IDAHO DEPARTMENT OF FISH AND GAME

Virgil Moore, Director

Project F16AF00908

Interim Performance Report

Statewide Wildlife Research

July 1, 2016 to June 30, 2019

Prepared by:

Mark Hurley
Wildlife Research and Data Manager
&
Shane Roberts
Principal Wildlife Research Biologist

September 2018
Boise, Idaho

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ANNUAL PERFORMANCE REPORT

State: Idaho

Grant number: F16AF00908 Amendment 1

Grant name: Statewide Wildlife Research

Report Period: July 1, 2017 through June 30, 2018

Report due date: September 28, 2018

Geographic Location Statewide

If the work in this grant was part of a larger undertaking with other components and funding, present a brief overview of the larger activity and the role of this project.
N/A

Describe how objectives were met:
See individual project reports contained herein.

Discuss differences between work anticipated in grant proposal and grant agreement, and that actually carried out with WSFR grant funds; include differences between expected and actual costs
N/A

List any publications or in-house reports resulting from this work.
See Appendix.

Bighorn Sheep Disease Ecology and Population Dynamics

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs to understand the factors responsible for disease in bighorn sheep populations.

Purpose

Monitor radio-collared bighorn sheep and their lambs to estimate vital rates, population demographics, movements, and disease status. Produce two manuscripts for peer-reviewed publication to document research outcomes by 30 June 2019.

Expected Results

- Understand the underlying causes, potential precipitating factors, and population level impacts of pneumonia in bighorn sheep.
- Develop vaccines or other measures to reduce disease in bighorn sheep.
- In the absence of medicinal or other solutions, develop and implement management strategies to maintain separation between bighorn and domestic sheep.
- Develop and implement a study plan to test and evaluate alternative methods to monitor bighorn sheep populations.

Project objectives

1. Measure 200 (50 in FY18) vegetation plots for nutritional quality and biomass of vegetation available to bighorn sheep in the Owyhee River and East Fork Salmon River by 30 June 2018.
2. Capture and sample 150 (50 in FY18) bighorn sheep to radio-collar, document body condition, and determine disease status by 30 June 2018.
3. Monitor 600 (300 in FY18) radio-collared bighorn sheep and their lambs to estimate vital rates, population demographics, and movements by 30 June 2018.
4. Produce two manuscripts from bighorn sheep research by 30 June 2018.

Approach:

We are using field monitoring and experimentation, laboratory investigation, and captive animal experimentation in this research.

Field monitoring:

We will capture, test, and individually mark approximately 50 bighorn sheep in 4 Hells Canyon populations using corral traps, ground darting, and helicopter netgunning. Capture is being conducted to monitor health and shedding status of Mycoplasma ovipneumoniae (M. ovi) as part of a 5 year study to investigate the role of chronically infected bighorn ewes in causing pneumonia epizootics in lambs and to mark individuals for evaluating alternative methods for population estimation.

We will monitor approximately 300 marked sheep (previously and newly collared) from the ground and from the air to estimate survival, cause-specific mortality, productivity, and population size and trend. This work is ongoing and complementary to laboratory and captive animal investigations. These data are also used for spatial assessment of risk of transfer of pathogenic organisms from domestic to wild sheep. Key cooperators include Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Bureau of Land Management (BLM), and U.S. Forest Service (USFS).

Laboratory investigation:
We plan to use multi-locus sequence typing to characterize strains of the bacterium M. ovi within and between bighorn sheep populations, We will assess the utility of using quantitative polymerase chain reaction (qPCR) and other diagnostic tests on swabs, blood, or serum that may correlate to health and carriage. Key cooperators include Washington State University (WSU), US Geological Survey Rocky Mountain Research Center (USGS), and Montana State University. Biological samples (e.g. ear swabs, nasal pharyngeal swabs, fecal, blood) are collected from bighorn sheep found dead, captured during radio-collaring efforts, and captured specifically to monitor disease status. Repeated sampling of individuals is ongoing to document changes (if any) in infection status through time.

Captive animal experimentation:
Controlled experiments on captive animals will test field hypotheses and observations about causes of pneumonia in bighorn sheep. These include hypotheses regarding pathogen transmission among bighorn sheep. Understanding the causes and epidemiology of disease in bighorn sheep is critical for developing successful management solutions and many of these questions can only be reliably investigated, at least initially, in a controlled setting. Key cooperator is WSU. A second ongoing experiment is designed to test the role of chronic shedders in maintaining disease. Lamb survival will be compared in shedders and non-shedders penned separately and commingled. Key cooperator is South Dakota State University. Captive bighorn sheep are maintained at WSU and South Dakota State University under their Animal Care & Use Committee permits.

Spatial structure and connectivity:
This work will use historic bighorn sheep location data and data collected during new, associated bighorn sheep projects to model space and habitat use, gene flow, and pathogen transmission, within and across Idaho bighorn sheep populations. This analysis will identify potential routes for gene flow and disease transmission to inform management strategies aimed at reducing disease impacts. The analyses will also address trade-offs between speeding colonization of vacant or under-occupied habitat through translocations and possible increases in disease transmission among bighorn sheep populations and contact with domestic sheep.

To estimate habitat connectivity for bighorn sheep across the study area, we will utilize an existing base map of suitable habitat and active domestic sheep allotments developed by the USFS for Idaho. Incorporating this map will ensure consistency with base information on which federal land management actions are evaluated. In FY18 we will continue to refine this map by using general linear mixed models (GLMM) to develop seasonal resource selection functions from GIS layers similar to those used in the USFS habitat model (terrain, vegetation, and water) to better describe habitats used by bighorn sheep statewide. Subsequently, we will estimate connectivity using a method such as circuit theory or least-cost path analysis. Our approach will provide statistical estimates of potential connectivity and predicted movement patterns within and among populations. These measures of connectivity will subsequently be incorporated into models of gene flow, pathogen transmission, and risk of disease transmission among wild sheep populations and from domestic sheep and goats. Key cooperators include University of Idaho, WSU, and USGS.

Alternative Monitoring Methods:
We will test and evaluate alternative methods to monitor bighorn sheep population sizes. We will collect scat for noninvasive genetic capture / recapture population or survival estimation, and ground-based surveys including capture / recapture population estimates of previously collared individuals.

When complete, we envision a multi-faceted approach to monitoring bighorn sheep that incorporates variables such as diverse topography and habitat, widely varying population density, and ground access, among others. This framework will produce various data products depending on statistical, logistical, and species natural history constraints. Key cooperators include Washington Department of Fish and Wildlife, Oregon Dept. of Fish and Wildlife, University of Idaho.

Habitat and Nutrition:
We will utilize collared bighorn sheep, vegetation surveys, and remotely-sensed data to examine the relationships between bighorn sheep nutrition, movements, population performance, and habitat quality. We will use helicopter net-gunning to capture and GPS-collar at least 30 bighorn sheep (ewes and rams of various age classes, =1.5 years of age) in the Owyhee River, East Fork Salmon, and Lost River Range study areas of southern Idaho along with the sheep collared in Hells Canyon as part of disease research. During capture we will sample sheep for disease exposure; estimate body condition through fat and musculo-skeletal measurements taken with a portable ultrasound unit, weight, and palpation-based condition scoring; collect fecal samples for diet analysis; and draw blood for DNA analysis and pregnancy testing. We will utilize pregnancy results from capture and fixed-wing aerial and ground observations during the lambing season to document lambing. We will then use GPS locations and at least monthly aerial (fixed-wing visual observations or infrared imagery) or ground observations of bighorn sheep lambs to monitor movements and early lamb survival (birth through September).

