
TOTAL n		104	422	238	379	132	36	12	8	2	1333
TOTAL %		8	32	18	28	10	3	1	<1	<1	

Table 2. Percent of hunter-harvested mule deer bucks by age class and associated antler points gathered by voluntary submission of incisor teeth and antler characteristics in Region 3, 1983–1987.

There were no post-hunt mule deer composition helicopter surveys flown during the timeframe of this study largely due to difficulties in achieving sufficient sample sizes. However, a helicopter survey was conducted in December, 2010 to help assess the sustainability of the combined any buck and 4-point season structure following methodology in Keegan et al. (2011). The area surveyed was a portion of one heavily hunted mule deer winter range in Wildlife Management Unit 3-28, consisting of a large 8-year-old burn with high visibility and ample road access. Some roads and trails have motor vehicle closures to reduce hunter traffic in the area during the fall hunting season. Survey results were evaluated against the provincial performance criteria of >20 bucks/100 does during the post-hunt period (Ministry of Environment 2010).

Results

The average reported harvest was greatest during the any-buck season structure (1987–91) when compared to those time intervals with 4-point regulations in the other two season structures in 1992–97 and 1998–2009 (Table 1, Figure 2). Some of the difference appeared to be attributed to the 4-point season in September, where 26% of the harvest occurred during the any-buck/4-point season structure and only 6% during the 4-point/any-buck/4-point season structure. Implementation of the 4-point season in November in 1992 and September in 1998 reduced average buck harvests in those months by 33 and 61%, respectively. Average harvest doubled in October during the 1998–2009 period relative to the 1987–91 and 1992–97 periods (Figure 2). The estimated harvest of mule deer bucks declined slightly during the any-buck/4-point (1992–1997) time period but increased substantially starting in 2000 during the 4-point/any-buck/4-point (1998–2009) time period (Figure 3). The total number of estimated hunters and hunter days appeared to be generally stable although an increase did occur from 2005–2009. A small reduction in hunter numbers was observed for several years following implementation of the 4-point buck seasons in November/December 1992, but the most recent estimate (2009) was the highest observed since 1987 (Figure 4). The decline in harvest, hunter numbers and hunter days in 2004 is thought to be due to sampling error (Figure 3-4).

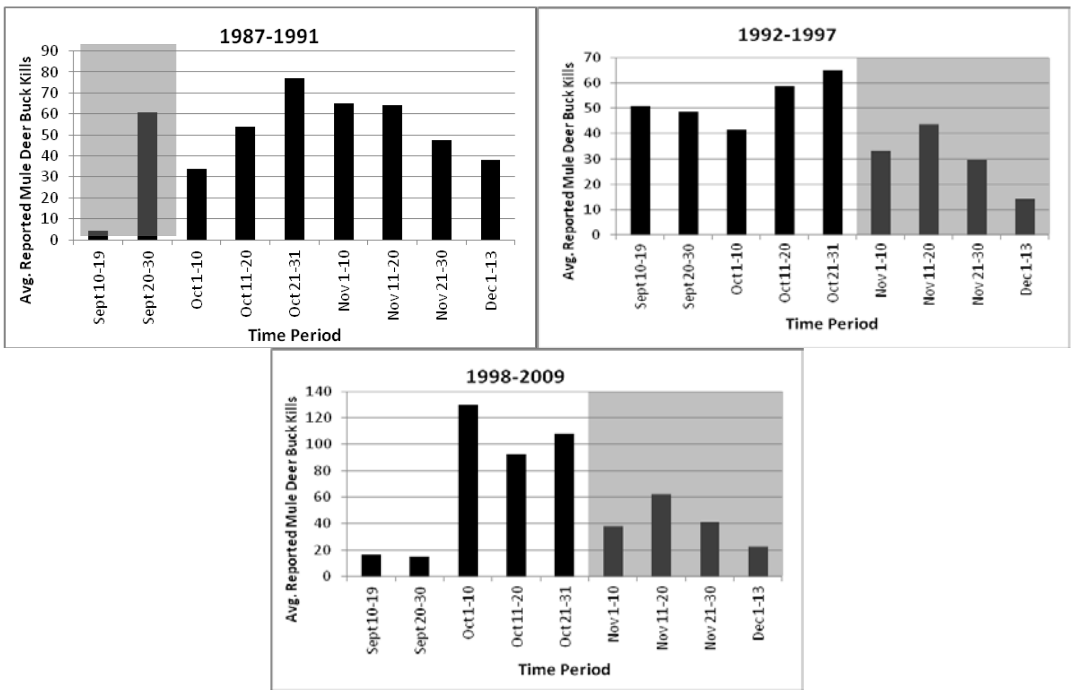

Figure 2. Average reported harvest of mule deer bucks by 10–13 day periods in three different harvest structures in southern British Columbia, 1987–2009. Shading denotes a 4-point antler point regulation.

Regional estimates of mule deer numbers provided by regional biologists were based on limited but best available information at the time. In hindsight, we believe the population recovery through the 2000s may have been under estimated, and more accurate population estimates for 2003 and 2008 would have been closer to the maximum end of the population estimate range, that is, 40,000 in 2003 and 50,000 in 2008 (Figure 5). We suspect a population decline during the late 1980's through to 2000, followed by recovery beginning in the early 2000s and continuing to present. This trend is supported by declines in both hunter harvests and success during the late 1980s and 1990s followed by substantial increases in harvests and success through the 2000s (Figure 3). The observed deer population recovery during the 2000s was likely due to a combination of factors, including mild winters, good forage production, and a 50% reduction in the antlerless limited entry hunting permit numbers starting in 2000.

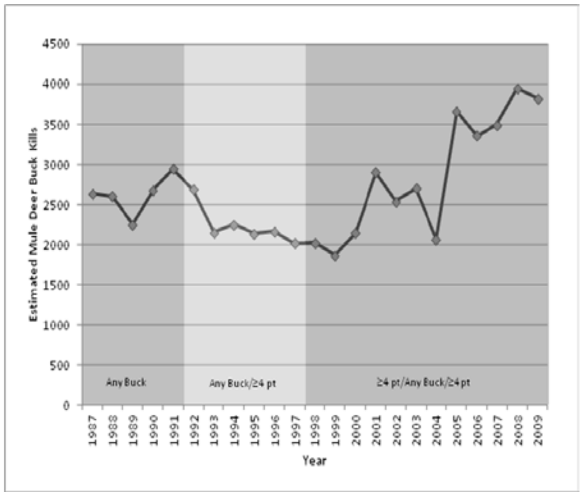

Figure 3. Estimated mule deer buck harvest in 20 Wildlife Management Units in southern British Columbia, 1987–2009.

The collection of mule deer antler/age data between 1983 and 1987 determined that about 25% of the 2 year old bucks were ≥ 4-points. For age classes 3+ years old, greater than 60% of the bucks were≥ 4-points (Table 2). During a post-hunt composition survey flown December 2010 to assess the sustainability of the 4-point season, 536 deer were classified and the sex ratio was 25 bucks/100 does. The observed ≥4-point bucks comprised at least 7% of the total observed bucks.

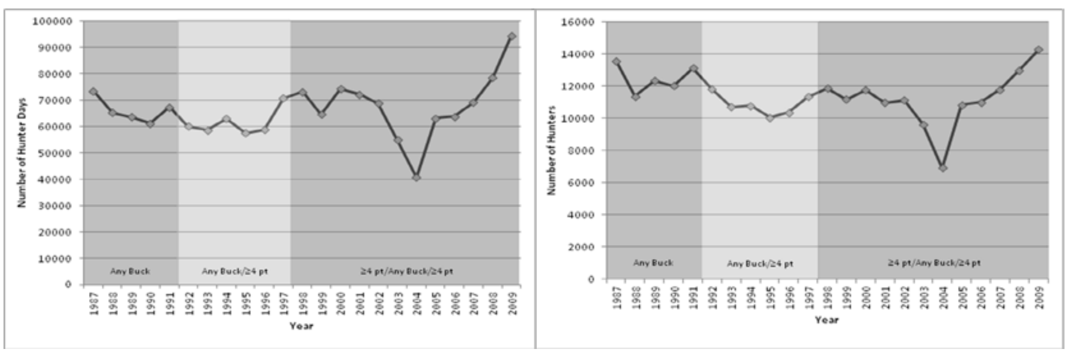

Figure 4. Estimated hunter numbers and hunter days for mule deer in 20 Wildlife Management Units in southern British Columbia, 1987-2009.

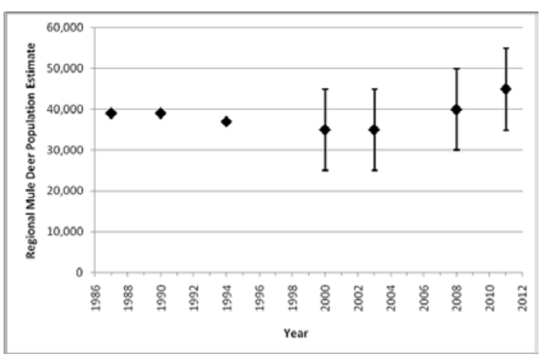

Figure 5. Region 3 pre-hunt mule deer population estimates from 1987–2011. Error bars represent plausible minimum and maximum ranges in years when available.

Discussion

We found that 4-point seasons reduced harvest during times when mule bucks were vulnerable to harvest such as early in the season (Harper 1998) and during the rut (Pac and white 2007).

Harper (1998) suggested that during a general open season hunters were apt to seek young bucks that were unwary of hunters early in the season. Our results may support this assumption as shown by the proportionally high harvest during the any-buck seasons in September from 1987–1997 compared to the September 4-point season from 1998–2009. The increased harvest observed during the any-buck seasons in October during the 3 time periods is likely related to a couple of different factors. First, many hunters prefer to hunt under an any-buck regulation as opposed to a 4-point regulation and as such, those hunters probably directed more effort to the any-buck seasons as opposed to the 4-point seasons. Second, the mule deer population appeared to be slightly increasing in this area since the early 2000s which is a likely reason for increased hunter success rates and harvests. And finally, hunter numbers were increasing during latter years of the 1998–2009 period which would also have generally increased harvest.

The 4-point seasons for mule deer did not appear to lead to reduced hunter numbers during this study. The short-term declines in hunter numbers following implementation of the 4-point seasons in November/December of 1992 are not likely a result of those seasons as overall hunter numbers, based on basic hunting licenses sold in the province, also began to decline in 1992 (Ministry Forests Lands Natural Resource Operations, unpublished data). Furthermore, while mule deer hunter numbers in this area began to recover and stabilize by 1997, provincial hunter numbers continued to decline until at least 2005 which provides further evidence that 4-point seasons have not influenced hunter numbers in this region (Ministry Forests Lands Natural Resource Operations, unpublished data). No reductions in hunter numbers were observed after 1998 when the 4-point season was increased from 40 to 61 days. Other jurisdictions have reported reductions in hunter numbers following implementation of APRs due to increased regulation complexity and lower hunter success. Finally, one important difference relative to other jurisdictions is that hunters in this study area have always had the option to hunt under any-buck regulations if they desired, which likely contributed to the maintenance of hunter numbers (Erickson et al. 2003).

One problem discussed in the literature is that APRs focus harvest on the older age classes of males which is counterproductive to the intent of increasing the proportion of older age class bucks in the population (Carpenter and Gill 1987, Erickson et al. 2003). Our study differs from most others in that two of the three harvest structures used a combination of any-buck and 4-point seasons where hunters were still allowed to harvest across the age structure of bucks during the any-buck season and the 4-point seasons were only in place when bucks were vulnerable (i.e. early season and rut). Our results show the majority of hunters preferred hunting when there was no 4-point seasons in place as 63–69% of the harvest occurred during any-buck seasons within the two hunting structures containing 4-point seasons, thus spreading the harvest across age classes. Buck age and antler data collected prior to and during the any-buck hunting structure (1987-1991) suggests that any-buck seasons likely do not only focus harvest on older age classes as 4-point bucks were a fairly common occurrence in all ≥2 year old age classes. We have no comparable age/antler data to examine if proportions of bucks in each age/antler class changed when a 4-point season was implemented. We assume the age structure is not substantially skewed against older bucks because anecdotal information indicates that large bucks are still regularly sighted and harvested under the current 92 day 4-point/any-buck/ 4-point structure.

Also, recent results from the 2010 post-hunt composition survey in a portion of the study area indicated a relatively high proportion of bucks (25 bucks/100 does) including 7% of the sampled bucks being ≥4-points.

Non-hunting mortality can influence effectiveness of hunting regulations. Pac and White (2007) found that non-hunting mortality among all classes of mule deer bucks limited the success of hunting regulations meant to enhance the availability of larger bucks. Bender et al. (2004) found hunting to be the main source of mortality for male black-tailed deer and suggested that reducing season length or hunter intensity were options to retain more males in the population. Similarly, Pac and White (2007) suggest caution with harvest intensity when the mule deer bucks are subjected to a combination of hunting and non-hunting mortality. Our study area had a suite of predators including wolves (*Canis lupus*), cougars (*Felis concolor*), grizzly bears (*Ursus arctos*) and black bears (*Ursus americanus*) with cougars being documented to prey substantially on mule deer in southeast BC (Robinson et al. 2002). Severe winters can also reduce mule deer populations as was the case in 1996/97 in southeast BC (Mowat and Kuzyk 2009). We concur that non-hunting mortality can influence hunting regulations and recommend that mule deer populations in southern BC continue to be closely monitored through harvest monitoring and sex/age composition surveys.

In conclusion, we summarize reasons why we suggest this APR has been successful at maximizing hunter opportunity while sustaining mule deer populations. Firstly, this season structure is a combination of any-buck and four-point season and is not exclusively an APR. This combination serves to maintain hunter opportunity, ensures harvest is not focused only on older age classes of bucks, and limits harvest during vulnerable periods. Secondly, the remoteness, ruggedness and heavily timbered nature of many deer ranges within this study area limit hunter intensity and success. The overall hunter density on fall mule deer ranges during this study was 0.2–0.4 hunters/km^2 which is likely much lower than many jurisdictions in the US that offer general open seasons for mule deer. We are conscious that access can, and is in some areas, increasing concurrent with industrial development which in turn could make mule deer bucks more vulnerable to harvest. We also recognize that non-hunting mortality especially from severe winters can impact deer populations.

