Multiple Data Source Approach to Monitoring and Management of Mule Deer: application in Deer Zones X9a and X9b (DAU 11, DMU 740 and 750, Mono and Inyo Counties)

Proposed Start and Completion Date: Start Date: October 1, 2011; Completion Date: August 2016.

Statement of Need

This prospectus has been prepared to provide background information and review by the Large Mammal Advisory Committee (LMAC) for their consideration and recommendation. Using excellent science-based capacity, this multiple data source approach to monitoring California's Casa Diablo, Round Valley, and Goodale deer herds will provide an understanding of the underlying processes that affect population change. This is part of an ongoing program to assess and manage deer populations and to evaluate the pertinence of new methodologies for population assessment which minimize helicopter time and help evaluate modifications to routine helicopter survey standards. The project will increase the precision and accuracy of population monitoring while reducing risks to Department personnel. The combination of population size estimation with vital rate and nutritional monitoring (hybrid population monitoring) can be a powerful tool for assessing the status of mule deer herds and determining if population objectives are being met.

Establishing survey protocols, including training of all staff on project, for each portion of this multiple data source collection will be essential for accurate data collection and database management over this 5 year project. Contracted assistance with project design and data analysis by Dr. Mary Conner, Utah State University, will provide outstanding expertise from a university. As this is a 5 year project, financial support from wildlife groups will be sought, once there is LMAC support.

Introduction

Abundance is the most commonly monitored attribute for tracking ungulate population dynamics, when the goal is to maintain population levels close to pre-defined numerical objectives that are sustainable (Thompson et al. 1998, Bowden et al. 2000, Williams et al. 2001). However, population size alone reveals little about the long-term sustainability or expected trajectory of a population (Lancia et al. 2005). Wildlife managers also need the ability to detect whether the population is increasing, decreasing, or remaining stable, to allow appropriate management action to meet future population size objectives (Thompson et al. 1998, Williams et al. 2001). This change in population size over time is defined as the finite rate of population change, commonly referred to as lambda (λ), or population growth rate (Gotelli 2001, Morris and Doak 2002).

The simplest method of determining λ during a set time interval (t) is to obtain estimates of population size (N) at the beginning and end of the time interval and then consider the

ratio of these 2 estimates, expressed mathematically as $\lambda_t = N_{t+1}/N_t$ (Morris and Doak 2002, Dinsmore and Johnson 2005). However, ungulate species are often spatially aggregated, which causes population abundance estimates based on counts (whether distance sampling or quadrats) to have high variance (Thompson et al. 1998), making it difficult to detect small or even moderate changes in population size (Gibbs et al. 1998). (Note: Mark-resight estimates typically have low sampling variance, but capture and collar costs sometimes prohibit use of this technique at a large scale). Furthermore, estimating population size alone does not provide information on the underlying processes that affect population change. An alternative approach is to determine λ by monitoring the vital rates of a population, namely the ratio of juveniles to adult females, juvenile survival, and adult female survival. Because mule deer are polygynous, monitoring can be restricted to females (White and Bartmann 1998, Morris and Doak 2002, Lancia et al. 2005). Using vital (i.e., demographic) rates, λ is calculated as a function of recruitment and survival, and has a much smaller variance compared with estimates of population size with a concomitant sensitivity to detecting a decline.
Even if the ultimate goal of a monitoring plan is to track population change over time via vital rates, population size must still be estimated occasionally to convert λ to easily interpretable numbers of mule deer (Bowden et al. 2000). More importantly, estimates of population size are still necessary to validate models of λ and recalibrate population models (Roseberry and Woolf 1991, Mayer et al. 2002, White and Lubow 2002). When White and Lubow (2002) combined vital rate and quadrat count (i.e., population size estimates) data into a population model, they found population size projections based only on vital rates can vary widely from observed population size estimated from quadrat count data. They concluded that very small errors in 'sensitive' vital rates that drive population dynamics, such as adult female survival for mule deer populations, can result in projections that diverge widely from true population sizes. Using count data in combination with vital rate data greatly improves the fit of observed and predicted population size.