We will use line-intercept sampling to estimate canopy cover, the disc pasture method to estimate plant biomass (Dorgeloh 2002), and establish plots to repeatedly-measure plant phenology throughout the growing season to quantify forage availability at random sites within habitat types occupied by bighorn sheep during the lambing and early lamb-rearing seasons (spring-summer). Line-intercept transects won't have any lasting markers post-measurement but we will mark the start, end, and frame corner points at phenology plots with metal or wooden stakes (<12 inches long) so we can effectively measure phenology on the exact same plants repeatedly. Stakes will be removed after the last phenology plot reading of the study. There will be 4-12 phenology plots at each study site, with the final number depending on the major canopy cover types and elevation gradients we need to sample to effectively characterize plant phenology for the entire lamb rearing season. The number of line-intercept transects will ultimately depend on the number of different vegetation types at each study site and the variation in species-specific canopy cover between transects within the same vegetation types (i.e., we will use this variation to determine the needed sample size and potentially even split or combine vegetation types based on this variation) but will likely exceed 25 per study site. Line-intercept transects and phenology plot measurements won't result in any significant disturbance to vegetation.

During mule deer research in Idaho, we have amassed a large library of the forage quality of many plants (particularly forbs and grasses) in various phonological stages across southern Idaho, but there may be some plant species that occur on these bighorn sheep study areas which we have not yet tested. For present grass and forb species or phenological stages for which we don't have forage quality estimates, we will use clipping to collect >¼ gallon of plant material for subsequent forage analysis. Plants will be clipped near, but not in, phenology plots and line-intercept transects. We will not clip any plants that are protected under the Endangered Species Act or that have a special management status from the appropriate land management agency (e.g., U.S. Forest Service sensitive species). The exact number of species and phenological stages we'll need to clip will not be known until they are encountered, but will likely exceed 30 at each study site. We will not clip multiple species from the exact same point (i.e., creating bare ground) and will spread clippings throughout the landscape. We will obtain appropriate permission to clip vegetation on special status federal lands (e.g., Owyhee wilderness). Vegetation sampling will result in measures of species-specific canopy cover, biomass, and forage quality along with site-specific plant phenology that can be related to remotely-sensed measures of vegetation growth, with the ultimate goal of measuring bighorn sheep forage quality from remotely-sensed data (e.g., NDVI) alone.

We will conduct aerial and ground surveys to estimate bighorn sheep population abundance, population structure (ram:ewe:lamb ratios), and ram age structure. The final analysis will investigate relationships between lamb and adult survival, sheep movements, landscape forage quality, population structure, and body condition. We will look for opportunities to collaborate with researchers in neighboring States investigating related aspects of bighorn sheep nutrition and disease status.

Project accomplishments

Objective 1: Measure 50 vegetation plots for nutritional quality and biomass of vegetation available to bighorn sheep in the Owyhee River and East Fork Salmon River by 30 June 2018.

We measured 36 vegetation plots for nutritional quality and biomass of vegetation available to bighorn sheep and conducted 4 monthly phenology plots in each study area (Owyhee, Lost River, and East Fork Salmon) to track the availability and succession of plant species. A total of 32 habitat plots were measured from April to July 2018. We conducted a total of 64 vegetation plots on the project during FY18.

Objective 2: Capture and sample 50 bighorn sheep to radio-collar, document body condition, and determine disease status by 30 June 2018.

We captured 129 sheep during February and March 2018 (Table 1). We weighed them and used ultrasound and palpation to document body condition and submitted serum and blood samples for trace element analysis at the University of Idaho Analytical Sciences Laboratory. We also collected samples to test for exposure to and carriage of the respiratory pathogen *Mycoplasma ovipneumoniae* (Movi, Table 2), and other bacteria, parasites and respiratory viruses.

Table 1. Bighorn sheep captured in Idaho July 2017 – June 2018.

Population	Adult Males	Adult Females	Yearling Males	Yearling Females	Total
Hells Canyon GMU 11	6	36	2	6	50
Owyhee River	0	5	0	0	5
East Fork Salmon R.	2	17	0	0	19
Lost River Range	11	44	0	0	55
Total	18	97	2	6	129

Table 2. Proportion of bighorn sheep sampled (n) that tested positive on nasal swabs for Movi shedding and proportion that tested positive for presence of serum antibodies to Movi in Idaho bighorn sheep populations February and March 2018.

Population	n	% Movi PCR positive (shedding)	% ELISA positive (exposed)
Hells Canyon GMU 11	50	4%	44%
Owyhee River	5	0	0
East Fork Salmon River	19	21%	83%
Lost River Range	53	21%	38%
Total	127		

Objective 3: Monitor 300 radio-collared bighorn sheep and their lambs to estimate vital rates, population demographics, and movements by 30 June 2018.

We monitored approximately 274 radio-collared bighorn sheep July 2017 – June 2018 including 120 in 4 focal populations (Table 3). We experienced significant collar failures in the East Fork Salmon River and Owyhee River populations which reduced our sample size. We also completed movement analyses of collared female bighorn sheep to confirm that ground surveys used to estimate lamb survival did not significantly alter the movement rates of females.

Geographic Location

The field portions of this project are in Hells Canyon of the Snake River in Idaho, Oregon, and Washington and the Owyhee River, East Fork Salmon River, and Lost River Range of Idaho. Idaho counties include Adams, Butte, Clark, Custer, Idaho, Lemhi, Nez Perce, and Owyhee. The laboratory portion is primarily at Washington State University. Captive animal experiments are conducted at Washington State University and South Dakota State University. The alternate monitoring methods will include areas in Hells Canyon and throughout the State, some of which are scheduled for aerial surveys and/or survival estimates identified within the Project Statement for the Statewide Wildlife Surveys and Inventories Grant.

Table 3. Survival and productivity of bighorn sheep in four Idaho populations, 2017 – 2018.

Population	No. marked females	No. marked males	Female survival	Male survival	Observed productivity 2017	Lamb summer survival	Lamb:ewe ratios at 6 – 9 months
Hells Canyon (GMU 11)	34	8	0.79	1.00	0.62	0.19	0.06
Owyhee River	20	8	0.92	0.57	0.75-0.90	0.50	N/A
East Fork Salmon R.	24	8	0.92	N/A	0.89	0.77	0.39
Lost River Range	12	6	0.83	0.83	0.98	0.80	N/A

Objective 4: Produce two manuscripts from bighorn sheep research by 30 June 2018.

We published two peer-reviewed papers during this reporting period (Appendix):

Cassirer, E. F., K. R. Manlove, E. S. Almberg, P. L. Kamath, M. Cox, P. Wolff, A. Roug, J. Shannon, R. Robinson, R. B. Harris, B. J. Gonzales, R. K. Plowright, P. J. Hudson, P. C. Cross, A. Dobson, and T. E. Besser. 2018. Pneumonia in bighorn sheep: risk and resilience. Journal of Wildlife Management 82:32-45.