As such, we stress the importance of monitoring mule deer populations, especially sex ratios to monitor the effectiveness of harvest strategies and suggest the following four options to manage buck harvest if sex ratios drop below the management objective of 20 bucks/100 does: 1)Season harmonization - pursue further harmonization of mule deer seasons in adjacent regions to distribute harvest and avoid concentrating hunters ; 2)Antlerless harvests - increase antlerless harvests provided populations can support increased harvests and management objectives can continue to be met; 3)Access management - implement more stringent access management regulations and/or work with industry to physically manage access through decommissioning/blockage of new and existing access points; 4)Season adjustments - adjust buck season timing and/or length to reduce hunter numbers and/or success.

Acknowledgments
We thank Dave Low for providing the antler point and age data and Mike Wolowicz for compiling the hunter sample information. Thanks also to Francis Iredale for assisting with GIS analyses.

Literature Cited

Denny, R. N. 1976. Regulations and the mule deer harvest: political and biological management. In Workman, G. W. and J. B. Low. Mule Deer Decline—A Symposium, Logan Utah.

Carpenter, L. H. and B. Gill. 1987. Antler point regulations: the good, the bad, and the ugly. Transactions of the Western Association of Game and Fish Commissioners 67:94-107.

Bender, L. C., G. A. Schirato, R. D. Spencer, K. R. McAllister, and B. L. Murphie. 2004. Survival, cause-specific mortality, and harvesting of male black-tailed deer in Washington. Journal of Wildlife Management 68:870–878.

Erickson, G. L., J. R. Heffelfinger, and J. H. Ellenberger. 2003. Potential effects of hunting and hunt structure on mule deer abundance and demographics. In deVos, Jr. J. C., M.R. Conover, and N.E. Headrick. Mule Deer Conservation: Issues and Management Strategies. Berryman Institute Press, Utah State University, Logan.

Freddy, D. J., D. L. Baker, R. M. Bartmann, and R. C. Kufield. 1993. Deer and elk management analysis guide, 1992–1994. Colorado Division of Wildlife Report No. 17, Fort Collins.

Geist, V., S. P. Mahoney, and J. F. Organ. 2001. Why hunting has defined the North American model of wildlife conservation. Transactions of the North American Wildlife and Natural Resources Conference 66:175–185.

Harper, F. E. 1998. Okanagan mule deer harvest strategy. Unpublished report for the Ministry of Environment, Lands and Parks, Kamloops, British Columbia, 7 pp.

Keegan T. W., B. B. Ackerman, A. N. Aoude, L. C. Bender, T. Boudreau, L. H. Carpenter, B. B. Compton, M. Elmer, J. R. Heffelfinger, D. W. Lutz, B. D. Trindle, B. F. Wakeling, and B. E. Watkins. 2011. Methods for monitoring mule deer populations. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies, USA.

Ministry of Environment. 2010. Southern Interior Mule Deer Harvest Management Procedure Manual. Victoria, BC.

Mowat, G. and G. Kuzyk. 2009. Mule deer and white-tailed deer population review for the Kootenay region of British Columbia. Unpublished report for the Ministry of Environment, Nelson B.C., 29 pp.

Pac, D. and G. White. 2007. Survival and cause-specific mortality of male mule deer under different hunting regulations in the Bridger Mountains, Montana. Journal of Wildlife Management 71:816-827.

Prukop, J. and R. J. Regan. 2005. In My Opinion: The value of the North American model of wildlife conservation—an International Association of Fish and Wildlife Agencies Position. Wildlife Society Bulletin 33:374-377.

Robinson, H. S., R. B. Wielgus and J. C. Gwilliam. 2002. Cougar predation and population growth of sympatric mule deer and white-tailed deer. Canadian Journal of Zoology 50:556-568.

Wakeling, B. F. and B. E. Watkins. 2010. Mule deer hunting: public attitudes and agency management. Western States and Provinces Deer and Elk Workshop Proceedings–2007. 6:11–21.

State Status Reports

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Abstract: Overall population estimates for all deer species continued to decrease from 2003 to 2009 across western North America, although some individual states or provinces realized increases. Population-weighted deer fawn-to-doe ratios decreased slightly from 2003 to 2009. Population estimates for all elk were more stable than deer, but still decreased from 2003 to 2009. Population-weighted elk calf-to-cow ratios stabilized across the West in 2009. Total deer harvest numbers decreased from 2003 to 2009. Total elk harvest decreased from 2003 to 2009. The broad-scale trend in deer indicated larger changes to populations and smaller changes to harvest as white-tailed deer become more prevalent in western North America. The broad-scale trend in elk indicated smaller changes to populations and larger changes to harvest as some key states or provinces realized large reductions in elk harvest. Additional information on hunter requirements and opportunity, predators, chronic wasting disease, and habitat was also included.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:46-64

Key Words: Cervus spp., chronic wasting disease, deer, elk, harvest, *Odocoileus* spp., population, predators, provinces, states

The host state of the Deer and Elk Workshop is tasked with collecting population and harvest information from member states and provinces. This information has been gathered with a varying degree of totality over the years and has not always been incorporated into the Deer and Elk Workshop presentations. Cox et al. (2005) presented a historical overview of the data from 1970 to 2003. Since then data were collected, though not presented, at the 2007 workshop, and not collected for the 2009 workshop. Given the variability in population estimates and harvest information, it is not instructive to collect and analyze trends on a biennial basis. However, it was time for an update.

I sent surveys to all 23 Western Association of Fish and Wildlife Agencies members. Alaska, Hawaii, and Saskatchewan did not provide responses. I asked respondents to provide information from the 2009 biological and harvest years for black-tailed (*Odocoileus hemionus columbianus* and *O. h. sitkensis)*, mule (*O. hemionus*) and white-tailed deer (*Odocoileus virginianus*), and Rocky Mountain (*Cervus elaphus nelsoni*), Roosevelt (*C. e. roosevelti*) and tule elk (*C. e. nannodes*). Survey questions included: survey methodology and timing, population estimate and management objective, observed young per 100 females, harvest and success rate by weapon type for antlered and antlerless hunts, number of hunters and hunter days by weapon type for antlered, either-sex, and antlerless hunts (Appendix A). In addition to these standard questions, I also included additional questions of particular interest to New Mexico Department of Game and Fish personnel.

Results and Discussion

Population

The overall population estimate for mule deer from responding states and provinces (excluding North Dakota) was approximately 3.1 million in 2009 (Figure 1). This was a 10.6% decrease in the population estimate from 2003 (excluding California and Montana). When black-tailed deer were included with mule deer the overall population estimate was approximately 3.8 million deer. This was a 10.1% decrease in the population estimate from 2003 (excluding Montana). California was not included in the mule deer comparison because they did not provide a separate estimate for mule deer in 2003. Montana was not included in either comparison because they provided different metrics for 2003 and 2009. North Dakota provided a mean density estimate of 8.5 mule deer per square mile, but no overall population estimate.

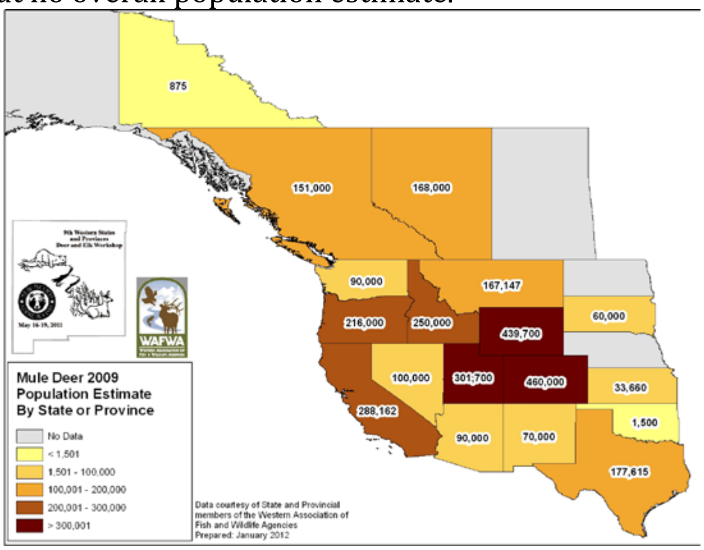

Figure 1. Mule deer population estimate by state or province for 2009. The estimates for BC, CA, OR, and WA did not include black-tailed deer. The estimate for CO included white-tailed deer. MT reported the number of deer observed.

The overall population estimate for white-tailed deer was approximately 4.6 million in 2009 (Figure 2). This was a 19.1% decrease in the population estimate from 2003 (for states and provinces that provided estimates in both years). This decrease is in large part due to a 1.2 million decrease in the population estimate in Texas. Montana was not included in the comparison because they provided different metrics for 2003 and 2009.

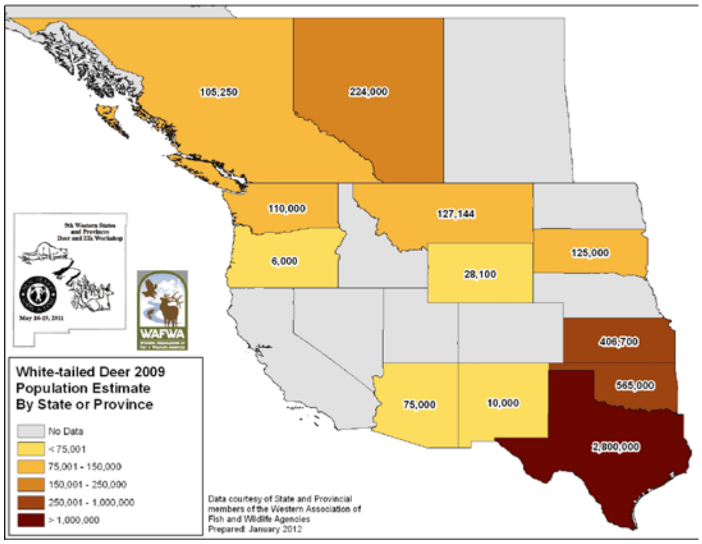

Figure 2. White-tailed deer population estimate by state or province for 2009. The white-tailed deer estimate for OR only included the Columbian subspecies. MT reported the number of deer observed.

The trend in total deer population estimates from 2000 to 2009 was variable by state or province (Figure 3). Some of these changes during this time frame may reflect west-wide mule deer population declines (Carpenter 1997, Unsworth et al. 1999, Heffelfinger and Messmer 2003). British Columbia, Kansas, New Mexico, Oklahoma, Utah, and Yukon reported increases in overall deer population estimates. The increase in New Mexico was caused by the inclusion of a white-tailed deer population estimate. Montana, South Dakota, and Texas reported sizeable declines in their population estimates. However, Montana reported different metrics in 2003 and 2009.

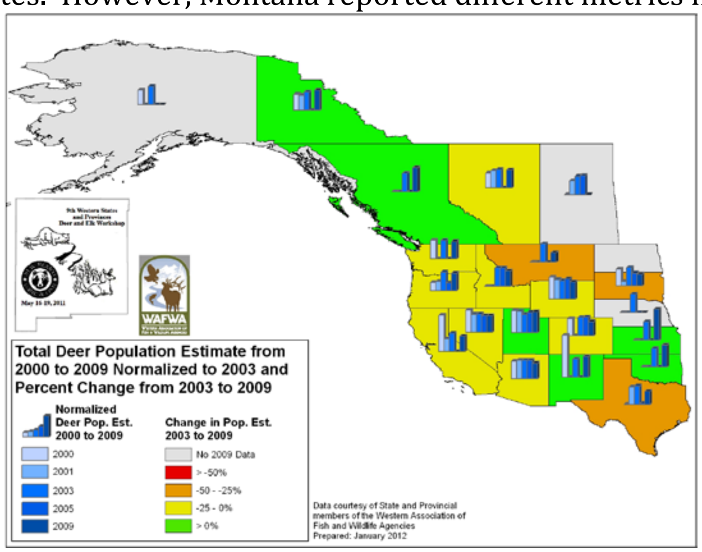

Figure 3. Total deer population estimate by state or province from 2000 to 2009 relative to 2003, and percent change from 2003 to 2009. Combined black-tailed, mule, and white-tailed deer population estimates. MT reported different metrics for the 2003 and 2009. Mule deer was the only species included for ID.

Following short-term increases in mean mule deer fawn-to-doe ratios in the early 2000s (Cox et al. 2005) the population-weighted mule deer fawn-to-doe ratio decreased slightly from 62 fawns per 100 does in 2003 to 61:100 in 2009. When black-tailed and white-tailed deer fawn-to-doe ratios were included the population-weighted fawn-to-doe ratio decreased to 49:100. The large deviation when all deer are included was driven by 38 fawns per 100 does in the estimated 2.8 million white-tailed deer in Texas. The deer fawn-to-doe ratios ranged from 9:100 in Arizona white-tailed deer to 136:100 in South Dakota white-tailed deer. Not surprisingly, all states or provinces that saw a decrease in fawn-to-doe ratios from 2003 to 2009 also saw a decrease in the overall population estimate. South Dakota saw a decrease in their overall population estimate for mule and white-tailed deer despite fawn-to-doe ratios over 100:100 for both species.

The overall population estimate for Rocky Mountain elk from responding states and provinces was approximately 999,000 in 2009 (Figure 4). This was a 1.2% decrease in the population estimate from 2003. When Roosevelt and tule elk were included with Rocky Mountain elk the overall population estimate was 1.1 million elk. This was a 0.6% increase in the population estimate from 2003. Washington was not included in the Rocky Mountain elk comparison because their estimate included Roosevelt elk.

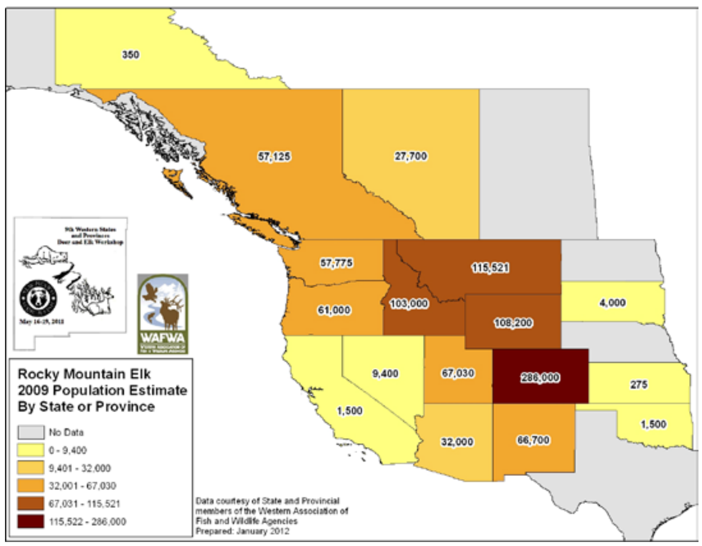

Figure 4. Rocky Mountain elk population estimate by state or province for 2009. The estimate for WA included Roosevelt elk. The estimates for BC, CA, and OR did not include Roosevelt elk. Subspecies for YK was reported as *Cervus elaphus manitobensis*.