Although vital rates provide critical information regarding the component of the population that is largely responsible for observed trends in population size, the underlying mechanism (i.e., predation, weather, nutrition) that determines the direction of change in vital rates may only be characterized with data on nutritional condition (Bowyer et al. 2005, Parker et al. 2009). Data collected on population dynamics of mule deer in the eastern Sierra Nevada, indicated that survival of adults and recruitment of young was largely determined by bottom-up limitation, and therefore, data on nutritional condition is essential for interpreting population dynamics (Monteith et al. 2009). Body fat of adult females following winter provided an encompassing measure of population health and held predictive value for adult female survival, reproduction, recruitment of young, an index to abundance of males, and overall population trajectory (λ) during the following year (Monteith et al. 2009). Moreover, data on nutritional condition likely holds insight into determining the nutritional carrying capacity of a particular range and thus, realistic objectives for population management (Piasecke and Bender 2009).

Other advantages of using a multiple data source approach (count, vital rate, and nutrition data) include robustness to missing data and, more importantly, the ability to use likelihood methods to estimate vital rates and AIC model selection to evaluate mechanisms driving population dynamics. For example, model selection can be used to determine if fawn survival is declining and whether the decline is related to nutrition and is responsible for population decline, etc. In addition, the method is flexible such that environmental covariates can be incorporated to estimate vital rates. Indeed, availability of forage on winter range in the eastern Sierra Nevada is largely determined by water content of the winter snow pack in April, which subsequently has a marked impact on over-winter nutritional condition of adult females the following March (Monteith et al. 2009). Therefore, data on winter snowpack could be used to predict survival, and its usefulness as a surrogate for survival can be tested in a model selection framework. Finally, flying is expensive; helicopter time now costs $1,200/hr and total flying time for surveys averages 38 hours/year for X9a and X9b deer zones. Moreover, flying in helicopters is inherently dangerous. Using a hybrid monitoring program that estimates λ based on annual vital rates, while validating population trajectories with periodic counts to estimate population size, potentially reduces costs and certainly reduces danger to personnel. Thus, the combination of population size estimation with vital rate and nutritional monitoring (hybrid population monitoring) can be a powerful tool for assessing the status of mule deer herds and determining if population objectives are being met.

Here, we present an example of a hybrid population monitoring plan for the Casa Diablo, Round Valley, and Goodale Deer Herds (Deer Zones X9a and X9b) that focuses primarily on monitoring vital rates and nutrition with periodic estimates of population size. The program consists of annual monitoring of age ratios (to estimate recruitment and overwinter fawn survival), annual survival of adult females, and annual estimates of nutritional condition, as well as field-based estimates of population size once every 4 years. We determined precision required to detect declines, and followed methodology of Bowden et al. (2000) to optimally determine sample sizes (e.g., number of doe collars, composition counts, etc.) that would maximize precision while minimizing costs.

<u>Study Objectives</u>

The overall goal of this project is to increase the precision and accuracy of population monitoring while reducing risks to Department personnel. The objective is to adopt the use of a hybrid, population monitoring plan to provide accurate estimates of λ and determine factors underpinning λ for the Casa Diablo, Round Valley, and Goodale deer herds to ensure appropriate management action to meet future population size objectives. We intend to understand the factors that drive population change across a broad region. This hybrid monitoring approach will be able to detect a 25% decline of λ over a 5-year period for each herd by using likelihood methods to estimate vital rates and AIC model selection to evaluate mechanisms driving population dynamics.

<u>Methods</u>

Primary lead for the project will be Ms. McKeever. Dr. Monteith, Mr. Taylor, and Mr. Morrison will be leads for daily activities, monitoring and collaring efforts. Dr. Monteith will oversee survivorship and population analyses, with the close assistance from Dr. Conner. Contracted helicopter service will be required for helicopter survey in Year 1 and 5; contracted deer captures are proposed in all 5 years. Staff training will include animal handling and participation as helicopter crew member. All captures will require assistance from the Wildlife Investigations Laboratory. Contracted fixed-wing time will be used to monitor survivorship. One temp help position is requested. Proposed project budget summary is in Table 2.