Plowright, R. K., K. R. Manlove, T. E. Besser, D. J. Páez, K. R. Andrews, P. E. Matthews, L. P. Waits, P. J. Hudson, and E. F. Cassirer. 2017. Age-specific infectious period shapes dynamics of pneumonia in bighorn sheep. Ecology Letters 20:1325-1336

Additional Accomplishments: We also evaluated the feasibility of ground-based mark-resight surveys for estimating abundance of bighorn sheep in the East Fork Salmon River. We conducted surveys over 4 days in December 2017. A minimum of 90 sheep were observed: 46 ewes, 15 lambs, and 29 rams. All 23 marked ewes were observed and identified to individual at least once. Two of 8 marked rams were observed and individually identified and at least one other unidentified marked ram was observed. This was the first mark-resight survey conducted in the East Fork Salmon River bighorn sheep population. More sheep were observed than in recent helicopter surveys and abundance was estimated with a 95% confidence interval of +/- 13% (Table 4). This is an effective alternative survey technique for monitoring this population.

Table 4. Abundance estimates (N) and 95% confidence intervals based on mark-resight surveys of the East Fork Salmon River bighorn sheep population, December 2017.

		Resight Probability	
	N	**11^{th}-13^{th}**	**19^{th}-21^{st}**
Ewes	49 (43 - 55)	0.71	0.78
Lambs	19 (16 – 21)		
Rams	32 (20 - 43)	0.67	0.76
Total	102 (89 – 115)		

Survival and Population Modeling of Mule and White-tailed Deer

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Idaho Department of Fish and Game needs to develop cost-effective methods to monitor and predict mule and white-tailed deer population status and trend.

Purpose

Updated estimates of mule and white-tailed deer vital rates and population demographics are needed to implement conservation and management actions.

Expected Results

- Develop fine-scale habitat maps for mule deer and white-tailed deer seasonal ranges to predict productivity.
- Estimate survival and cause-specific mortality for wintering fawns and adult females in 11 Population Management Units.

Project objectives:

1. Capture 80 male mule deer for survival estimation by 30 June 2018.
2. Monitor 200 mule deer males to estimate survival relative to hunting season structure and habitat and geographic features (i.e., security cover) by 30 June 2018.
3. Develop fine-scale habitat maps for mule deer and white-tailed deer seasonal ranges to predict productivity by 30 June 2018.
4. Estimate survival and cause-specific mortality annually for wintering fawns and adult females in 11 Population Management Units by 30 June 2018.

Approach

We will continue to refine mule deer fawn and adult doe survival models and the web-based integrated population model we've developed for mule deer population estimation in southern Idaho. Survival models incorporate weather and habitat quality variables. To accommodate ever-changing habitat quality, we must be able to measure it repeatedly and efficiently. Therefore, the development of a fine-scale vegetation model/map and methods to estimate mule deer body condition (i.e., portable ultrasound measurements of rump fat) will be crucial to this effort. Integrated population models have been constructed that include an interface for data entry and predictive modeling scenarios. These Bayesian state-space models allow for the combination of several metrics (i.e. survival, fawn ratios, population estimates) with inherently varying data quality. Data quality, importance to population estimation, and cost effectiveness will be evaluated with respect to estimate bias and variance of the predicted population size and trend. This analysis will provide a measure of minimum cost tools and gain in precision as additional funds are expended on each monitoring technique. The online interface will be improved to incorporate fawn and adult survival models and other data acquisition and analysis interfaces (e.g., harvest data, sightability models, etc.). The final product will include a detailed manual including instructions for data acquisition and model usage.

Alternative Monitoring Methods:
We will test and evaluate alternative methods to monitor mule deer. At a minimum, this evaluation will include scat collection for genetic mark-resight modeling, noninvasive genetic surveys, UAVs equipped with infrared (thermal) imaging for estimating presence and abundance, aircraft mounted infrared imaging, and ground-based surveys, among others. These techniques will be evaluated during scheduled aerial surveys for comparison. This evaluation will also include the continued development of methods involving remote cameras to estimate abundance and occupancy from unmarked animals and the further development of model-based aerial survey methodology that would allow us to utilize habitat and geographic variables to accurately estimate deer and elk abundance with aerial survey flight time. We will also evaluate new technologies for monitoring wildlife movements and survival, including solar-powered GPS transmitters in an eartag attachment package.

S**easonal Range and Migration Modelling**:
We have developed modeling techniques that use machine learning to estimate mule deer summer and winter ranges, and transitional habitats for mule deer across areas were we have location data. These seasonal range and transition habitat maps have been ‘updated’ using location data ‘streams’ provided by current GPS collaring efforts. Migration habitat has been estimated for mule deer and we are developing methods that estimate prioritized migration routes by mule deer elk numbers occurring in the vicinity. Further work in the coming year will include analysis of population spatial structure, updating covariates with more accurate information, and further scenario prediction (for example bad winter vs good winter, infrastructure development assessment). This work is complementing other studies on ungulate movement patterns for wildlife vehicle collisions, interstate ungulate range and movement (ID and adjacent areas of neighboring WY and MT), and regional ungulate range assessment. It will also be used to refine Idaho’s big game management units/zones to more accurately reflect biological populations.

Habitat Change and Connectivity Modelling:
This is a long term project to evaluate the effects of habitat change on survival and landscape connectivity. Subprojects include: 1) evaluation of population level effects of deer-vehicle collisions and the effectiveness of mitigation efforts, 2) evaluation of landscape connectivity for multiple species and potential barriers to movement, and 3) evaluation of large-scale agricultural landscape habitat changes (i.e., CRP vs ag vs native) and how populations are influenced. These questions will be addressed using existing deer population demographics and movement data (e.g., radio and GPS collar data) and fine-scale spatial data (e.g., fine-scale vegetation map) and analyses. We will look for opportunities to collaborate with other State agencies and

conservation organizations to incorporate additional data and broaden the applicability of the results and products. This research will help us better predict impacts of development (urban, roads, habitat modification), increasing the reliability of our information when we consult with other agencies and private landowners.

Buck Vulnerability:
We will initiate a project designed to predict the effects of hunting season structure and habitat security on male mule deer survival. Because one season type or structure will not produce the same mortality results in Game Management Units (GMU) of different hunter access and security cover, we will alternate through tests of season type and habitat security while maintaining adequate control GMUs. This project will utilize the ongoing statewide vegetation model/map project to provide vegetation security cover estimates. We will capture, collar, and monitor movements and cause-specific mortality of male mule deer of various ages in GMUs throughout southern Idaho that represent varying levels of human access, hunting season structure, and vegetation composition. Helicopter drive-nets (Beasom et al. 1980) will be used to capture deer but occasionally a netgun fired from a helicopter (Barrett et al. 1982) or clover traps (Clover 1956) were also used. Deer were physically restrained and blindfolded during processing with an average handling time of < 6 minutes. Male mule deer will be captured during statewide capture efforts for mule deer survival monitoring, using the same capture techniques described above. Males will be monitored with eartag transmitters, GPS collars, or a combination of both to allow monitoring of all age classes. A blood sample, body measurements, and ultrasound estimation of fat accumulation will be taken from each captured male for relation to habitat characteristics and survival rates. The research will provide managers with objective estimates of the effects of changing hunting season structure or habitat security, with the goal of maintaining hunter opportunity.

Project accomplishments

Objective 1: Capture 80 male mule deer for survival estimation by 30 June 2018.