Overall trends in total elk population estimates (Figure 5) were more stable than for deer (Figure 3) from 2000 to 2009. South Dakota reported the largest decrease in elk population from 2003 to 2009, but the 2009 estimate was larger than the 2005 estimate. This suggests the elk population in South Dakota is rebounding from the dramatic population decrease between 2003 and 2005. Alberta, Idaho, Montana, New Mexico, and Oklahoma all reported slight decreases in total elk population estimates. All other responding states and provinces reported stable or increased population estimates in 2009.

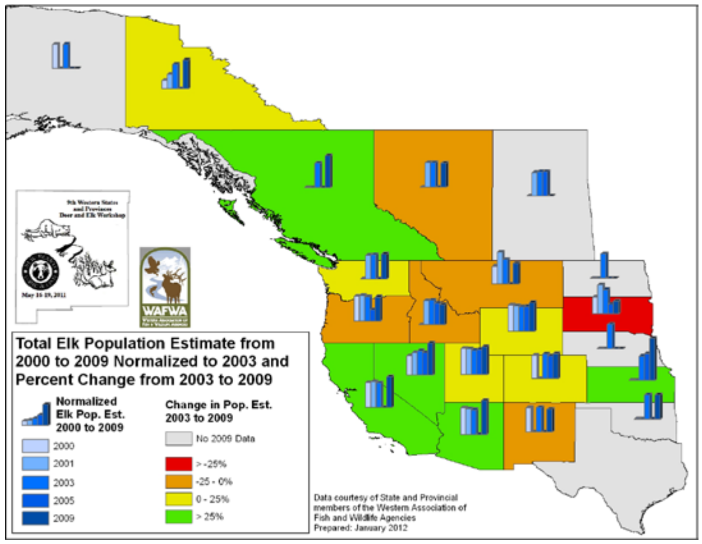

Figure 5. Total elk population estimate by state or province from 2000 to 2009 relative to 2003, and percent change from 2003 to 2009. Combined Rocky Mountain, Roosevelt, and tule elk population estimates.

Following decreases in mean Rocky Mountain elk calf-to-cow ratios from the 1990s to 2000s (Cox et al. 2005), the population-weighted Rocky Mountain elk calf-to-cow ratio was 36:100 in 2009. This may indicate an overall stabilization of an elk population that was expanding in the 1980s and 1990s. When Roosevelt and tule elk calf-to-cow ratios were included the population-weighted elk calf-to-cow ratio decreased slightly to 35:100.

Although most population estimation models use buck-to-doe or bull-to-cow ratios to some degree (Bender and Spencer 1999), I did not gather them here as they are extremely variable metrics heavily dependent on survey methodology and timing, which is not consistent across the West. Their utility as a useful metric in the state and provincial status report, without a measure of precision, is negligible.

<u>Harvest</u>

Assessing harvest information and trends by state or province was more difficult than population information and trends because there was less consistency with data collection and reporting. Many states and provinces were not able to differentiate the harvest numbers as finely as requested. In several instances, multiple animals were harvestable under one hunting license with multiple weapons. As a result all weapon types and species (or subspecies) were combined for deer and elk, unless otherwise specified.

Of the estimated 8.4 million deer, 1.2 million were harvested in 2009 (Figure 6). This was a 7% decrease in harvest from 2003 for responding states and provinces, but a 5% increase from 2000 for states or provinces with data in both years (Figure 7).

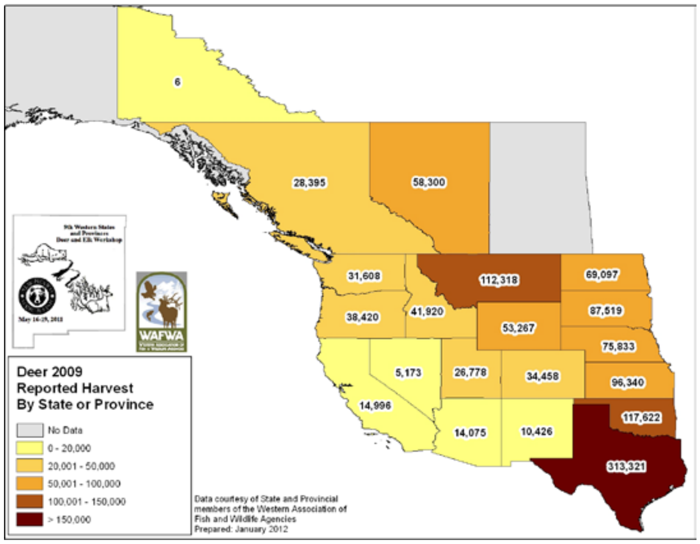

Figure 6. Total deer harvest by state or province for 2009. Combined black-tailed, mule, and white-tailed deer harvest information. Combined rifle, muzzleloader, and archery; and male and female harvest.

Many states or provinces that primarily consist of black-tailed and mule deer continued to report decreased harvest numbers, while most of the Great Plains states reported increased harvest numbers for all deer (Figure 7). Larger increases were reported for the white-tailed deer portion of the harvest than for black-tailed or mule deer. California, North Dakota, and Texas reported the largest declines in harvest of all responding states or provinces from 2003 to 2009, but California and North Dakota both reported large increases in harvest numbers in 2003 compared to previous years. The declines in harvest in California and Texas follow declines in overall population estimates (Figure 3).

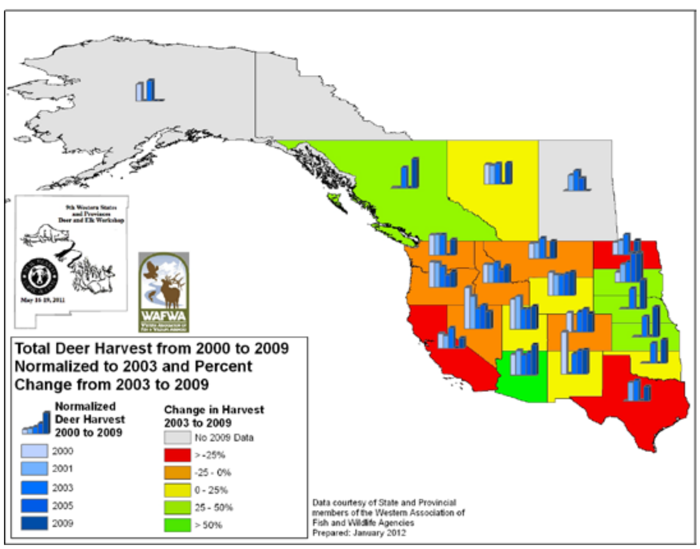

Figure 7. Total deer harvest by state or province from 2000 to 2009 relative to 2003, and percent change from 2003 to 2009. Combined black-tailed, mule, and white-tailed deer harvest information. Combined rifle, muzzleloader, and archery; and male and female harvest.

Of the estimated 1.1 million elk, 170,000 animals were harvested in 2009 (Figure 8). This was a 16% decrease in harvest from 2003 for responding states and provinces, and an 11% decrease in harvest from 2000 (Figure 9). Although 11 of 19 responding states or provinces reported an increase in elk harvest from 2003 to 2009, their harvest numbers were not substantial enough to offset the larger decreases in the other 8 states or provinces (e.g. the 11 increasing states or provinces reported an increase of 10,772 elk harvested, while Colorado reported 21,040 fewer elk harvested).

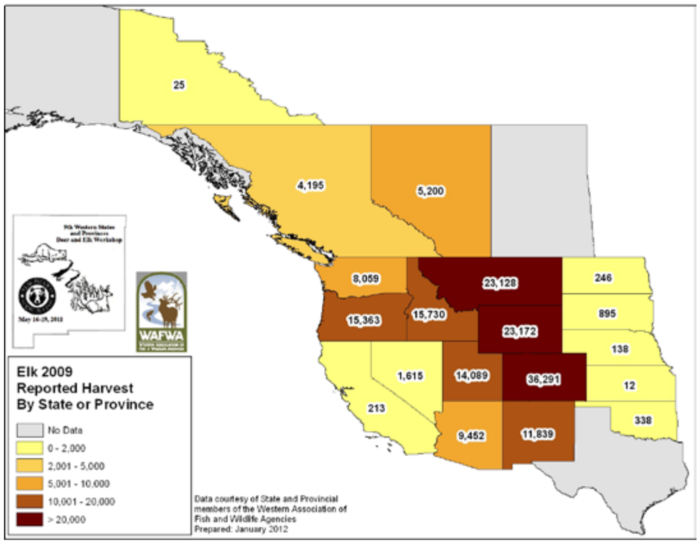

Figure 8. Total elk harvest by state or province for 2009. Combined Rocky Mountain, Roosevelt, and tule elk harvest information. Combined rifle, muzzleloader, and archery; and male and female harvest.

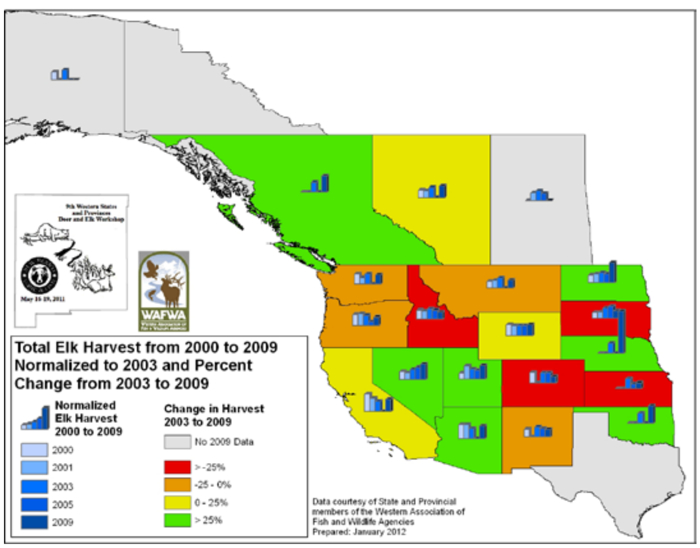

Figure 9. Total elk harvest by state or province from 2000 to 2009 relative to 2003, and percent change from 2003 to 2009. Combined Rocky Mountain, Roosevelt, and tule elk harvest information. Combined rifle, muzzleloader, and archery; and male and female harvest.

Hunter Information

Mandatory harvest reporting for deer and elk varied by state or province (Figure 10). Fourteen of 20 respondents required some type of harvest reporting, of which 10 required harvest reports for deer and elk, 3 required harvest reports for elk only, and 1 required harvest reports for some of their limited entry hunts. Colorado Division of Wildlife performs a variety of surveys to gather pertinent information from a sample of their hunters, but does not require harvest reporting.

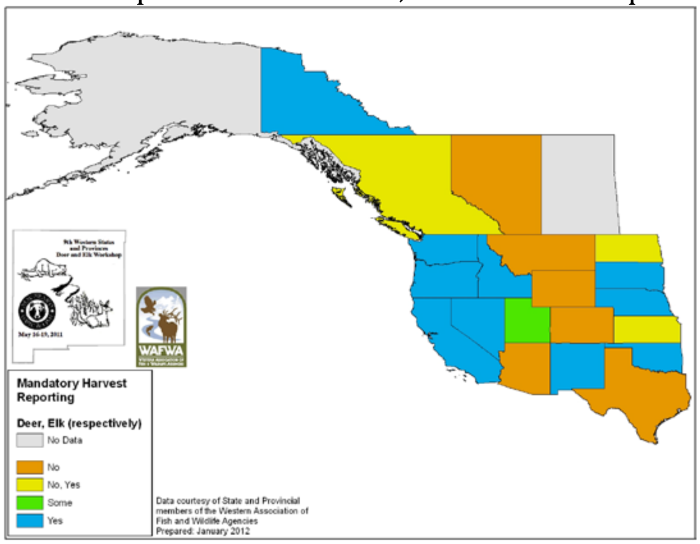

Figure 10. Mandatory harvest reporting requirements by state or province for deer and elk

The ability to harvest multiple animals within a single license year also varies by state or province (Figure 11). States or provinces with limited elk populations generally do not allow the harvest of multiple elk within a single license year. Only 4 of 19 responding states or provinces do not allow the take of multiple animals within a single license year for both deer and elk (Arizona, Neveda, New Mexico, and Yukon).

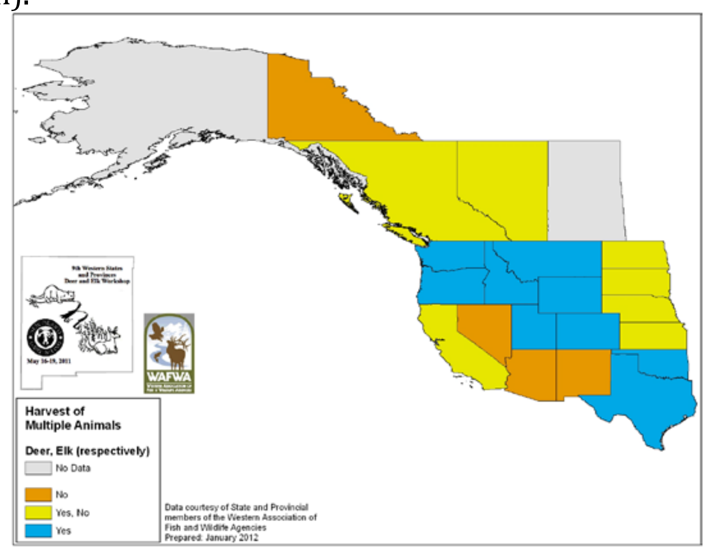

Figure 11. Harvest of multiple animals allowed in the same license year by state or province for deer and elk.

Nonresident hunter limits were extremely variable by state or province and limits were set by a percentage or a specific number of licenses. Those agencies that limited nonresident hunting by a percentage varied from 1–35%, and some varied within a state or province depending on the type of hunt. In general, those states or provinces with limited elk populations restricted nonresident hunting of elk, many not allowing nonresident elk hunting at all.

States and provinces were more willing to provide special opportunities for youth deer hunters (Figure 12) than they were for youth elk hunters (Figure 13). This follows the more structured pattern for elk hunting in states and provinces with smaller elk herds and limited harvest opportunities.