The sampling design allows for a large variance in population size estimates (i.e., the average for Casa Diablo and Goodale herds over the past 10 years), while maintaining sample sizes required for monitoring λ and nutritional condition to meet our design parameters. Requirements for this design in each herd include:

1. To quantify changes in population performance, ensure a minimum of 30 adult females (some extra collars to allow for collar failure and mortality during severe winters) remain radiocollared each winter (new marks first year, and replacement on subsequent years).
2. Monitor nutritional condition of 25 adult females during March each year. This capture effort will provide an opportunity to place radiocollars on additional females to replace those lost to mortality the previous year and all females will be marked with non-transmitting collars to allow mark-resight estimates in subsequent years.
3. Collect annual survival data for adult females (either by ground or fixed wing).
4. Conduct age and sex ratio surveys during the winter (ground survey).
5. Estimate population size every 4^{th} year (i.e., 3 years between helicopter surveys) at approximately the same time age and sex ratio surveys are conducted.
6. Determine a sampling plan (ground surveys) for estimating age and sex ratios so that sampling variance can be estimated.

Helicopter surveys for abundance data and herd composition will follow established protocol for each deer herd, and will be outlined in the Helicopter Survey Plans. Typically surveys for these three herds take a total of 21 hours of helicopter time, including transit time, and surveys will take place during January (Goodale and Round Valley) and March (Casa Diablo). Transects will be flown and data analyzed in Distance 6 (Thomas et al. 2009), until marked deer can be used for mark/resight (i.e., sufficient marked deer available in population). Near the same time as the helicopter survey and during each January and March, a ground survey will be conducted for age and composition data. Ground survey protocol will be established prior to survey; and ground survey protocol will be redesigned so sampling variance can more readily be separated from process (temporal) variance.

Helicopter capture and collaring effort (at an estimated cost of $1,200.00 per hour) will take place in March (adult females only) of each year and include maintaining the sample at 30 adult does for monitoring survival. For this project, it is anticipated that five days of capture time will be needed in the first year (spring 2012) and up to 3 days of time in each subsequent year.

In Year 1, ninety ATS radio collars will be needed for the project at an estimated cost of $250 each for an adult doe collar. Battery life of collars will be sufficient for the duration of the study. During subsequent years, radiocollars recovered from mortalities will be placed on additional females to replace those lost the previous year.
The annual sample size necessary to detect a change in nutritional condition (ingesta-free body fat (IFBFat)) of 2% is 25-26 animals in each deer herd. Therefore, we propose to capture 25 adult females in each herd unit per year during the spring capture. Females need not be marked and can be captured at random to maximize efficiency and helicopter effort. The nutritional condition (IFBFat) and fetal rate of each female will be determined using ultrasonography and the accompanying body condition scoring (Stephenson et al. 1995, Stephenson et al. 2002, Cook et al. 2007; 2010). These data will allow us to monitor patterns of reproduction and nutritional status within each respective population. In addition, all females captured each March for monitoring of

nutritional condition will be fitted with non-transmitting collars (i.e., simple, inexpensive mark at about $25 per collar) to allow mark-resight estimates of population size in subsequent years based on the estimated number of marks available (determined by number of marks placed in population and annual survival of adult females).

Fixed wing flights will be accomplished by a local private contracted pilot experienced in this type of data collection in this area of the Eastern Sierra. Contracted costs currently are about $270 per hour. In Years 2 -5, just before and right after each March capture and collaring effort, a fixed-wing flight will occur to determine current number of mortalities and how many "new" adult deer need to be radiocollared during the next capture. The fixed-wing flight after the capture will determine how many mortalities were capture related, so that they may be censored from the sample. For the current year (March 2012), within a few weeks of the spring deer capture, a fixed wing flight will take place to determine any mortalities related to the capture itself. Then, in mid-August, early January, and twice in March, a fixed-wing flight will occur to collect survival data for the ninety radiocollared animals (Table 1). Summer range flights during August will take approximately twice as long as winter range flights because of the expansive summer ranges and additional effort required to locate each female to characterize summer residency. Alternatively, efforts will be made to obtain winter range locations and survival data from the ground in Round Valley and Goodale herds to minimize fixed-wing costs, and current estimates of fixed wing time when deer are on the winter range only includes time for the Casa Diablo deer herd.

The Wildlife Investigations Lab (veterinarian and technicians) will be needed for March capture efforts. Nine months of temporary help will be needed for field monitoring of marked females, ground composition survey assistance, retrieval of radiocollars, and as a helicopter observer, once trained. Radio collar costs include $1000 per year for refurbishing, and collars are expected to last the duration of the study period.