We captured and radio-collared 117 6-month-old male fawns and 2 yearling males in January 2018 for survival and cause-specific survival estimation in conjunction with work described in F16AF00888 Mule Deer. These captures were distributed across 7 mule deer population management units (PMU) in the State. Within 3 of these PMUs, 18 males were also marked with new experimental solar-powered GPS eartags from the GPS Collars Unlimited. Both GPS collar and eartag allowed us to evaluate the performance of the new eartags with regard to successful GPS location capture and automated upload to servers. The eartag performance was less than desired, only the eartags in close proximity to Boise reliably uploaded. The company determined the GSM cellular modem was not adequate for areas with limited cell phone coverage and thus have worked with IDFG to solve these issues by redesigning the tags to allow access to all cellular networks and 4G data sources. The company has provided IDFG with 20 of the next generation eartags and we are currently testing these for a full deployment in December 2018.

Objective 2: Monitor 200 mule deer males to estimate survival relative to hunting season structure and habitat and geographic features (i.e., security cover) by 30 June 2018.

We monitored 117 male mule deer fawns and 13 adult males since January of 2018. Forty-three percent of the fawns died prior to 1 June. The largest source of mortality was coyote or lion predation, accounting for 47% of the total mortalities. The marked mule deer males remaining on 30 August will be monitored for survival and movement through the hunting season. We have developed covariates for road density and topography to estimate the effects of hunter access on buck survival as the hunting season survival data is collected.

Objective 3: Develop fine-scale habitat maps for mule deer and white-tailed deer seasonal ranges to predict productivity by 30 June 2018.

Development of the fine-scale habitat map is progressing, requiring 4 processes to complete: 1) stand delineation though image segmentation using eCognition, 2) generation of landscape-level covariates for use in predicting plant species presence, 3) producing a 1m resolution layer of structural shrub and tree overstory for use in predicting understory plant composition, and 4) predicting understory plant presence, abundance and composition of the stands identified in step 1.

Stand Delineation - We collaborated with the University of Idaho to develop initial image segmentation products for stand delineation using eCognition and artificial intelligence software. We received those products from U of I in FY17 and have completed quality control checks and data manipulations to be able to associate field data and remotely sensed data (e.g., topographic characteristics from digital elevation models) to delineated stands in FY18.

Landscape level covariates - We reclassified Land Fire Existing Vegetation Type (EVT, https://www.landfire.gov/evt.php) to include dominant overstory vegetation classes. The Land Fire forage classification has been developed for the entire state of Idaho, plus 120 miles into adjacent states, so analyses of transboundary ungulate movements will not be burdened by covariate data ending at state boundaries. These forage classifications will be used for a variety of vegetation specific spatial covariates across the State. We have also developed soil characteristics, topography, climate, and potential vegetation type covariates to be used in predicting the vegetation composition of a stand.

Fine-scale vegetation structure models - We are developing vegetation structure models across the state of Idaho that are derived from NAIP 2014 imagery ($1m^2$). Previously, NAIP imagery was 'segmented' into groups of near continuous physiognomic classes (classes of similar structure) but upon model development it was determined that these modeling base units needed to incorporate more explicit information on these structural components. Meaning, a polygonal segment needed data on the amount and percent of bare ground, grass, shrub and tree cover, in order to more accurately estimate the presence and abundance of understory plant species. To do so, NAIP imagery had an additional 'normalized difference of vegetation index' (NDVI) band added to the original 4-band NAIP imagery. NDVI is used to help discriminate shrub from tree cover, with trees having a presumed higher NDVI from foliage. Working from the 5-band NAIP imagery, 100,000 USGS quadrangles were evaluated for different classification techniques that would be most accurate in estimating bare ground, mesic grass, xeric grass, mesic shrub, xeric shrub, conifer canopy, broadleaf deciduous canopy, and open water classes. We found that more traditional maximum likelihood classifications (MLC) were more accurate then newer techniques (such as ‘support vector machines’ and ‘random forest’ techniques), but required higher personnel time in order to acquire class signatures. One reason for this is from the wide seasonality of the aerial image collection, where the NAIP imagery could contain images from different dates or even seasons adjacent to each other (e.g., an aerial image acquired in June is spatially adjacent to an image taken in November). This introduced seasonal reflectance variability increased the inaccuracy of more automated techniques. Approximately 50% of the state has since been classified using MLC techniques.

Fine scale vegetation modeling - The computer code was developed and tested for modeling understory plant species composition and abundance, using a Bayesian hierarchical modeling framework, for each of the 130 candidate understory species. The best predictive models using the above covariates will be produced when the structural modeling is complete. The models will then be combined to estimate plant composition of each stand identified in the previous sections. After the fine-scale vegetation model is complete, we will begin the final stage of this project to estimate forage quality within mule deer and white-tailed deer summer ranges. This vegetation quality can then be linked to survival and carry capacity. Vegetation phenology is an important aspect in the annual forage quality estimate and we are being forced to change our typical methods due to changing technology. Seasonal vegetation growth (from satellite derived NDVI) has recently been monitored in Idaho using the MODIS series of satellites in operation since 2000. Recently, USGS EROS data center discontinued one of the MODIS data streams (eMODIS derived from the Terra satellite platform). We’ll need to transfer monitoring data to 8-day NASA surface reflectance composite products (lpdac: MOD09Q1) and derive NDVI from these image databases to provide a reliable stream of data for our forage quality models.

Objective 4: Estimate survival and cause-specific mortality annually for wintering fawns and adult females in 11 Population Management Units by 30 June 2018.

We continue to make improvements to our population modeling software, PopR, to include features that provide enhanced estimate tools and more user options. In FY18, we changed the interface to a dashboard style where the user can see all of the input data prior to running models, allowing for better data quality control prior to modeling. We have changed survival modeling from a monthly survival status to a higher frequency status update to coincide with our ability to more-frequently determine survival status with the new GPS collars we are using on deer. We have provided a survival tab for automated survival modeling. We have modified the aerial survey estimation to simplify data entry and provide additional models (elk).

Using PopR, we estimated age-specific survival and abundance for 10 of our mule deer PMUs. We estimated cause specific mortality for 248 fawns and 553 adult females in 7 PMUs in conjunction with project number F16AF00888 Mule Deer of the Survey and inventory grant. Winter fawn mortality was 43% and adult doe winter mortality was low at 6%. The primary cause of mortality in both age classes was predation, which is common in low snowfall years.

Geographic Location

Project activities will primarily be model and software development and assisting management biologists with mule deer capture, collaring, and monitoring in Adams, Washington, Payette, Gem, Boise, Elmore, Valley, Custer, Lemhi, Clark, Butte, Blaine, Camas, Gooding, Lincoln, Twin Falls, Cassia, Power, Oneida, Bannock, Bingham, Bonneville, Caribou, Franklin, and Bear Lake counties. Capture of male mule deer will occur during, and in the same locations as, female and fawn mule deer capture for the statewide monitoring project with the exception of the addition of Owyhee County for male captures. The alternate monitoring methods will include additional areas that are scheduled for aerial survey population and/or survival estimates identified within the Project Statement for the Statewide Wildlife Surveys and Inventories grant.

Prepared by: Mark Hurley, Scott Bergan, Brendan Oates, Mark Hebblewhite, Paul Lukacs, Josh Nowak, and Charles Henderson

Effects of Wolf Predation on Elk and Moose Populations

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Idaho Department of Fish and Game needs to precisely estimate the effect of wolf predation on elk and moose to determine appropriate conservation and management actions, including harvest seasons.