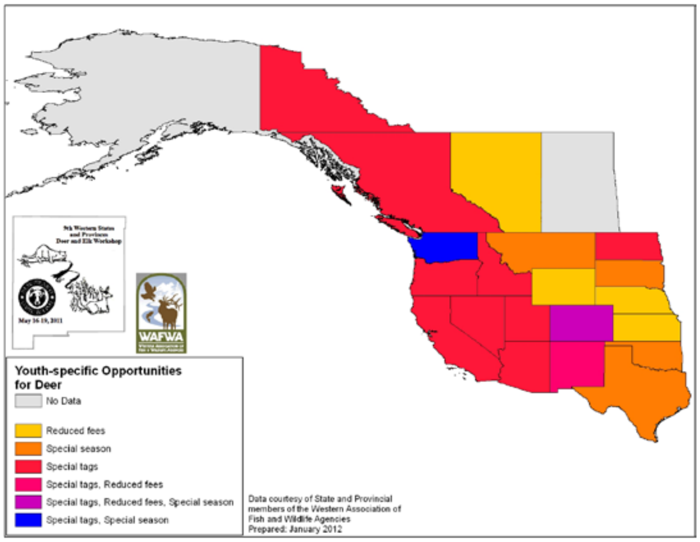

Figure 12. Type of youth opportunity available by state or province for deer.

Hunt management was dominated by opportunity over quality in most states or provinces. Arizona, Idaho, Nevada, and Wyoming reported quality and opportunity hunt management as approximately equal. Texas was the only respondent that reported a desire for more quality over opportunity hunt management. Despite the overwhelming desire for opportunity, most states or provinces provided some type of quality hunt structure through license number restrictions, antler point restrictions, or hunt timing.

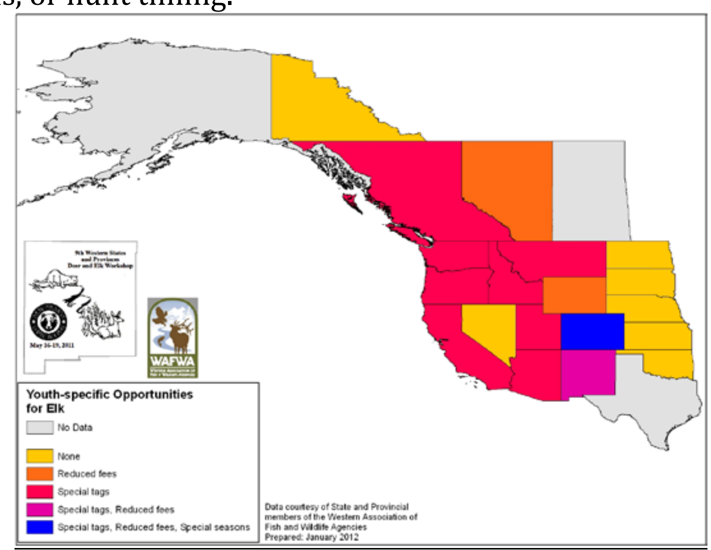

Figure 13. Type of youth opportunity available by state or province for elk.

Predators

Twelve of 23 states or provinces have wolves, although Alaska and Saskatchewan did not respond to the questionnaire (Figure 14). Arizona, New Mexico, Oregon, and Washington have yet to realize any impacts to their deer or elk herds attributable to wolves, although all have small wolf populations. Those states or provinces with larger wolf populations have realized impacts to their deer or elk populations, and Alberta, Idaho and Montana have adjusted license numbers for deer or elk following wolf impacts (Wyoming did not provide an answer to this question).

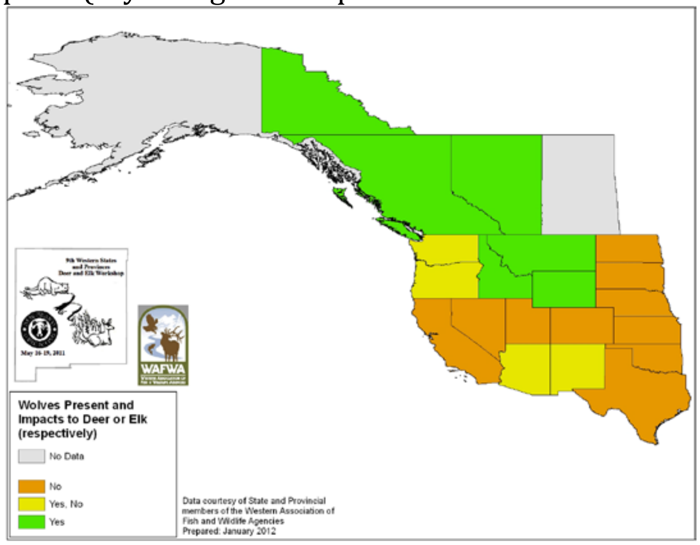

Figure 14. Presence of wolves and impacts to deer or elk populations by state or province.

Idaho, Nevada, Oregon, Utah, and Wyoming all reported that state-sponsored predator control programs had been implemented as an attempt to increase deer or elk population parameters. Idaho, Nevada, and Utah have programs specifically targeting increasing deer populations primarily through coyote removal and none of the programs have resulted in changes to deer population parameters. Idaho and Oregon have programs specifically targeting increasing elk populations and have increased calf survival through additional bear and cougar harvest. Wyoming did not specify deer or elk, but noted they have not seen a measurable response.

Chronic Wasting Disease

Chronic wasting disease (CWD) has been a growing burden on wild cervid populations expanding from 12 counties in the USA in 2000 to 111 counties or municipal districts in the USA and Canada in 2011 (National Wildlife Health Center 2011). Hunter harvest and targeted sampling of sick animals has helped with detection of CWD in wild cervid populations in several states or provinces (Figure 15). Generally, states or provinces affected by CWD or adjacent to an area with CWD in wild populations spend more money on monitoring for the disease than other states or provinces (Figure 15). Chronic wasting disease has been detected in captive herds in Montana and Oklahoma, but has not yet been detected in the wild in either state.

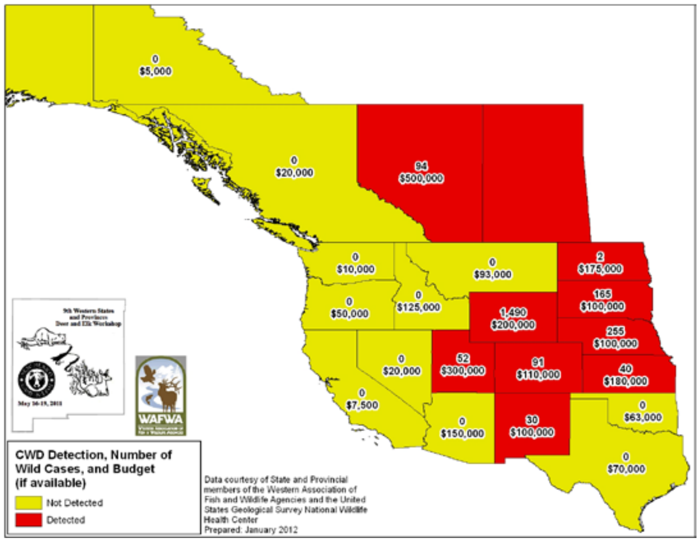

Figure 15. Chronic wasting disease (CWD) detection, number of wild cases, and detection budget by state or province.

Many states or provinces have no restrictions on the transportation of CWD-infected animals or parts out of infected areas (Figure 16). New Mexico and Wyoming were the only respondents with exportation restrictions, while most of the states that have not detected CWD have importation restrictions. Yukon has voluntary importation restrictions. Transportation restrictions do not impact portions of the animal that do not contain nervous tissue (e.g. processed meat, clean skull plates, hides, taxidermied mounts).

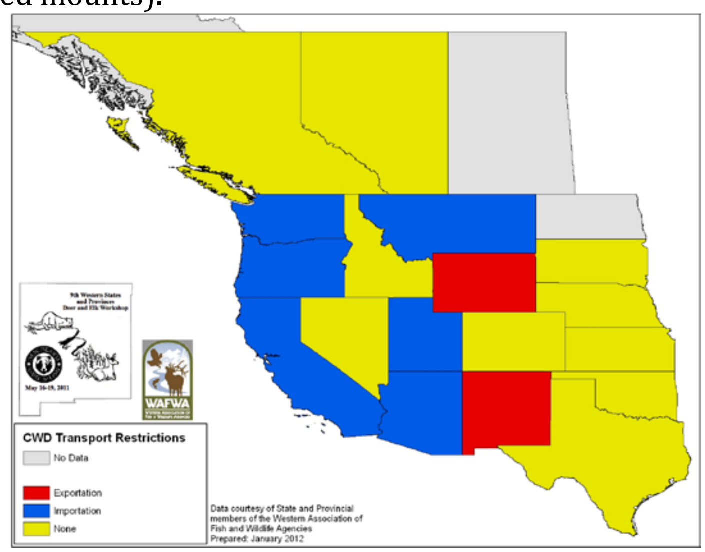

Figure 16. Chronic wasting disease (CWD) transportation restrictions by state or province.

<u>Habitat</u>

The most commonly identified threat to deer and elk populations in western North America was some type of habitat deficiency. Specifically, habitat loss and fragmentation impact deer and elk through excessive grazing, oil and gas development, urbanization, road building, and conversion of lands to agriculture; forest succession through fire suppression and limited timber harvesting. Predation, disease, and weather were included as major threats to deer populations. Social acceptance by cattle growers and farmers was an additional hurdle to elk populations in several states and provinces.

Overall, respondents felt the aforementioned impacts to deer and elk populations could be mitigated. Habitat enhancement and land use planning are possible solutions to forest succession and urban development. Increasing harvest on predators may provide benefit to some cervid populations. However, disease and weather do not have direct solutions.

Most states and provinces coordinate work with federal agencies on habitat improvement projects that may provide a benefit to deer or elk. Efforts focus on forest thinning, prescribed fire, water development, grazing management, and invasive species control. Each agency takes a different role whether it is design and technical input, funding, people on the ground, or some combination of all three. Collaborative work runs into hurdles, but mostly funding issues or conflicts with the US National Environmental Policy Act. Those that do not work with federal agencies (i.e. Alberta, California, Nebraska, North Dakota, Texas, and Yukon) run into a different suite of issues, such as limited federal ownership and extreme variation in management objectives between state and federal agencies.

Literature Cited

Bender, L. C. and R. D. Spencer. 1999. Estimating elk population size by reconstruction from harvest data and herd ratios. Wildlife Society Bulletin 27:636-645.

Carpenter, L. H. 1997. Deer in the West. Pages 1-10 *in* Proceedings of the 1997 deer/elk workshop, Rio Rico, Arizona. J. C. deVos, Jr., editor. Arizona Game and Fish Department, Phoenix.

Cox, M., T. Wasley, and J. Copper. 2005. Status and trend of population and harvest of deer and elk in western North American, 1970-2003. Pages 56-76 *in* Proceedings of the 6th western states and provinces deer and elk workshop. M. Cox, editor. Nevada Department of Wildlife, Reno.

Heffelfinger, J. R. and T. A. Messmer. 2003. Introduction. Pages 1-11 *in* Mule deer conservation: Issues and management strategies. J. C. deVos, Jr., M. R. Conover, and N. E. Headrick, editors. Berryman Institute Press, Utah State University, Logan.

National Wildlife Health Center. 2011. Distribution of chronic wasting disease in North America. http://www.nwhc.usgs.gov/images/cwd/cwd_map.jpg Accessed 15 April 2011.

Unsworth, J. W., D. F. Pac, G. C. White, and R. M. Bartmann. 1999. Mule deer survival in Colorado, Idaho, and Montana. Journal of Wildlife Management 63:315-326.

Appendix A: Questionnaire

State or Province:
Agency:
Report Submitted By:
Email:
Phone:

Survey Information

Survey Methodology	Method (Ground, Fixed-wing, or Helicopter)
Deer	
Elk	

Survey Period	Month(s)
Deer	
Elk	

Comments:

Population Information

If population estimates are on a pre-hunt basis, calculate a post-hunt estimate by subtracting estimated harvest and wounding loss. Report specific wounding loss rates in the Comments. If no specific wounding loss information is available, use 10% and 15% of harvest as wounding loss rates for deer and elk, respectively.

2009 Post-hunt Population Estimate	Mean	Range
Black-tailed Deer		
Mule Deer		
White-tailed Deer		
Rocky Mountain Elk		
Roosevelt Elk		
Tule Elk		

Comments:

——————————

If population objectives are on a management-unit basis, enter the sum of the management unit objectives. If population objectives are on a pre-hunt basis, calculate the post-hunt objective by subtracting the harvest objective adjusted for wounding loss (as noted above).

Post-hunt Management Objective	Mean	Range
Black-tailed Deer		
Mule Deer		

White-tailed Deer		
Rocky Mountain Elk		
Roosevelt Elk		
Tule Elk		

Comments:

———————————

Observed Young per 100 females	Average	High	Low
Black-tailed Deer			
Mule Deer			
White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

———————————

Harvest

Is harvest reporting mandatory for deer or elk in your State or Province?

Deer: Yes or No

Elk: Yes or No

If all subspecies are combined, please indicate the approximate proportion of each in the appropriate comment space.

2009 Antlered Harvest	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			
White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

2009 Antlered Success Rate	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			

White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

$$AntleredSuccessRate = \frac{AntleredHarvest}{AntleredHunters + \left(EitherSexHunters * \frac{ESAntleredHarvest}{TotalESHarvest} \right)} * 100$$

Comments: ___________

2009 Antlerless Harvest	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			
White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

2009 Antlerless Success Rates	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			
White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

$$AntlerlessSuccessRate = \frac{AntlerlessHarvest}{AntlerlessHunters + \left(EitherSexHunters * \frac{ESAntlerlessHarvest}{TotalESHarvest} \right)} * 100$$

Comments: ___________

Average Hunter Days	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			

White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

<u>Hunter participation</u>

Can a hunter legally harvest >1 animal in a given license year in your State or Province?

Deer: Yes or No

Elk: Yes or No

Has the hunt structure in your State or Province changed drastically since 2003 (e.g. over-the-counter to draw-only)? Yes or No (If for 1 species only, indicate species ____________)

Does your Agency limit the number of non-resident hunters by statute or rule? Yes or No

If so, what percentage ______%

How many total youth-only opportunities are available in your State or Province?

Deer: ______________________________

Elk: _______________________________

Indicate the percentage of non-resident hunters in parentheses for each entry if different from the aforementioned percentage.