The monitoring design was based on adult and fawn survival data from Round Valley. Sample sizes and costs will be re-evaluated for Goodale and Casa Diablo herds after several years of vital rate data are collected. If needed, sample sizes will be adaptively adjusted for all herds after sufficient data is collected to evaluate the monitoring plan and determine if we are meeting objectives (e.g., adequate sample sizes to detect a 25% decline in λ over a 5-year period for each herd).

Products (and estimated dates of completion)

This project consists of annual monitoring of age ratios (to estimate recruitment and overwinter fawn survival), annual survival of adult females, and annual estimates of nutritional condition, as well as field-based estimates of population size once every 4 years. Annual monitoring of age and composition data will be provided to the Deer Program within one week of survey. In Years 1 and 5, helicopter survey data and shapefiles will be provided after flights are completed. Estimates of nutritional status, reproductive performance, and survival will be provided at the end of each fiscal year in the post project report. Projected population size will be evaluated based on monitored vital rates. We also intend to assess proximity to carrying capacity for each herd based on vital rates, population growth rates, and nutritional status. An understanding of the projected population performance may be used to adjust management objectives.

Collaborators

Project Lead is Ms. Jane McKeever, with assistance from Dr. Kevin Monteith, Mr. Tim Taylor, and Mr. Mike Morrison. Project Supervisor is Dr. Tom Stephenson. Contracted support for study design and analyses by Dr. Mary Conner, Adjunct Assistant Professor, Utah State University, is also sought through this funding approval process.

Funding

Funding is being requested through Dedicated Deer Account. At this time, only Dedicated Deer Account approval and funding is requested with the anticipation that outside funds will be pursued during the appropriate request periods, once the Department has approved and funded the project.

Issues to be Resolved

LMAC support and Executive Branch approval, and approval and funding of Big Game Analysis Grant with Dr. Mary Conner, through Utah State University. Funding outside of DFG will be sought.

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Table 1. Fixed-wing flight timing and costs ($270/hour) for 5-year project for Casa Diablo, Goodale and Round Valley combined.

Year	January	Pre-Spring Capture	Post-Spring Capture*	August	Total
2011/12	--	--	6	18	24
2012/13	18	2**	2	18	40
2013/14	18	2	2	18	40
2014/15	18	2	2	18	40
2015/16	18	2	2	18	40
				Total Hours	**184**
				Total Cost	**$49,680**

*Initiation of project will occur in March 2012.

** In spring, Year 2013 – Year 2016, telemetry location and survival will be from the ground, except for Casa Diablo.

Table 2. Proposed Budget Summary

Item Description	Year 1 2011/2012	Year 2 2012/2013	Year 3 2013/2014	Year 4 2014/2015	Year 5 2015/2016
Temporary Help	9 months @ $18,000	9 months @ $18,000	9 months @ $18,000	9 months @ $18,000	9 months @ $18,000
Helicopter Survey For Abundance Data @ $1,200/hour	21 hours @ $25,200	--	--	--	21 hours @ $25,200
Ground Survey for Ratio Data	$300 (January)	$300 (January)	$300 (January)	$300 (January)	$300 (January)
Ground Survey for Spring Ratio Data	$300 (March)	$300 (March)	$300 (March)	$300 (March)	$300 (March)
Spring Helicopter Capture/Collaring Effort @ $1,200/hour	30 does x 3 herds 35 hours @ $42,000	25 does x 3 herds 21 hours @ $25,200	25 does x 3 herds 21 hours @ $25,200	25 does x 3 herds 21 hours @ $25,200	25 does x 3 herds 21 hours @ $25,200
Radio collars	$22,500	--	--	--	--
Radio collar Refurbishing/Purchase		$1,000	$1,000	$1,000	$1,000
Color Collars (25 each year)	$625	$625	$625	$625	$625
Fixed wing contract	$6,480	$10,800	$10,800	$10,800	$10,800
Travel	$1,000	$1,000	$1,000	$1,000	$1,000
Total Estimated Project Cost	**$116,405**	**$57,225**	**$57,225**	**$57,225**	**$82,425**
Total Est. DHMPIP Funds Requested	**$116,405**	**$57,225**	**$57,225**	**$57,225**	**$82,425**
Total Project Cost: $370,505					
Total DHMPIP Cost: $370,505					