Purpose

Collect, analyze, and report on winter calf and annual adult female survival and habitat use information. Implement a study plan to investigate the cause of moose decline in portions of Idaho. Pregnancy is an essential, but not easily obtained at the population scale, vital rate for modeling elk populations within the IPM framework. This research is evaluating several methods of estimating pregnancy from remote (e.g., NDVI from satellite) or non-invasive (e.g., fecal) methods. This work is designed to further investigate the cause of declining moose populations in Idaho and will help larger, North American research efforts by determining if habitat quality/nutrition may be playing a role in population performance.

Expected Results

- Develop a model of elk survival that incorporates the effects of wolf predation risk.
- Quantitatively evaluate the influence of other covariates (weather, vegetation condition, and alternate prey) on that relationship.
- Estimate survival and population demographics of moose with respect to predation, disease and parasites, and climate.
- Develop and implement a study plan to test and evaluate alternative methods to monitor elk and moose populations.

Project objectives

1. Develop one (manuscript) integrated population model for estimating wolf pack abundances through time by 30 June 2018.
2. Develop one draft manuscript on winter calf survival by 30 June 2018.
3. Develop one manuscript on annual adult female survival by 30 June 2018.
4. Develop one model-based approach manuscript for estimating elk abundance by 30 June 2018.

5. Implement study plan to evaluate cause of moose decline in parts of Idaho by 30 June 2018.
6. Collect fecal samples through foot and motorized surveys to predict pregnancy with remotely-sensed spatial data or fecal diet selection data alone by 30 June 2018.
7. Complete 120 fecal pellet transects for moose by 30 June 2018
8. Complete 160 vegetation transects for moose by 30 June 2018.

Approach

To date, we've compiled cause-specific survival data from 1,121 adult cow and 879 6-month-old calf elk collared statewide since 2004 and have developed an integrated population model to reconstruct wolf pack abundances based on ~275 collared wolves statewide. The wolf IPM will be used to spatially and temporally describe wolf abundance during the lives and deaths of collared elk. During FY18 we will construct final elk survival models, which consider wolf abundance and various other covariates that could affect survival (e.g., vegetation growth from NDVI) and/or the predator-prey relationship between elk and wolves (e.g., snowpack data from SNOTEL sites), and write a final report describing findings.

Modeled Effects of Predator Harvest on Ungulate Survival:
We will utilize all of the historic ungulate and predator population monitoring data in the State, new data collected during statewide elk and mule deer population monitoring, and data acquired from collaborating States and the scientific literature, to evaluate the effect of removing predators on prey populations, other predator populations, and the cascading effects on their prey populations. This modeling-only effort will estimate how the harvest of various predators (wolf, bear, or lion) will impact growth of ungulate populations. Models developed during this project will then be tested and refined as new ungulate and predator population data is acquired.

Elk Population Modeling:
The following integrated population model (IPM) development will be based on information collected primarily from elk radio-collared as part of the statewide elk monitoring program. We will assist management with helicopter net gunning, aerial or ground darting, or clover trap elk captures. Elk will be physically restrained or chemically-immobilized and blindfolded during processing with an average handling time of <6 minutes. During processing, we will collect age, body measurements, blood samples, and fecal samples. We will estimate elk survival and cause-specific mortality across the range of major habitat types and productivity levels in Idaho by maintaining a sample of over 800 GPS-collared adult female and 6-month old male and female elk statewide. Collared elk will be allocated across the State based on habitat type/productivity and elk abundance. In addition to survival, we will measure elk pregnancy through blood collection and nutritional condition with rump fat measurements taken with a portable ultrasound unit. All of this information will be used to inform a web-based elk IPM similar to the one developed for mule deer.

Predicting Elk Pregnancy:
Pregnancy is an essential, but not easily obtained at the population scale, vital rate for modeling elk populations within the IPM framework. If we were able to accurately estimate pregnancy rates without collecting hundreds of blood samples each year it would dramatically improve our

efficiency. This research is evaluating several methods of estimating pregnancy from remote (e.g., NDVI from satellite) or non-invasive (e.g., fecal) methods. We will collect vegetation biomass, forage quality, and fecal samples from elk within at least three study site elk zones of differing habitat types and presumed different forage quality (Diamond Creek, Salmon, and Sawtooth elk zones). Vegetation sampling protocols will be similar to those outlined for the bighorn sheep nutrition, demographics, and movements project outlined previously, with the exception of biomass will be estimated on this project by clipping, drying, and weighing samples from each elk forage species. Like with the bighorn sheep vegetation collection, we will obtain all necessary permits from the land management agency and refrain from collecting special-status plants. We will attempt to collect fecal samples from both the population within each zone and from collared individuals so we can link diet selection back to individual pregnancy. We will collect fecal samples through foot and motorized surveys to observe elk. Motorized vehicles will remain on roads and trails open to motorized travel. We will relate pregnancy rate to habitat quality, diet selection, and remote measures of vegetation greenness (i.e., NDVI) with the ultimate goal of predicting pregnancy with remotely-sensed spatial data or fecal diet selection data alone.

Seasonal Range and Migration Modelling:
We have developed modeling techniques that use machine learning to estimate elk summer and winter ranges, and transitional habitats for elk across areas were we have location data. These seasonal range and transition habitat maps have been 'updated' using location data 'streams' provided by current GPS collaring efforts. Migration habitat has been estimated for elk and we are developing methods that estimate prioritized migration routes by elk numbers occurring in the vicinity. Further work in the coming year will include analysis of population spatial structure, updating covariates with more accurate information, and further scenario prediction (for example bad winter vs good winter, infrastructure development assessment). This work is complementing other studies on ungulate movement patterns for wildlife vehicle collisions, interstate ungulate range and movement (ID and adjacent areas of neighboring WY and MT), and regional ungulate range assessment. It will also be used to refine Idaho's big game management units/zones to more accurately reflect biological populations.

Moose Population Performance:
This work is designed to further investigate the cause of declining moose populations in Idaho and will help larger, North American research efforts by determining if habitat quality/nutrition may be playing a role in population performance. We are working collaboratively with other state moose researchers as part of a collaborative effort to understand North American moose population changes. Our main objectives in this study are to 1) estimate forage quality and quantity across study area with varying moose population performance and 2) link forage quantity and quality to moose body condition and population performance. For objective 1, we are using measurements taken from >250 vegetation transects, and associated vegetation clipping and forage quality analysis, to estimate total shrub biomass, willow (Salix spp.) biomass, and the relative quality of forage. For objective 2, we are estimating moose abundance with pellet counts and using fecal nitrogen from collected fecal samples to estimate digestible energy intake. Additional products will include 1) an estimation of changes in shrub biomass over time using measurements taken during this project and aerial imagery take during this project and in previous years to estimate changes in biomass, 2) maps of moose forage quality at each study

area, and 3) a thorough species list of moose diet from fecal collections that can facilitate future work.

The current research in north Idaho will conclude during FY18 with all final analyses and a final report. Field work during FY18 will include continuation of work assessing the impacts of nutrition and habitat on moose population trajectory, with potential expansion of the project into additional moose habitat types in southeastern Idaho (i.e., aspen-dominated landscapes) where nutritional condition is presumed high but moose population performance has declined in during the last decade. We may also expand the project to examine relationships between habitat, movements, and parasites/disease.

Project accomplishments

Objective 1: Develop one (manuscript) integrated population model for estimating wolf pack abundances through time by 30 June 2018.

We completed and submitted a manuscript in March 2018 to the Journal of Wildlife Management describing an integrated population model (IPM) that we developed for estimating wolf pack abundances. In addition to providing monthly estimates of wolf pack sizes across Idaho from 2005 – 2016, the IPM also allowed us to estimate probabilities of harvest and dispersal as well as pup recruitment into packs. We used the IPM to determine trends in harvest, evaluate recruitment during periods with and without harvest, and estimate the degree to which harvest is additive versus compensatory.