Antlered Hunter Numbers	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			
White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

Either-sex Hunter Numbers	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			
White-tailed Deer			

Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

Antlerless Hunter Numbers	Rifle	Muzzleloader	Archery
Black-tailed Deer			
Mule Deer			
White-tailed Deer			
Rocky Mountain Elk			
Roosevelt Elk			
Tule Elk			

Comments:

<u>Wolves</u>

Does your State or Province have wolves? Yes or No

Have you seen any impacts to deer or elk populations that can be attributed to wolves? Yes or No

If so, have you had to adjust license numbers as a result of these impacts? Yes or No

What approaches have you used, if any, to deal with public concerns about wolf impacts to deer or elk populations?

<u>Chronic Wasting Disease (CWD)</u>

Does CWD occur in the wild in your State or Province?

If so, how many cases have been confirmed to date? ____________________

How does your Agency pursue surveillance of CWD (e.g. hunter harvest, live sampling)? ______________________________

Approximately how much does your Agency spend on CWD surveillance in a given year (Canadian provinces please report in Canadian dollars)? ________________________________

Has your Agency increased or decreased license numbers in response to CWD? Increased or Decreased or N/A

Does your Agency restrict the movement of harvested animals (or parts) out of CWD-infected areas?

If so, please specify restrictions. ____

Habitat Enhancement

Is your Agency actively involved with deer or elk habitat enhancements on Federal lands? Yes or No

If so, what specific work is being done (e.g. fire, forest thinning, water development) and what is the average size (in acres) of most projects? __________________________________

At what level is your Agency involved in the habitat enhancement work on Federal land (e.g. design, funding, biologist working on the ground)? __________________

What are the biggest hurdles your State or Province has with completing projects and restoring habitat on Federal lands? _______

____

Private-land Programs

Does your Agency have a program that provides monetary compensation for private landowners to grant access to public deer/elk hunters? Yes or No

If so, name of program: _____

Approximately how many acres of private land have been opened to public deer or elk hunting in your State or Province through these programs? *Please indicate individual species acreage separately if available* ____

Does your Agency currently provide any type of incentive to private landowners engaging in habitat enhancement/restoration projects targeting deer or elk?

____

Hunt Management

Does your Agency have specific areas that are managed more for Quality (i.e. trophy or older-age-class males) than for Opportunity (i.e. more emphasis on hunter participants rather than increase age structure of males)? Yes or No

If so, what proportion of your deer or elk populations is managed as Quality areas?

____

What management strategies (e.g. license number restrictions, antler point restrictions) does your Agency use to implement quality management? _________________________

Do you feel the majority of the hunters in your State or Province lean towards Quality or Opportunity hunt management? Quality, Opportunity, or N/A

Predator Control

Does your Agency currently implement any kind of formal predator controls, specifically to increase deer or elk numbers or specific parameters such as fawn or calf survival? Yes or No

If so, what types of programs have been implemented? ___________

Have you seen a measurable response in these programs? Yes or No

If so, which parameters have responded (e.g. population size, survival rates)? ____

Is predator control controversial in your State or Province? Yes or No

If so, is predator control so controversial that it has altered management decisions? Please elaborate ____

Major Threats to Populations

What do you feel are the biggest threats to maintaining deer or elk populations in your State or Province? _________________________

Do you feel these impacts can be, or are they, currently mitigated in any way? ____

Spread Of Chronic Wasting Disease: Did Mule Deer Draw The Short Straw?

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Abstract: Chronic wasting disease (CWD) is an infectious and fatal prion disease of cervids now found in over 20 states or provinces across the United States and Canada. In Canada, CWD was detected in wild deer in the prairie regions of Saskatchewan (SK) in November 2000 and in Alberta (AB) in September 2005, and has been increasing steadily ever since in both provinces. Active surveillance in AB since 1998 detected 94 deer with CWD (85 mule deer, 9 white-tailed deer). The two deer species are sympatric in affected areas, and reasons for the higher prevalence in mule deer in both AB and SK are not known. We assess information on behavioral and demographic differences between the species to try to understand why the CWD occurrence is predominantly in mule deer in the prairie-parkland system, and what this tells us about CWD transmission and spread. In terms of behavior, home range sizes, daily movements, and migration rates were similar, but mule deer exhibited more concentrated spatial distribution, and had larger group sizes, which modeling shows increased contact rates. We also show how higher rates of reproduction in white-tailed deer may contribute to lower CWD prevalence in white-tailed deer compared to mule deer in sympatric species. We discuss the implications of these finding for comparing prevalence rates among cervid species and for CWD management in this region.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:65

Mule Deer Habitat Selection In Nevada: Effects Of Introduced Elk

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Abstract: Competition for spatial and temporal resources between sympatric species of ungulates has been well documented in the wildlife literature. Previous studies have examined both the spatial and dietary differences between populations of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) that have co-existed for many years; however, the short-term effects of introduced competition has not been tested. We hypothesized that mule deer would be strongly affected in both spatial distribution and selection of different habitat types after the introduction of a larger and highly gregarious competitor. We used geospatial statistics and generalized linear models to analyze helicopter survey data of mule deer and elk in eastern Nevada to compare the distribution and use of winter ranges before and after elk introduction. Additionally, we quantified relative changes in habitat quality using Normalized Difference Vegetation Index (NDVI) based on satellite imagery of vegetative cover. Our results suggest that deer selected habitats differently and exhibited a shift in use of space during winter, after the introduction of elk. Deer partitioned space differently by using lower elevations, different slope-aspects, and a more southeast distribution. Deer in our study area also selected habitat components with less mountain mahogany compared to pre-elk introduction levels. The observed results may help to evaluate the effects of future elk introductions on mule deer populations throughout Nevada.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:66

Development Of An Elk Sightability Model For The Black Hills, South Dakota

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Abstract: Elk (*Cervus elaphus nelsoni*) are important in the Black Hills of South Dakota because they are a prized game species, but they also have negative impacts on private landowners through crop depredation. As a result, elk abundance is essential information required to successfully manage this population. Few studies have evaluated aerial survey methodology for visibility bias in this region. We developed a sightablility model that is calibrated to the conditions specific to the elk population that resides within the Black Hills of South Dakota. Sightability trials of radio collared individuals were conducted during January and February 2009, 2010, and 2011 using a Robinson R-44 helicopter with 2 observers and the pilot. We observed 89 out of 154 observations of groups containing ≥1 radio-collared elk, for a sightability rate of 57.5%. Logistic regression was used to model covariates and information-theoretic methods were used to determine important factors. The best model for estimating sightability was vegetation (%) + group size + snow cover (%). Model weight (ω_i = 0.840) and model fit (ROC = 0.819) was high relative to other models (e.g., vegetation cover (%) + Group size; ω_i=0.154, ROC = 0.802). Current progress is being made to cross-validate population estimates derived from the developed model with estimates derived by other methods including mark-resight. Implementation of advanced methods of population estimation with increased precision will allow sound management decisions to be made for elk in the Black Hills for all stakeholders.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:67

A Sightability Model For Aerial Surveys Of Mule Deer In Western Texas

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Abstract: Effective wildlife management requires knowledge of population size and composition. Helicopters are used for surveying wildlife populations because they allow large areas to be surveyed quickly. The value of raw survey data is limited due to the failure to count all animals. Resulting trend data are not as valuable as unbiased population estimates in setting regulations and assessing deer management goals. Our objectives were to quantify factors affecting visibility of mule deer during helicopter surveys, and develop a sightability model to estimate mule deer (*Odocoileus hemionus*) population size in Texas. We fitted thirty-six deer with GPS collars on each of 6 sites covering distinct habitat types of mule deer range including the Trans-Pecos and Panhandle regions. Upon observation of a group; group size, sex, age class of each deer, whether it was collared, dominant vegetation type, activity, sunlight conditions, terrain, and perpendicular distance from the transect were noted by observers. To obtain comparable data for marked deer not seen, we used remote sensing based on deer's GPS locations during the survey. We modeled group size from a subsample of missed deer. We used logistic regression to derive a sightability model using variables that influenced sightability of deer. Population size estimated using sightability models averaged 97.0% of the mark-resight estimates from MARK. Group size, activity, terrain, and distance from the transect had the largest effect on sightability. Implementing sightability models will improve the information available for mule deer management decisions in Texas.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:68

Recovery And Monitoring Of A Small Western Washington Elk Population

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Abstract: After the Nooksack elk herd declined from about 1,700 elk to possibly as few as 300 elk, the Washington Department of Fish and Wildlife and the Pt. Elliot Treaty Tribes collaborated to recover the herd. In 1997, a joint harvest moratorium was invoked. In fall 2003 and fall 2005, elk were helicopter drive-trapped from the Mt. St. Helens elk herd and translocated to the Nooksack to enhance recovery. A total of 39 elk (2003) and 52 elk (2005) were translocated, mostly adult cows. We radiocollared elk that were translocated and also helicopter darted and radiocollared native Nooksack elk to monitor survival and to support population monitoring. We conducted helicopter survey trials during spring 2006-2009 to collect data for developing a sightability model and to support mark-resight estimates. We used logistic regression and model selection (AICc) to identify a 3-covariate model to predict elk sightability. We also generated mark-resight estimates using the logit-normal mixed effects (LNME) model and implemented the model in Program MARK. Although diagnostics suggested our sightability model effectively modeled sighting trial data, derived population estimates were low relative to mark-resight estimates and minimum known alive estimates. We believe availability bias was a substantial issue limiting the sightability model application. LNME estimates appeared reasonable given population modeling and minimum known alive estimates. LNME model estimates and sightability model estimate did yield very similar estimates of trend (λ). Results suggested the population had recovered to approximately 700 elk by 2006 and supported reinitiating limited entry bull harvests in the fall of 2007.

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:69

An Evaluation Of Survey Techniques For Desert Mule Deer In West Texas

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Abstract: Few studies have evaluated survey techniques for mule deer (*Odocoileus hemionus*) in west Texas. For wildlife agencies and private landowners to adequately manage mule deer, accurate population and herd composition estimates are essential. The goal of this study was to evaluate survey techniques commonly utilized or recommended in west Texas and find which of these yields the most accurate, precise, and effective population and herd composition estimates. The methods involved in this study included (1)conducting helicopter surveys, spotlight surveys, and roadside (day-time) surveys on 3 different study sites, (2)apply distance sampling to each ground survey technique, (3)evaluate survey techniques by comparing population and herd composition estimate data, and (4)compare distance sampling estimates to traditional index methods. A total of 17 helicopter surveys, 15 spotlight surveys, and 15 roadside surveys was conducted on 3 study areas. Distance sampling was applied simultaneously with traditional methods while surveys were being conducted. Survey data that was compared between each survey technique were mule deer density estimates, doe: buck ratio estimates, and fawn: doe ratio estimates. Helicopter surveys were most precise for deer densities and herd composition estimates when compared to spotlight and roadside surveys. Roadside surveys consistently yielded a low deer density, however, resulted in similar herd composition estimates as helicopter surveys. Spotlight surveys yielded similar deer density estimates as helicopter surveys, however, spotlight surveys were typically the most variable in herd composition estimates when compared to the other survey techniques. Distance sampling consistently yielded a higher deer density than surveys results calculated using traditional statistical analysis. Data from this study will provide wildlife agencies and private landowners in west Texas more information on establishing survey techniques that are more precise and accurate for mule deer population and herd composition estimates.
Key Words: *Density estimation, desert mule deer, distance sampling, helicopter surveys, herd composition estimation, roadside surveys, spotlight surveys, survey techniques, Trans-Pecos, Texas,*

WESTERN STATES AND PROVINCES DEER AND ELK WORKSHOP PROCEEDINGS 9:70-85

Mule deer (*Odocoileus hemionus*) inhabit west Texas as well as southern portions of New Mexico, Arizona, and California, and southward into the Mexican states of Sonora, Baja California, Chihuahua, Coahuila, and Durango (Heffelfinger 2006). Mule deer occupy nearly all types of habitats in the Trans-Pecos from elevations ranging from 762 m to 2500 m. Large private landholders have taken advantage of this precious economic commodity and are considered of great economic importance as a big game animal in the Trans-Pecos area (Davis and Schmidly 1994).

Since the arrival of the Managed Lands Deer Permit (MLDP) program and other similar programs, the need to obtain the most precise and accurate population estimates has never been more important. To manage deer herds effectively and to continue to capitalize on this resource financially, land managers must conduct periodic surveys to obtain population size, but more important herd composition and characteristics (Richardson 2002). Deer harvest is the primary factor affecting deer herds in the Trans-Pecos and is one of the few factors which managers actually have control, it is vital that survey techniques are as precise and accurate as possible (Richardson 2002). Because of the little information on mule deer management relative to the Trans-Pecos, ecological importance, and continuing economic significance; research is warranted specific to mule deer in west Texas.

One of the most difficult tasks that face wildlife biologists and land managers is estimating the size of a wildlife population. Reliable estimates of population size and herd composition are required to develop and implement proper conservation policy and management protocols for large mammals (Gelatt and Siniff 1999). Without precise and accurate population estimates, management decisions such as harvest rates, sustainability, population protection, and control are based on faulty data that can potentially lead to long-term, detrimental effects on a wildlife population.

Few studies have evaluated mule deer survey techniques specific to west Texas. By evaluating these survey techniques, this information will provide wildlife managers and game agencies a better understanding of the strengths and weaknesses associated with each survey method. By knowing the downfalls of each technique, this allows wildlife biologists and agencies to create and implement strategies to prevent inaccurate data. Each survey method has advantages and disadvantage and may function differently from each location or situation. Lancia et al. (1994) suggests when evaluating the effectiveness of survey techniques that population and herd composition estimates (and their accompanying variability) be compared using several independent techniques. Thus, we evaluated helicopter surveys, spotlight surveys, roadside (day-time) surveys, and applying distance sampling to both spotlight and roadside surveys. The goal of this research was to compare population and herd composition estimates between each survey method on 3 separate study sites in the Trans-Pecos ecological region of west Texas. Our objectives were to (1)conduct helicopter, spotlight, and roadside surveys to estimate herd composition and population of each study site (2)compare population and herd composition estimates between each survey technique and study site, (3)compare the application of distance sampling to spotlight and roadside surveys to traditional statistical analysis. Comparing survey data from each survey technique will help determine which survey method is the most precise, accurate, and effective in estimating mule deer population parameters under certain conditions.

Study Area

This study was conducted in the Trans-Pecos ecological region of Texas on 3 separate study sites. These sites are Sierra Diablo Wildlife Management Area (SDWMA) located near Van Horn, Texas; Boracho Peak Ranch (BPR) located near Kent, Texas; and the Miller Ranch located near Valentine, Texas. The regional climate for these sites is semi-arid with cool-dry winters and hot-dry summers with most of the precipitation occurring July to October in heavy monsoonal rains. The average annual precipitation is <30.5 cm. The Trans-Pecos ecological region consists of 7.3 million ha where the Pecos River serves as the northeastern border and the Rio Grande serving the southern border (Hatch et. al 1990). This ecological region contains a variety of habitat types and vegetation ranging from desert valleys and plateaus to wooded mountain slopes. Elevations throughout the Trans-Pecos region fluctuate from 762-2,667 m. The variable elevation throughout the region influences different climatic conditions affecting the types of habitats, soils, and ecosystems. This scenario gives rise to an abundance and diversity of flora and fauna making this area one of the most ecologically diverse in Texas. The average annual temperature is 20.4° C with variations depending on elevation. Soil types of the Trans Pecos region vary from deep sands present along desert washes, gravel mulch in desert lowlands, and shallow, rocky soils present on slopes and mountains (Harveson 2007).

Sierra Diablo Wildlife Management Area (SDWMA) SDWMA was the first wildlife management area established in the state of Texas. It lies west of Texas Hwy 54, 60 km north of Van Horn, Culberson County, Texas. SDWMA serves as a study site and refuge for reintroduced desert bighorn sheep (*Ovis canadensis*). Because of this, SDWMA has restricted public access for the sensitive nature of desert bighorn sheep. SDWMA contains 4,704 ha with extremely rugged topography. The average elevation is 1,889 m, some 609 meters above the surrounding desert (Hodge 2000). The annual precipitation is <30.5 cm occurring in sporadic rainfall events mostly during the months July-October. Temperatures average near 20.4° C. Natural water sources consist in random limestone potholes holding little rainfall. Thus, TPWD has established artificial water sources across SDWMA. Vegetation at lower elevations of the study site consists of sotol-lechuguilla (*Dasylirion wheeleri*) (*Agave lechuguilla*) association common to the Chihuahua Desert (Hodge 2000). Yuccas (*Yucca spp.*) and junipers (*Juniperus spp.*) dominate the mid-level portions of the area with pinyon pines (*Pinus monophylla*), junipers (*Juniperus spp.*), and oaks (*Quercus spp.*) covering the higher elevation areas. Grass species that exist on SDWMA are gramas (*Bouteloua spp.*), bluestems (*Schizachyrium spp.*) and a variety of others (Hodge 2000).

Boracho Peak Ranch (BPR) The BPR is located 24.1 km east from Van Horn, Texas encompassing both Culberson and Jeff Davis counties. BPR consists of 40,241 ha with topography ranging from gently rolling hills to steep mountains with multiple canyons and washes. Average annual precipitation is 35 cm with the majority of precipitation occurring during the months of June-September. Habitat varies on the BPR between desert shrub-lands and desert grasslands providing a variety of different vegetation types. Typical plants occurring in abundance on the BPR include creosotebush (*Larrea spp.*), lechuguilla (*Agave lechuguilla*), yucca (*Yucca spp.*), and native grasses.

Miller Ranch (MR) The MR is located approximately 48 km southwest of Valentine, Texas on US Highway 90 in Jeff Davis County consisting 13,354 ha. The topography consists of gently rolling hills to steep slopes of the Sierra Vieja Mountains with canyons and washes interspersing the landscape. Habitats vary between desert grasslands to desert shrub-land. Portions of the ranch are covered with grama and bluestem grass species with alligator junipers (*Juniperus deppeana*) and Emory oak (*Quercus emoryi*) occurring in canyons and washes. Average annual precipitation rarely exceeds 35 cm. The annual temperature averages 20.4° C. A variety of fauna is abundant on the MR.

Methods

A total of 30 spotlight and roadside surveys were conducted on 3 separate study sites during January-April. Of the total 30 spotlight and roadside surveys conducted, 3 spotlight and 3 roadside surveys were conducted on the BPR. On the MR and SDWMA, a total of 6 spotlight surveys and 6 roadside surveys were conducted. Helicopter survey data was provided from another concurrent research project on the SDWMA and MR study sites. Survey routes were designed to sample all major habitat types proportionately of habitat types at each study site.

Helicopter Surveys A Robinson R44 was used to conduct helicopter surveys as described by Gray (2011). The timing of helicopter surveys were divided into 2 separate timeframes: morning and evening. The timing of these surveys reflected when temperatures were cooler and deer most active. Morning surveys were generally conducted between sunrise and 1100 hr. Evening surveys were conducted between 1500 hr to sunset. During the surveys, the helicopter maintained an altitude at about 15 m depending upon terrain and brush canopy. Flight speed was generally maintained at 73-80 kilometers per hour. The flight path consisted of north-south orientated transects equally spaced 200 m apart to cover 100% of the study area. A global positioning system (GPS) was utilized by the pilot to ensure the helicopter maintained correct survey transects to properly survey the area. The survey crew consisted of the pilot and 3 additional passengers during surveys. The crew member in the left front seat and right rear seats were the lead observers with the pilot serving as a secondary observer. The remaining crew member located in the left-rear seat recorded data. Mule deer were recorded in a transect belt of 100 m from the helicopter on either side. In addition, observers paid particular attention for radio-collared deer as well as the color combination of the ear tags. The width of the transect belt was multiplied by the length of the transects to determine the effective area observed. The area observed was then divided by the total number of deer detected providing an estimate of mule deer density. All helicopter survey data was presented as raw or corrected which included mule deer density, sex ratios, fawn crops, proportions of does and bucks observed, and average buck and doe sightability rates. Raw data was calculated using simple statistical analysis. Mule deer densities were calculated by dividing the observed area by the amount of observed deer (ha/deer). Sex ratios were calculated by dividing the number of does observed by the amount of bucks observed (No. does/No. bucks), Fawn crop percentages were calculated by dividing the number of fawns observed by the amount of does observed (No. fawns/No. does).

Spotlight Surveys A total of 15 spotlight surveys were conducted. On the BPR, 3 spotlight surveys were conducted along a 20.28 km survey route. On MR and SDWMA, a total of 6 spotlight surveys were conducted on survey routes totaling 21.24 km and 16.41 km respectively. The timing between each spotlight survey for a specific site was divided by at least 2–3 days. The survey guidelines followed Richardson's (2002) protocol. Once mule deer were observed, the following data was taken: sex, age, presence of radio-collars, and ear tag color. In addition, one observer used a laser rangefinder (Leopold Digital Rangefinding Binoculars RXB-IV) to retrieve the distance and direction of the observed deer from the vehicle. All survey data was recorded on a Garmin M5 PDA with CyberTracker software installed. The CyberTracker program was used to collect all survey data. The software also geo-referenced all deer observations. Mule deer observed were recorded regardless of distance from vehicle to enable us to compare data between traditional and distance sampling methods. All deer observed using the traditional method were recorded within a range not exceeding 300 m. For distance sampling, all observed deer were used for analysis. Prior to any surveys, visibilities were taken once on each survey route during daylight hours. Visibility estimates (distance that deer can be seen) were taken on both sides of the vehicle every 0.16 km to use in calculating observed area. If terrain or vegetation did not compromise visibility, a 300 m maximum distance (maximum distance of spotlight ability) was recorded. All other distances were taken by a laser rangefinder to improve accuracy. Once data was recorded, it was then placed into the following formula to determine area observed: [length of route (miles) x 1,760 yards/mile] x [avg. visibility right (yards) + avg. visibility left (yards)] divided by 4,840 square yards/acre = acres observed. Mule deer densities, sex ratios, fawn crop percentages, and others were estimated under the same assumptions as the helicopter survey raw data for traditional spotlight survey method. Distance sampling data was analyzed by using the computer software DISTANCE.

Roadside Surveys A total of 15 roadside surveys were conducted. Three roadside surveys were conducted on each survey route for each study site. These surveys were conducted on the same routes as spotlight surveys. Protocols used for spotlight surveys were followed for roadside surveys; however, roadside surveys were conducted during daylight hours. Roadside surveys were conducted either in the morning or evening. Morning surveys typically occurred following sunrise and ending 1–3 hours following start time. Evening surveys typically began 2–3 hours prior to sunset depending on the distance of the survey route. Visibility estimates remained the same since roadside surveys were conducted on the exact same survey routes as the spotlight surveys. Distance sampling data was analyzed using the computer program DISTANCE. ***Spotlight and Roadside Surveys – Distance Sampling.*** Distance sampling was applied to each of the 15 spotlight surveys conducted on all 3 study sites. Surveys were conducted in such a way to allow for traditional and distance sampling survey methods to both be implemented at the same time and later compared from survey results. Observers recorded every deer sighted regardless of the distance and direction of the observed mule deer for distance sampling. Once the surveys were completed, we separated the number of observations between traditional and distance sampling methods by counting only those deer observed >300 m for the traditional method. All deer observed regardless of distance were used for the distance sampling method and analyzed in DISTANCE using methods provided by Gundel (2009). Once the data was imported, a series of analysis were performed using 4 statistical tests. These tests included the Half Normal Cosine, Half Normal Polynomial, Hazard Rate Polynomial, and Hazard Rate Cosine. We selected the lowest Akaike's Information Criterion (AIC) of the 4 tests to serve as the population density (Buckland 1993).

Results

Helicopter Surveys

Sierra Diablo Wildlife Management Area Helicopter survey data was provided by concurrent studies on each study site. During a 1-month period, a total of 8 helicopter surveys were conducted on the SDWMA with 4 occurring in the morning and 4 in the evening. Surveys were separated approximately 1 week apart with morning and evening surveys being conducted on the same day. Mule deer densities ranged from 15.77 to 21.64. Helicopter surveys yielded the highest deer density estimate compared to spotlight and roadside surveys (Figure 1). In addition, helicopter surveys yielded the lowest doe: buck ratio compared to spotlight and roadside surveys conducted on the SDWMA (Figure 2). Helicopter surveys produced the only fawn: doe estimates of all the survey techniques implemented on SDWMA (Figure 3).

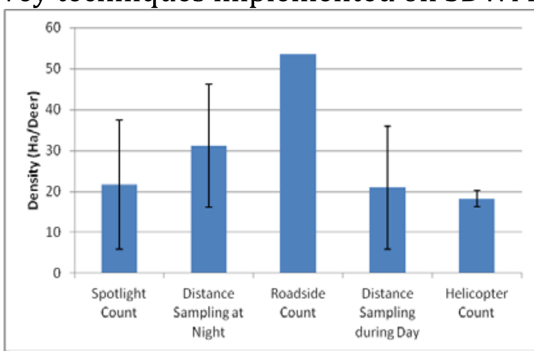

Figure 1. Mule deer density estimates of each survey technique on the SDWMA study site.

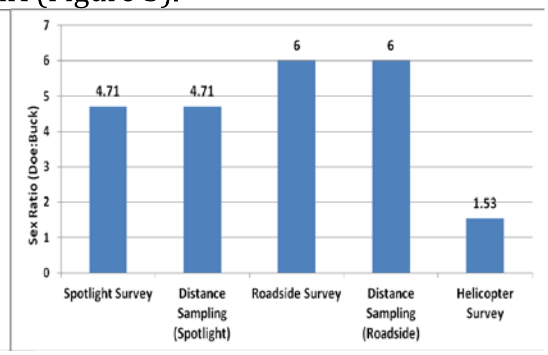

Figure 2. Doe: buck ratio estimates of each survey technique on the SDWMA study site.

Miller Ranch Similar to the SDMWA study site, helicopter surveys yielded the highest deer density of the survey techniques conducted on the MR site. (Figure 4) Raw deer densities ranged from 16.47 to 33.20. However, unlike the SDWMA survey results, the MR helicopter surveys did not yield the lowest doe: buck ratio with roadside surveys having a lower ratio (Figure 5). Fawn to doe ratios were similar to the SDWMA site, however, fawns were observed during spotlight and roadside surveys, but fawn: doe estimates remained relatively low on the MR site with estimates ranging from 0 to 0.15 (Figure 6). In addition, helicopter surveys yielded the lowest fawn: doe estimate among all of the survey techniques conducted on the MR (Figure 6).

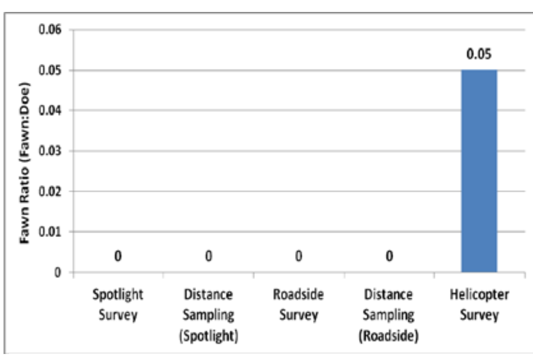

Figure 3. Fawn: doe estimates of each survey technique on the SDWMA study site.

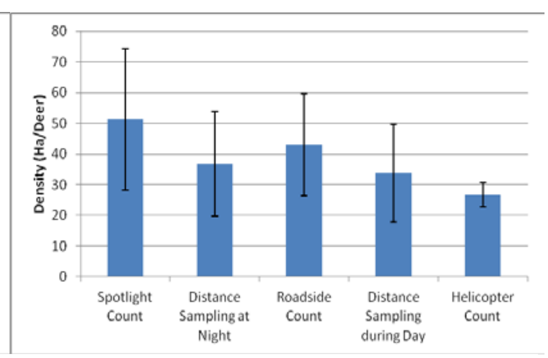

Figure 4. Mule deer density estimates of each survey technique on the MR study site.

Boracho Peak Ranch A total area of approximately 22434 hectares was surveyed flying a total of 1105.7 kilometers. For the BPR study site, only one helicopter survey was conducted. These surveys yielded similar herd composition estimates as spotlight and roadside surveys; however, since the area surveyed by helicopter was much larger than the study area on BPR (3541 ha), mule deer densities were considerably lower than the other implemented survey techniques (Figure 7). Despite helicopter surveys surveying a much larger area, herd composition estimates were quite similar between each survey technique (Figures 8 and 9).