Objectives 2 & 3: Develop one draft manuscript on winter calf survival and one manuscript on annual adult female survival by 30 June 2018.

Following submission of the wolf IPM manuscript, we incorporated the results of that model into the analysis of calf and cow elk survival. We completed the majority of a draft manuscript (introduction, methods and results) by the end of this reporting period. We decided not to write separate cow and calf manuscripts because they were closely related and combining them made for a more complete study. Anticipated submission of this manuscript is fall 2018. Our survival models for cows and calves allowed us to quantitatively predict the effects of changes in wolf pack size, snow depth, chest girth (calves), and age (cows) on elk survival.

Objective 4: Develop one model-based approach manuscript for estimating elk abundance by 30 June 2018.

We intended to evaluate a model-based approach for estimating elk abundance using aerial surveys. However, progress on this objective was contingent on securing a post-doc research scientist to work on the project. We were unable to secure an acceptable post-doc who had the skills to complete this objective. Thus, no progress was made on this objective during this reporting period.

Objective 5: Implement study plan to evaluate cause of moose decline in parts of Idaho by 30 June 2018.

To understand the causes of moose declines, it is first necessary to understand how abundance changes over time and space. Therefore, we developed and executed a pilot project to monitor moose abundance in GMUs 76 and 10A in southeast and north Idaho, respectively. In GMU 76, we deployed 45 trail cameras to a study area of 1.5 km^2 grid cells (approx. 207 km^2) during early March when moose are concentrated on winter range. Cameras were programmed to take photos using both motion-trigger and 2-minute time-lapse. In GMU 10A, we took advantage of an existing grid of cameras used for elk monitoring to assess whether we could monitor moose and elk simultaneously. In both study areas, we also captured and fitted adult female moose (n=5 in GMU 10A and n=8 in GMU 76) with GPS collars to better understand movement rates and habitat selection within each study area. We are currently processing and analyzing camera data to model abundance and ratios of adults to young in the study areas. Using the camera locations, we will be able to relate environmental factors (e.g., snow depth, drought conditions, NDVI, vegetation composition) to abundance to evaluate population performance.

Objective 6: Collect fecal samples through foot and motorized surveys to predict pregnancy with remotely-sensed spatial data or fecal diet selection data alone by 30 June 2018.

We collected 80 additional blood and fecal samples for pregnancy status of adult cows in the Sawtooth and Diamond Creek elk zones and South Fork of the Clearwater drainage area during the 2017-2018 winter. Late season hunters were helpful in collecting samples in both zones. We are currently working on mapping the nutritional landscape, with biomass regressions completed for each study area, and the FRESH nutrition model completed for the Diamond Creek Zone. Our expected completion date for all analyses is mid-October 2018.

Objectives 7 & 8: Complete 120 fecal pellet transects and 160 vegetation transects for moose by 30 June 2018.

Moose fecal collections and vegetation transects occurred during FY17. During FY18, the graduate student project utilizing the fecal pellets and vegetation transects to assess relationships between moose diet selection, forage quality and availability, and population declines was completed. The following is the citation for the resulting thesis.

Schrempp, T. 2017. Diet selection, forage quality, and forage availability: could forage limit moose populations in northern Idaho? M.S. Thesis, University of Idaho, Moscow.

During the project we evaluated diet selection with fecal samples, analyzed forage shrubs for nutritional quality, conducted field sampling to model forage availability, and looked for evidence of forage limitations. Moose in northern Idaho exhibited greater selection for forage species that are of moderate to high quality and highly available on the landscape. Variation in predicted forage quantity among GMUs was correlated with variation in indices of population performance. Results suggest that forage is an underlying factor in moose population performance trends observed across northern Idaho. This information can be used to shape forest management strategies and harvest recommendations, and to direct future research into proximate factors influencing Shiras moose throughout their range.

Additional accomplishments:
We cleaned our elk GPS location database and removed duplicates to Sept. 2016. We are using this data to identify, quantify, and qualify movement corridors statewide (and beyond the state lines for areas of transboundary ungulate movement, WY and MT). We used the net squared displacement technique to delineate winter range, spring migration, summer range, and fall migration statewide for available locations. We also developed an integrated model that calibrates and prioritizes elk movement corridors according to their estimated use (e.g., numbers of elk likely using the corridor). Elk numbers were estimated from winter count and composition surveys (2000-present). Winter and summer range locations were estimated using a maximum entropy (machine learning algorithm) to estimate these ranges using landscape composition, meteorological, and phenological spatially explicit covariates. Once start and end points were identified from net squared displacement seasonal ranges, elk were simulated to cross a 'resistance surface' to the corresponding migration end point. The resistance surface values were estimated using maximum entropy derived estimates from elk migrating within the region in a circuit theory estimation framework. Resulting migration route spatial estimates were then calibrated from the number of elk likely to use them and summed across all elk populations being estimated in the region. This tool will be useful in estimating potential ungulate movement corridors where location data is sparse but regional assessment of ungulate spatial behavior is available.

Geographic Location

Elk survival and population modeling work will occur in Boundary, Bonner, Shoshone, Kootenai, Clearwater, Idaho, Valley, Adams, Washington, Boise, Elmore, Custer, Camas, Blaine, Gooding, Lincoln, Butte, Lemhi, Clark, Bonneville, Bingham, Caribou, and Bear Lake counties. Moose population performance work will occur in Kootenai, Clearwater, Idaho, Bonneville, Bingham, Caribou, and Bear Lake counties.

Prepared by: Jon Horne, Scott Bergan, Brendan Oates, Tom Schrempp, and Sierra Robatcek

Greater Sage-grouse Ecology and Management

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs knowledge on factors affecting sage-grouse populations, including land-use practices and environmental factors, to make science-based recommendations for conservation and management.

Purpose

Conduct research on 4 study areas and monitor VHF radio-collared female sage-grouse to investigate effects of livestock grazing on vital rates and population demographics. Prepare manuscript assessing habitat requirements for sage-grouse. The greater sage-grouse population within the greater Curlew area of Idaho has been declining during recent years, prompting IDFG to close sage-grouse hunting seasons in most of Oneida and Power counties. We plan to provide technical assistance for study design, data analysis, and reporting and financial support of GPS data acquisition to the BLM, USFS, and IDFG regional management biologists undertaking the data collection aspects of the project.

Expected Results

- Investigate effects of livestock grazing on sage-grouse vital rates to guide habitat conservation/improvement efforts.
- Assessment of sage-grouse production, habitat use, and movements within high-elevation sagebrush habitats.

Project objectives

1. Capture, mark with VHF radios, and monitor 465 (250 in FY18) sage-grouse to estimate vital rates and population demographics by 30 June 2018.
2. Conduct nondestructive vegetation sampling on 450 (350 in FY18) vegetation plots to estimate habitat relationships for nesting and brood rearing for sage-grouse by 30 June 2018
3. Prepare one manuscript describing habitat requirements for sage-grouse by 30 June 2018.
4. Conduct spring helicopter aerial surveys to determine the current distribution and status of occupied and historic sage-grouse leks in the greater Curlew area by 30 June 2018.

5. Conduct habitat assessments using BLM HAF methods at sage-grouse use sites (nests) and at random locations throughout available shrub-steppe habitat in the greater Curlew area by 30 June 2018.
6. Maintain a sample of at least 30 adult sage-grouse (all female if possible) fitted with GPS transmitters (PTT) throughout the study area to assess adult survival, nest site selection, nest success, brood success, and seasonal movements by 30 June 2018.
7. Provide 25 days field and technical support for high-elevation and Curlew sage-grouse projects by 30 June 2018.

Approach

Effect of Livestock Grazing:
Greater sage-grouse were once widespread within sagebrush-grassland ecosystems of western North America, but populations have declined since the mid-1960s (Schroeder et al. 2004, Garton et al. 2011). Land-use practices including livestock grazing within sage-grouse breeding habitat will continue to be closely scrutinized because the major threats to sage-grouse populations include reduction in the quantity and quality of their habitat Livestock grazing is the most extensive land use within greater sage-grouse habitat and the effect of grazing on sage-grouse is controversial (Beck and Mitchell 2000). Despite many studies of sage-grouse habitat requirements, we know surprisingly little about the effects of livestock grazing on sage-grouse populations and habitat characteristics. As a result, various groups make claims about the presumed effects of livestock grazing on sage-grouse, and litigation over this issue is common. A thorough review of the effects of grazing on sage-grouse habitat reported a lack of rigorous information and the need for replicated field experiments to determine the effects of grazing on sage-grouse demographic traits (Beck and Mitchell 2000). Thirteen years have passed since that review, but replicated grazing experiments have not been conducted. Several current studies are evaluating the relationship between cattle grazing and sage-grouse, but these studies are taking different approaches to evaluate the effects of grazing on sage-grouse. A current study in Montana is designed to: 1) measure the effects of a rest-rotation grazing system (where cattle typically spend <2 weeks in a pasture before they are moved) on vegetation parameters that likely influence nest-site selection and nest survival of sage-grouse, and

2) evaluate whether patterns of nest placement and nest survival of radio-marked hens differ among continually grazed pastures and two types (currently rested and currently grazed) of rest-rotation pastures. A study in Utah is comparing demographic traits between two sites, one site with a rotational grazing system and a second site with annual grazing that will be switched over to rotational grazing in the third year of the study. However, nesting propensity was low (32%) and a higher-than-expected number of the radio-marked hens moved long distances and did not nest within the two treatment areas. Hence, the sample sizes available to evaluate grazing effects on sage-grouse are limited in the Utah study. This gap in our knowledge prevents federal land managers from instituting science-based management plans on public lands that harbor sage-grouse populations. To address this need, we proposed a rigorous large-scale set of replicated experiments to examine the effects of different levels of spring cattle grazing on a suite of sage-grouse behavioral and demographic traits. We will focus on spring grazing because grazing could potentially affect sage-grouse via multiple mechanisms during spring and early summer.

This study will provide the first rigorous assessment of the effects of cattle grazing on sage-grouse populations.

Objectives:
We will pursue the following 3 objectives that examine the effects of grazing on sage-grouse. The field work required to address all 3 objectives will be conducted in the same study sites.

1. Document the effects of different levels of cattle grazing intensity on sage-grouse demographic and behavioral traits including: nesting propensity, nest initiation date, clutch size, daily nest survival, re-nesting rate, brood size, brood survival, post-fledging movements, natal recruitment, hen survival, inter-annual nest-site fidelity, and site occupancy.
2. Document the effects of different levels of cattle grazing intensity on density and diversity of insects (species common in sage-grouse diets) within sage-grouse breeding habitat.
3. Document the effects of different levels of cattle grazing intensity on nest concealment, sagebrush canopy cover, density and diversity of grasses and forbs, and other vegetation features that contribute to sage-grouse habitat suitability.

Methods:
For these objectives, we will employ a two-tiered approach (correlative and experimental) to evaluate effects of different intensities of spring cattle grazing on sage-grouse habitat selection, insect abundance and diversity, and a suite of sage-grouse demographic and behavioral traits including: nesting propensity (likelihood that a radio-collared female initiates a nest), nest initiation date, clutch size, daily nest survival, re-nesting rate (probability that a radio-collared hen whose nest fails initiates a new nest the same season within the same area), brood size, brood survival, post-fledging movements, natal recruitment (probability that a banded chick that fledged from a nest is detected as an adult the subsequent year), and hen survival (probability that a banded or radio-collared hen that nested in an area is detected the subsequent year). For the correlative approach, we will document the relationships between spatial foraging patterns of cattle and our suite of sage-grouse response variables (see list above). We will then use the information on sage-grouse nest placement gained from the correlative portion of the study to identify areas where we will experimentally alter the extent of herbaceous offtake by cattle and assess the effects of these changes on our suite of response variables. We will compare areas where up to 40% of the available forage has been taken by herbivores to areas that are not grazed for three consecutive years. The exact location of these experimental grazing treatments at each site will be identified at the end of the initial, correlative phase of the study (once we know where hens typically place nests at each site). We will use water, salt, herding, topography, and fencing (existing and new temporary electric fencing) to alter grazing intensity in our treatment areas. We will also include the duration of spring cattle grazing as a covariate in the analysis to account for variation in duration of grazing among allotments which may influence the extent to which spring grazing affects sage-grouse populations.

In addition to sage-grouse demographic traits, we will also measure the following sage-grouse habitat characteristics, both before and after treatment: sagebrush canopy cover and height, cover and height for other shrub species, cover, height, and diversity of grasses and forbs, frequency of herbaceous species, litter, bare ground, and insect abundance. We will compare habitat characteristics, both before and after grazing treatments are implemented, to values reported in peer-reviewed literature for other populations of sage-grouse.

Properly evaluating the effects of experimental changes in grazing on sage-grouse reproductive parameters is challenging for an animal where individuals move such great distances between breeding site (lek), nest site, and brooding-rearing site. Success of this project will depend on: 1) a sufficient number of replicates (study sites); 2) a commitment to monitor response variables at each study site for numerous years before and after experimental manipulation of grazing intensity; and 3) collaboration among many individuals and organizations, including experts in sage-grouse ecology, GIS, rangeland management, botany, entomology, and plant/wildlife nutritional ecology.

Sage-grouse fitness in high-elevation sagebrush habitats:
We are cooperating on a BLM-led project examining sage-grouse habitat selection and fitness in high-elevation sagebrush habitats of eastern Idaho. We plan to provide field support, support for PTT data acquisition, technical advice, and analysis and writing support for this research project.

Sage-grouse inhabiting mountain foothill, higher-elevation habitats (i.e., dominated by mountain big sagebrush and/or low sagebrush above 1,500 m elevation; hereafter high-elevation sagebrush) may or may not interact with their habitat similarly to sage-grouse inhabiting the more-studied, lower-elevation habitats of southern Idaho (i.e., dominated by Wyoming big sagebrush). In recent years there have been numerous, independent efforts to document location-specific sage-grouse movements and seasonal habitat use throughout high-elevation sagebrush habitats in eastern Idaho. This project seeks to pool survival, reproduction, location, and vegetation data across these locales to model the relationship between sage-grouse fitness and habitat and model movement corridors in these unique habitats. This coordinated modeling effort will provide useful information for habitat management and restoration efforts that will have population-level impacts and negate the need to monitor birds in every specific high-elevation sagebrush habitat locale. Analyses conducted at multiple spatial scales (i.e., traditional microsite habitat characteristics plus macrosite or landscape scale habitat evaluation) will facilitate application of research results within the landscape scale at which federal agencies manage habitats. Model results identifying the attributes of high-elevation sagebrush habitats where sage-grouse are successful at recruiting young and surviving will be compared to attributes of habitat at manipulated sites (e.g., burns of varying age/type, grazing of various types/intensities) to evaluate the benefits or detriments of various management activities on sage-grouse production and persistence, thereby informing future management actions.