Spotlight Surveys

Sierra Diablo Wildlife Management Area The SDWMA routes averaged 283.3 m with an observed hectare total 451.43 which covered approximately 13% of the study area. The distance sampling method yielded 43 total deer observations with an additional 23 deer observed beyond 300 m. Spotlight surveys on the SDWMA resulted in a total average of 7.17 deer with surveys ranging from 0 to 26 individuals. The total number of bucks observed was 7 accounting for 16% of total deer observed. Does accounted for the highest proportion of deer observed during spotlight surveys. Spotlight surveys yielded a total of 24 does observed accounting for 56% of the total deer observations with surveys ranging from 0 to 8 does. Fawn estimates were not calculated since no fawns were observed during spotlight surveys on the SDWMA study site (Figure 3).Spotlight surveys yielded total of 12 unidentified deer accounting for 28% of total deer observed. Unidentified deer averaged 3 per survey ranging from 0 to 7 individuals Deer density estimates for spotlight surveys yielded a similar density as helicopter surveys (Figure 1). Also, helicopter surveys yielded a lower doe: buck ratio estimate than the other survey techniques (Figure 2). In addition spotlight surveys yielded an overall total average of 0.43 deer per kilometer.

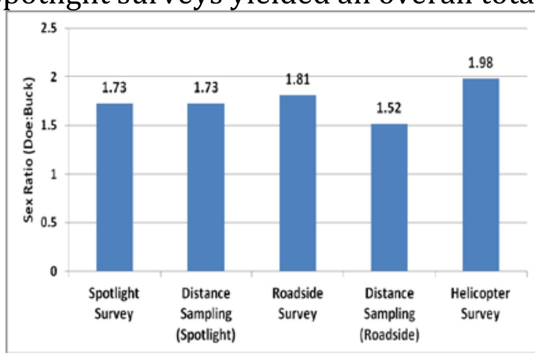

Figure 5. Doe: buck ratio estimates of each survey technique on the MR study site.

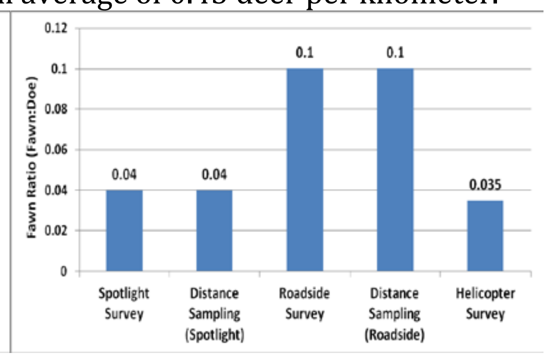

Figure 6. Fawn: doe estimates of each survey technique on the MR study site.

Miller Ranch The MR routes averaged 424.3 m with an observed hectare total of 872.95 which covered approximately 23% of the survey area. Surveys were conducted during the months of February and March with surveys being conducted approximately 1 week apart. An overall total deer observed on both survey routes resulted in 59 total deer observations with an additional 2 deer observed beyond 300 m. Spotlight surveys on the MR site resulted in an overall total average of 9.83 observations with one survey route averaging 9.7 and the other 10 ranging from 4 to 17 individuals. Of the total deer observed, bucks accounted for 25% of the total deer observations ranging from 1 to 6 individuals. Does accounted for 43% of total deer observed averaging 4.33 per survey ranging from 6 to 12 individuals for a total 26 does observed. Only a single fawn was observed on spotlight surveys accounting for 2% of total deer observed averaging 0.17 per survey. Spotlight surveys resulted in a total of 17 unidentified deer accounting for 29% of total deer observations averaging 2.83 per survey ranging from 1 to 9. Deer density estimates were unique for the MR study site when compared to the other 2 study areas. Roadside surveys yielded a higher deer density than spotlight surveys. Overall, deer densities were similar between each survey technique (Figure 4). Spotlight surveys yielded a more variable doe: buck ratio estimates compared to the other survey techniques conducted on the MR site (Figure 5). Since only a single fawn was observed during spotlight surveys; a very low fawn crop percentage resulted (Figure 6). Spotlight surveys yielded a total average of 2.78 deer per kilometer.

Boracho Peak Ranch The BPR average survey route width was 454.16 m with an observed hectare total of 922.48 accounting for 26% of total survey area. A total of 124 total mule deer were observed with an additional 23 mule deer beyond 300 m. Spotlight surveys provided consistent observations with each survey observing 38 (30% of total), 36 (29% of total), and 50 (41% of total) individuals with surveys averaging 41.33 deer. Spotlight surveys resulted in a total number of bucks of 16 averaging 5.33 per survey ranging from 4 to 8. Does accounted a more higher proportion of deer observed with a total number observed of 58 accounting for 48% of the total deer observed. Averages of 19.33 does were observed per survey ranging from 12-30 individuals. Fawn observations remained the same but accounting for 7% of the total deer observed on spotlight surveys. Fawn observations averaged 3 per survey and ranged from 2 to 4. Spotlight surveys yielded the highest deer density estimate with little variation than any other survey technique conducted on the BPR study site (Figure 7). In addition, doe: buck ratio estimates were similar between each survey technique with spotlight surveys slightly yielding the highest doe: buck ratio estimate (Figure 8). Spotlight surveys showed little variability between other survey techniques for fawn: doe ratio estimates (Figure 9). Spotlight surveys resulted in a total deer observed per kilometer average of 2.10 ranging from 1.78 to 2.47 deer observed per kilometer.

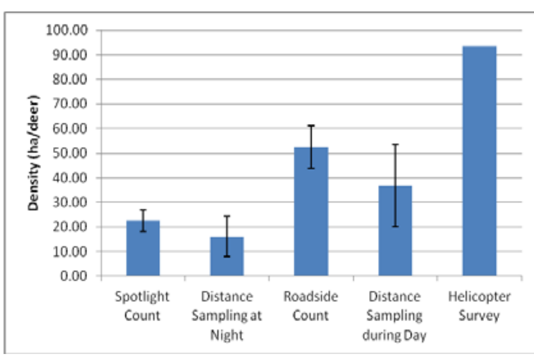

Figure 7. Mule deer densities of each survey technique on the BPR study site.

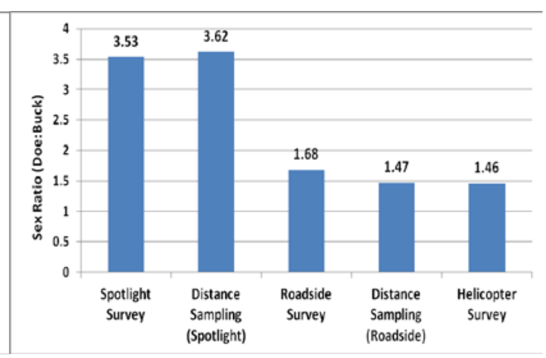

Figure 8. Doe: buck ratio estimates of each survey technique on the BPR study site.

<u>Roadside Surveys</u>
A total of 15 roadside (daytime) surveys were conducted on 3 separate study sites. Roadside surveys were either conducted during the morning and evening hours similar to the timing of helicopter surveys. Each survey route on each study site was both surveyed in the morning and

evening to allow comparison between morning and afternoon population and herd composition estimates. Roadside surveys were conducted on the same exact routes; therefore, survey route width, total observed hectare, and percentage of survey area observed are the same as spotlight surveys.

Sierra Diablo Wildlife Management Area Roadside surveys on SDWMA yielded a total of 21 deer observations for all 6. An overall total average of 3.5 deer was observed during all 6 surveys with observations ranging from 0 to 7 individuals. In addition, a total of 3 bucks were recorded accounting for 14% of total deer observed. Bucks averaged 0.5 per survey with observations ranging from 0 to 2 individuals. Does served as the highest proportion of deer observed with a total of 18 observations. Does accounted for 86% of the total deer observed and averaged 3 per survey with total number of individuals per survey ranging from 0 to 7. Fawn estimates were not calculated nor recorded because no fawns were observed on this study site (Figure 3). In addition, roadside surveys yielded 0 unidentified deer. Roadside surveys yielded a lower deer density than the other survey techniques conducted on the SDWMA study site (Figure 1). Doe: buck ratio estimates were varied between each survey technique with roadside surveys accounting the highest ratio with little variation (Figure 2).The total deer per kilometer estimate of SDWMA was 0.21. Deer per kilometer estimates during surveys ranged from 0.0 to 0.24.

Miller Ranch Roadside surveys yielded a total of 66 total deer observations during roadside surveys with an additional 25 deer observed beyond 300 m. An overall average deer observed per survey was 11 with observations ranging from 3 to 21 individuals. In addition, the total number of bucks observed was 21 accounting for 32% of total deer observed. Bucks averaged 3.5 per survey with observations ranging from 1 to 8 individuals. Does again accounted for the highest proportion of deer observed with a total of 32 in all 6 surveys. Does accounted for 48% of the total deer observed averaging 5.33 per survey with observations ranging from 1 to 12 individuals. A total of 5 fawns were observed accounting for 8% of the total deer observations. Fawns averaged 0.83 per survey ranging from 1 to 3 individuals in each of the surveys. Roadside surveys recorded a low total amount of unidentified deer with a total of 8 accounting for 12% of the total deer observed. Unidentified deer averaged 1.33 per survey ranging from 0 to 8 individuals. Deer densities were variable throughout roadside surveys on the MR site. Surveys yielded densities ranging from 23.83 to 67.42. Unlike the other study sites, roadside surveys produced a higher deer density than spotlight surveys (Figure 4). Doe: buck ratio estimates were similar between each survey technique. Roadside surveys yielded a slightly lower doe: buck ratio estimate than other surveys and show the same precision as helicopter surveys (Figure 5). Fawn crop percentages showed variation among surveys. Roadside surveys resulted in a higher fawn: doe ratio estimate than the other survey techniques but with high variability (Figure 6). In addition, roadside surveys yielded total deer per kilometer estimate of 0.52.

Boracho Peak Ranch Roadside surveys on the BPR study site were very consistent and showed little variation. Roadside surveys yielded a total of 54 deer observations with an additional 4 deer observed beyond 300 m. Each survey observed 15 (28% of total), 20 (37% of total), and 19 (35% of total) mule deer. An overall average deer observed per survey was 18. In addition, bucks accounted for 35% of the total deer observations with a total of 19 individuals observed in all 3 surveys. Bucks overall averaged 6.33 per survey with observations ranging from 2 to 9 individuals. Does again accounted for the highest proportion of deer observed with a total of 28 observations in all 3 surveys accounting for 52% of total deer observations. Doe observations averaged 9.33 per survey with observations ranging from 6 to 16 individuals. Surveys yielded a total of 7 fawns accounting for 13% of the total deer observed averaging a total of 2.33 per survey with observations ranging from 1 to 5 individuals. Deer densities were consistent and showed little variation. Roadside surveys yielded densities ranging from 45.68 to 60.91 (Figure 7). In addition, roadside surveys yielded a slightly lower doe: buck ratio estimate than the other survey methods, however, roadside surveys show higher variation than the other survey techniques (Figure 8.) Roadside surveys followed the same trend as sex ratio estimates with higher variability, however, resulted in a higher fawn: doe ratio estimate than the other survey techniques (Figure 9). Roadside surveys on the BPR site yielded a total deer per kilometer estimate of 0.89 with estimates ranging from 0.25 to 0.33 in each of the 3 surveys conducted.

Spotlight Surveys – Distance Sampling

Each spotlight survey conducted on all 3 study sites were applied under the distance sampling simultaneously while conducting the traditional method. The program DISTANCE only provides a population density or size. Unlike traditional survey analysis that provides not only population densities but also herd composition estimates. However, this additional data is provided because all deer regardless of distance that are observed are recorded and calculated for population and herd composition estimates. Although this program may only provide a population density, if a resource manager were to follow the criteria of the distance sampling method and not utilize the traditional survey method simultaneously, survey results will be different because more deer are recorded under this method influencing population and herd composition estimates. This information was provided specifically to show surveys being conducted solely using the distance sampling method and how it compares to solely conducting surveys under the traditional method. By comparing these 2 survey methods, wildlife managers can understand how utilizing each method yields different survey data because of the amount of deer that's recorded and calculated to produce estimates.

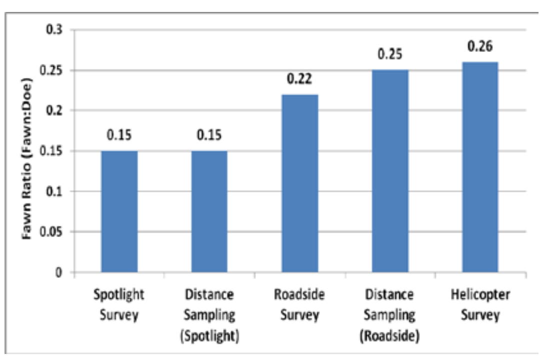

Figure 9. Fawn: doe estimates of each survey technique on the BPR study site.

Sierra Diablo Wildlife Management Area The distance sampling method yielded 66 total deer observations including those individuals observed beyond 300 m. In addition, the overall total average deer observed on each survey was 11 using the distance sampling method. When spotlight survey data was incorporated in program DISTANCE, it produced a lower deer density than spotlight surveys not under the application of distance sampling (Figure 1). The total number of bucks observed was 7 using both survey methods but accounted for 11% of total observed deer using the distance sampling method. Also, this method yielded a total number 33 does averaging 5.5 per survey Doe observations ranged from 0 to 14 during spotlight surveys. Distance sampling method resulted in 26 total unidentified deer accounting for 39% of total deer observed. Observed unidentified deer in total averaged 4.33 per survey ranging from 0 to 10 individuals. Because more deer observations were made following the distance sampling protocols, herd composition estimates differ between simple or traditional statistical analysis and the distance sampling method. This same trend also exists for the other 2 study sites. As a result, the distance sampling method yielded a much higher doe to buck ratio than traditional spotlight surveys with an overall total doe to buck ratio of 4.71:1 with ratios ranging from 0:0 to 7:1. In addition, this method yielded a total deer per kilometer estimate of 1.51 with survey estimates ranging from 0 to 1.52.

Miller Ranch Spotlight surveys applied under the distance sampling method resulted in 61 total deer observation including those individuals sighted beyond 300 m. The distance sampling method resulted in an overall total average of deer observed was 10.17 ranging from 4 to 18 individuals. Deer densities differ between both traditional and distance sampling methods. Distance sampling yielded a higher density than the traditional statistical analysis density estimates (Figure 4). Of the total deer observed, bucks accounted for 25% of the total deer observations ranging from 1 to 6 individuals. Does accounted for 43% of total deer observed averaging 4.33 per survey ranging from 6 to 12 individuals for a total 26 does observed. Only a single fawn was observed on spotlight surveys accounting for 2% of total deer observed averaging 0.17 per survey. The distance sampling method resulted in a total of 19 unidentified deer observed accounting for 31% of total deer observations averaging 3.17 per survey ranging from 1 to 10 individuals. The total average of deer observed per kilometer was 2.87 using the distance sampling method.

Boracho Peak Ranch Spotlight surveys using the distance sampling method yielded a total of 147 deer observations including those individuals beyond 300 m. Surveys using both methods provided consistent number of observations with each survey observing 50 (34% of total), 41 (28% of total), and 56 (38% of total) individuals with surveys averaging 49 deer for the distance sampling method. Deer density estimates were similar between both the traditional and distance sampling survey methods. Applying distance sampling to spotlight surveys yielded the highest density estimate than the other survey techniques conducted on the BPR study site (Figure 7). Distance sampling method resulted in a total number of bucks observed was 17 with an average of 5.6 observed per survey ranging from 4 to 9 accounting for 12% of total deer observed.. Does accounted for a higher proportion of deer observed with a total number observed was 60 individuals with an average of 20 per survey ranging from 12 to 32 accounting for 41% of total deer observed. A low number of fawns were observed with a total of 9 individuals observed averaging 3 per survey ranging from 2 to 4 and only accounting for 6% of total deer observed. Unidentified deer accounted for the same proportion of deer observed as does accounting for 41% of total deer observed. Unidentified deer observed average 20.3 per survey ranging from 12-28 with fewer unidentified deer being observed from the first survey conducted to the last. Doe to buck ratios were similar and consistent between both the distance sampling and traditional spotlight survey methods. Distance sampling method resulted in a total doe to buck ratio of 3.53:1 ranging from 3:1 to 4:1. Fawn crop percentages were very similar between both spotlight survey methods. The distance sampling method resulted in an overall fawn crop percentage of 15% ranging from 9 to 33%. Deer observed per kilometer resulted in a total average of 2.41 ranging from 2.02 to 2.47 deer observed per kilometer using the distance sampling method.

<u>Roadside Surveys – Distance Sampling</u>
As the same as spotlight surveys conducting using distance sampling, all roadside surveys were also concurrently conducted using both the traditional and distance sampling methods. Like above, we differentiated the survey data to represent how utilizing both traditional and distance sampling methods separately may not only represent different population densities but how each may yield different herd composition estimates as well. Distance sampling only provides a population density, however; because more deer observations are recorded compared to traditional methods, herd composition estimates may be different between both traditional and distance sampling methods.

Sierra Diablo Wildlife Management Area The purpose of differentiating distance sampling and traditional survey data is show comparison of differences that both result, however; when applied to the SDWMA study site, survey data from both the traditional and distance sampling methods were exactly the same with the exception to mule deer densities. Deer densities varied considerably between traditional roadside surveys to roadside surveys using distance sampling, however; it yielded a similar density estimate as the helicopter survey (Figure 1). As for the other herd composition estimates, distance sampling yielded the same number of deer observations, averages, and proportions of does, bucks, fawns, and unknowns as well as the same herd composition estimates including doe to buck ratios and fawn crop percentages.

Miller Ranch The distance sampling method on the MR study site yielded a total of 91 total deer observations during roadside surveys including those individuals sighted beyond 300 m. An overall total average of deer observed per survey was 15.17 with each survey route averaging 17.33 and 13. Deer observations during surveys ranged from 3 to 30 individuals. The distance sampling method applied to roadside surveys yielded a similar deer density estimate as the traditional method with a slightly lower deer density estimate (Figure 4). In addition, a total of 27 bucks were observed in all 6 surveys accounting for 30% of total deer observations made during roadside surveys utilizing the distance sampling method. Bucks averaged 4.5 per survey with observations ranging from 2 to 10 individuals. Does were the highest proportion of deer observed accounting for 54% of total deer observed with 49 observations. Does averaged 8.17 per survey ranged from 1 to 16 individuals. Fawns accounted for 5% of the total deer observed with 5 observations. Fawns averaged 0.83 per survey ranging from 0 to 3 individuals in the 6 surveys conducted. Unlike the BPR study site, both methods recorded unidentified deer during roadside surveys. The distance sampling method resulted in 11 unidentified deer observations accounting for 12% of total deer observed. Unidentified deer averaged 1.83 per survey ranging from 1 to 8 individuals. Doe to buck ratios showed little variation and were relatively consistent especially the distance sampling method. This method resulted in a total doe to buck ratio of 1.81. Ratios throughout roadside surveys ranged from 1.0 to 3.5. Fawn crop percentages using the traditional method were higher compared to the distance sampling method. This method yielded a total fawn crop percentage of 10%. In addition, the distance sampling method yielded a total deer per kilometer estimate of 0.71.

Boracho Peak Ranch Roadside surveys on the BPR site using distance sampling yielded a total of 58 deer observations including those individuals observed beyond 300 m. Observations ranged from 19 to 20 individuals per survey. Surveys observed 19 (33% of total), 20 (34% of total), and 19 (33% of total) with all contributing at nearly the same percentage of total deer observations using this method. An overall total average of 19.33 deer per survey was recorded. When distance sampling was applied to roadside surveys on the BPR study site, a similar deer density resulted with distance sampling yielding a slightly higher deer density than the traditional method (Figure 7). In addition, a total of 19 bucks were observed in all 3 surveys accounting for 33% of the total deer observed. A total average of 6.33 bucks was observed per survey with observations ranging from 2 to 8 individuals. An overall total of 32 does were observed in all 3 surveys averaging 10.66 per survey with observations ranging from 6 to 16 individuals. Doe observations accounted for 55% of the total deer observed during roadside surveys on the BPR study site. Surveys yielded a total of 7 fawns in all 3 surveys accounting for 12% of total deer observed in roadside surveys. Fawns averaged 2.33 per survey with observations ranging from 1 to 5 individuals. Unlike spotlight surveys which yielded a high proportion of unidentified deer, roadside surveys for either distance sampling or traditional method yielded no unidentified deer. Distance sampling method resulted in a total doe to buck ratio of 1.68 with ratios ranging from 1.0 to 8.0. In addition, the distance sampling method yielded a total fawn crop percentage of 22% with variable percentages ranging from 6% to 83% in all 3 surveys. Deer per kilometer estimates were consistent through each of 3 surveys especially when utilizing the distance sampling method.

Discussion

The size of the confidence intervals for population densities revealed that helicopter surveys on all 3 study sites proved to be the most precise (repeated counts of similar results) than the other survey technique. In addition, helicopter surveys conducted during this study yielded higher deer density estimates compared to the other survey techniques. Richardson (2002) stated that wildlife managers may be in a constant debate on helicopter surveys providing population and herd composition estimates, however; precision is rarely question when utilizing this survey type. Not only were helicopter surveys more precise with mule deer density estimates, but showed little variability in herd composition estimates when compared to the other survey techniques that were conducted which concurs what Richardson (2002) reported that helicopter surveys are a good indicator of deer herd population structure. In addition, when comparing herd composition estimates between helicopter surveys to roadside and spotlight surveys, generally each survey method yielded similar estimates. From a cost standpoint, roadside and spotlight surveys may suffice to estimate mule deer population and herd composition as seen on the BPR and MR study sites. Helicopter surveys observe considerably higher numbers of deer observations providing a larger sample size. This allows for less variability and better precision than smaller sample sizes that often resulted for roadside and spotlight surveys that were conducted. However, when survey techniques were implemented, only a total 3 repetitions of spotlight and roadside surveys were made while helicopters surveys conducted 8 surveys on SDWMA and MR study sites only. The

SDWMA and MR sites serve as good examples. Spotlight and roadside surveys with similar density estimates as helicopter surveys show more variability and less precision, however, if these ground surveys were to be conducted at the same repetition of helicopter surveys, precision may have improved and yielded relatively the same density. As found in all surveys for this study, fawn: doe ratio estimates were considerably low. Surveys are generally conducted during the months of November-December; however, circumstances lead us to conduct these surveys during the months of February-April. During these months, fawns are nearing one year of age and may resemble a young doe and may have been improperly identified during surveys.

Mule deer density estimates were the most similar between spotlight and helicopter surveys. However, when comparing herd composition estimates between spotlight and helicopter survey results, helicopters typically yielded more precise and accurate herd composition estimates. DeYoung and Fafarman (1986) and McCullough (1982) revealed spotlight surveys yielding less accurate herd composition estimates. Survey data from the surveys we conducted support this finding especially sex ratio estimates made during surveys on the MR study site (Figure 6). Spotlight and roadside surveys resulted in a higher proportion of does observed indicating that ground surveys particularly spotlight surveys may have overestimated doe: buck ratio estimates when compared to helicopter survey results. In addition, the most precision found in our spotlight surveys was on the BPR study site. Surveys resulted in relatively consistent number of deer observations throughout each survey repetition. However, low sample sizes and inconsistent number of deer observations occurred on spotlight and roadside surveys on the MR and SDWMA. We may have identified that helicopter surveys may have potentially influence the number of deer observations made during roadside and spotlight surveys. Ground surveys were conducted near or at the same timeframe as helicopter surveys. DeYoung (1985) found that subsequent flying of helicopter surveys may make deer in an area weary and may influence normal deer movements in an area, thus resulting in lower deer observations. Roberts (unpublished data 2009) conducted spotlight surveys a few months before this study was performed and found a much higher deer density and more deer observations than what resulted from this study's survey results. When comparing spotlight and roadside surveys results between the study sites where helicopter surveys were occurring to the BPR study site, there is a clear distinction on the difference of deer observations, density estimates, and overall sample sizes. There may be a possibility that repeated helicopter surveys altered deer movements in these areas resulting in fewer deer observations directly affecting our estimates. As a result, more research is warranted to investigate how subsequent helicopter surveys may have influential impacts on deer movements in an area.

Roadside surveys consistently provided a lower deer density at each study site with the exception of the MR. There were actually more deer observed during roadside surveys when compared to spotlight surveys. In this case, roadside surveys yielded a higher deer density. In addition, roadside surveys typically showed less variation in herd composition estimates than spotlight surveys. When applied under the application of distance sampling, deer densities consistently yielded higher deer densities than traditional statistical analysis. When distance sampling was applied to roadside surveys on the MR study site, deer density estimates yielded nearly the same as helicopter surveys. Richardson (2002) recommends conducting roadside surveys in conjunction with spotlight surveys to not only increase sample size, but more importantly to improve the accuracy of herd composition estimates.

Management Implications
Our study found that helicopter surveys proved to be the most precise and effective when estimating mule deer densities and herd composition. Helicopter surveys provided a larger sample size which in turn provided less variability and more precision for herd composition and population estimates. Even though helicopter surveys yield precise and accurate survey estimates when compared to other survey techniques, landowners may find this method not cost-effective when surveying individual properties. In addition, our study found similar population and herd composition estimates between each survey technique. Because of the similarity between spotlight and roadside surveys to helicopter surveys, landowners can use more cost-efficient survey techniques other than helicopter surveys to suffice for a substantial population and herd composition estimates to be adequate for future harvest recommendations. In addition, our study found that roadside surveys provides improved herd composition estimates and increases sample size in areas of low numbers of deer observations. As a result, we recommend utilizing both spotlight and roadside surveys concurrently to better estimate deer density and to improve herd composition estimates. Distance sampling typically yielded higher deer densities than traditional statistical analysis, however, circumstances common in west Texas where low sample sizes and limited visibility in mountainous areas may cause inaccuracies in the program and may cost the expense of estimating accurate herd composition estimates. In conclusion, evaluating survey techniques allows wildlife managers to identify strengths and weaknesses of each method. Because of the variable terrain, mule deer distribution, and other factors, each survey technique may function differently from one site to another. More research is warranted to investigate what influences survey technique precision, accuracy, and effectiveness under certain conditions. Lastly, research is needed to continue evaluating survey techniques in areas of west Texas to implement methods that best estimate accurate mule deer populations and herd composition.

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Literature Cited

Brewer, C. E. 2005. Mule deer monitoring. Unpublished Report. Texas Parks and Wildlife Department, Austin, Texas, USA.

Buckland, S. T. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, Boston, MA, USA.

Cantu, R., and C. Richardson. 1997. Mule deer management in Texas. Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas, USA.

Davis, W. B., and D. J. Schmidly. 1994. The mammals of Texas. Texas Parks and Wildlife Press Austin, Texas, USA.

DeYoung, C. A. 1985. Accuracy of helicopter surveys of deer in south Texas. Wildlife Society Bulletin 13:146–149.

Fafarman, K. R., and C. A. DeYoung. 1986. Evaluation of spotlight counts of deer in south Texas. Wildlife Society Bulletin 14:180–185.

Gelatt, T. S., and D. B. Siniff. 1999. Line transect survey of crabeater seals in the Amundsen-Bellingshausen Seas, 1994. Wildlife Society Bulletin 27:330–336.

Grundel, R. 2009. Karner blue butterfly: a guide to the use of distance sampling to estimate abundance. U.S. Geological Survey, Great Lakes Science Center, Porter, Indiana, USA.

Harveson, L. A. 2007. Quails on the Trans-Pecos. Pages 202–216 *in* L.A. Brennan, editor. Texas Quails: ecology and management. Texas A&M University Press, College Station, Texas, USA.

Hatch, S. L., K. N. Gandhi, and L. E. Brown. 1990. Checklist to the vascular plants of Texas. Publication MP-1655, Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas, USA.

Heffelfinger, J. 2006. Deer of the southwest. Texas A&M University Press, College Station, Texas, USA.

Hodge, L. D. 2000. Guide to Texas wildlife management areas. Texas Parks and Wildlife Press, Austin, Texas, USA.

Krebs, C. J. 1999. Ecological methodology. Second edition. Benjamin/Cummings, Menlo Park, California, USA.

Lancia, R. A., J. D. Nichols, and K. H. Pollock. 1994. Estimating number of animals in wildlife populations. Pages 215–253 *in* T. A. Bookhout, editor. Research and management techniques for wildlife and habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland, USA.

McCullough, D. R. 1982. Evaluation of night spotlighting as a deer study technique. Journal of Wildlife Management 46:963-973.

Rabe, M. J., S. S. Rosenstock, and J. C. deVos, Jr. 2002. Review of big-game survey methods used by wildlife agencies of the western United States. Wildlife Society Bulletin 30: 46-52.

Richardson, C. 2002. Comparison of deer survey techniques in west Texas. Pages 62-72 *in* L.A. Harveson, P.M. Harveson, C. Richardson, eds. Proceedings of the Trans-Pecos Wildlife Conference. Sul Ross State University, Alpine, Texas, USA.

Schmidly D. J. 1977. The mammals of Trans-Pecos Texas. Texas A&M University Press College Station, Texas, USA.