Objectives:
The following are our objectives for researching sage-grouse production, habitat use, and movements within high-elevation sagebrush habitats of eastern Idaho:

1. Model sage-grouse nest and brood site selection and success in relation to habitat, climatic, landscape, and anthropogenic variables to identify source and sink habitats across three high-elevation sagebrush study sites in eastern Idaho.

2. Compare characteristics of source and sink habitats identified in #1 to habitats manipulated with various management prescriptions (e.g., prescribed fire of various age, wildfire of various age, varying grazing regimes, etc.) to evaluate management action benefits and detriments to sage-grouse population dynamics.
3. Identify sage-grouse seasonal habitat use areas (i.e., breeding, early brood rearing, late brood rearing, wintering) and movement corridors throughout each high-elevation study site.

Methods:
We will capture sage-grouse on and near leks with standard spotlighting techniques or rocket netting. Captured hens will be weighted, aged, leg-banded, fitted with either a rump-mounted, GPS platform terminal transmitter (PTT) or VHF radio-collar and released on site. Captured males will be weighed, aged, leg-banded and released on site. PTTs will be programmed to collect 6 locations per day for approximately 2 years. Our goal is to monitor at least 30 hens/year at each of the three study sites (Sand Creek, Lemhi, Pahsimeroi). We will monitor hens from capture to mortality or collar failure to document nesting attempts, nest success, brood success (survival to 42 days of age), and annual survival. Inspection of nest remains after the hen has left the nest or during incubation recesses will be used to determine nest status/fate. Vegetation measurements at nests and random sites will be conducted within 7 days hatching or at expected hatch date (27 days from start of incubation), after the hen has departed the area. Hens with successful nests will be flushed at 42-days post-hatch and surviving chicks counted. Otherwise, all attempts will be made to not disturb birds during monitoring.

We will define available nesting/early brood-rearing habitat (hereafter nesting habitat) for each study site as all suitable sage-grouse habitat—as identified by the 2013 Idaho Sage-grouse Habitat Planning Map cooperatively developed between IDFG, U.S. Forest Service, Idaho National Laboratory, Idaho Sage-grouse Local Working Groups and other cooperators—within 18 km of capture leks. Within available nesting habitat, we will use orthophotography, soils information, fire history, grazing history, habitat delineations (e.g., Idaho GAP land cover) and other available spatial data to delineate polygons of likely monotypic vegetation type and structure. Then we will conduct line transect surveys using the BLM's Habitat Assessment Framework (HAF) protocols to describe vegetation type and structure within each delineated polygon. Polygons will then be attributed with HAF plot data in GIS, forming a fine-scale map of available nesting habitat for each study area that includes polygon-specific shrub, forb, and grass density and diversity that can be used in subsequent habitat analyses. These habitat maps will be used to assess macrosite or landscape-scale habitat selection for nests and broods and how that selection may influence success or failure. We will also conduct HAF transects at each nest site (HAF transect centered on nest site at random bearing) to assess microsite nest characteristics. Microsite characteristics at nests will be compared to characteristics of one or more random HAF plots within the study area.

We will use resource selection functions to evaluate nest and brood habitat selection with respect to habitat, anthropogenic, and topographic variables and Cox proportional hazards modeling to evaluate the influence of these variables on nest and brood success. Then we will combine the selection results (i.e., habitat with high probability of use as nest or brood habitat) with the success results (i.e., habitat where nests or brood were successful) to identify habitats that are both selected and beneficial to success (i.e., source habitat) versus habitats that are selected but not beneficial to success (i.e., sink habitat). We will map source and sink habitats across each study area using GIS. We can then overlay layers of past management prescriptions (i.e., prescribed fire, grazing pastures, etc.) on the source-sink map to assess each specific prescription's impact on sage-grouse fitness. We will assess home ranges, seasonal movement paths, and important stopover sites with Brownian Bridge Movement Models (BBMM).

Demographics and Lek Distribution in the Curlew:
The greater sage-grouse population within the greater Curlew area of Idaho has been declining during recent years, prompting IDFG to close sage-grouse hunting seasons in most of Oneida and Power counties. The BLM and U.S. Forest Service (USFS) have initiated research to determine what factors are contributing to the decline and investigate why the population seems unable to rebound in years when other populations are increasing. We plan to provide technical assistance for study design, data analysis, and reporting and financial support of GPS data acquisition to the BLM, USFS, and IDFG regional management biologists undertaking the data collection aspects of the project.

The specific objectives of the project are to 1) conduct spring helicopter aerial surveys to determine the current distribution and status of occupied and historic sage-grouse leks in the greater Curlew area, 2) conduct habitat assessments using BLM HAF methods at sage-grouse use sites (nests) and at random locations throughout available shrub-steppe habitat in the greater Curlew area, and 3) maintain a sample of at least 30 adult sage-grouse (all female if possible) fitted with GPS transmitters (PTT) throughout the study area to assess adult survival, nest site selection, nest success, brood success, and seasonal movements.

Sage-grouse will be captured on or near leks using standard spotlighting and rocket net techniques during the spring breeding season. Captured birds will be fitted with a rump-mounted, solar PTT GPS transmitter or VHF collar and released at the site of capture. Inspection of nest remains after the hen has left the nest or during incubation recesses will be used to determine nest status/fate. Vegetation measurements at nests and random sites will be conducted within 7 days hatching or at expected hatch date (27 days from start of incubation), after the hen has departed the area. Hens with successful nests will be flushed at 42-days post-hatch and surviving chicks counted. Otherwise, all attempts will be made to not disturb birds during monitoring.

Project accomplishments

Objective 1: Capture, mark with VHF radios, and monitor 465 (250 in FY18) sage-grouse to estimate vital rates and population demographics by 30 June 2018.

We captured, marked, and monitored 209 female greater sage-grouse for the grazing sub-project and 82 females for the high elevation sub-project during FY18.

Objective 2: Conduct non-destructive vegetation sampling on 450 (350 in FY18) vegetation plots to estimate habitat relationships for nesting and brood rearing for sage-grouse by 30 June 2018.

We sampled vegetation at 151 nest plots, 433 independent random plots, and 3,987 utilization plots for the grazing sub-project. In addition, we sampled 178 plots for insects using pitfall traps and sweep net transects for the grazing sub-project. We sampled vegetation at 72 nests and 28 random plots for the high elevation sub-project.

Objective 3: Prepare one manuscript describing habitat requirements for sage-grouse by 30 June 2018.

One manuscript describing nesting requirements of sage-grouse and developing new methods to quantify vegetation for sage-grouse was submitted to the Journal of Fish and Wildlife Management. A revision of the manuscript is currently underway and it will be resubmitted for peer-reviewed publication in FY19.

Objective 4: Conduct spring helicopter aerial surveys to determine the current distribution and status of occupied and historic sage-grouse leks in the greater Curlew area by 30 June 2018.

Four mornings of helicopter surveys were conducted in the Curlew study area in spring 2017 (FY17) to document current lek distribution and abundance for comparison to past survey data. No aerial lek surveys were planned or flown in FY18.

Objective 5: Conduct habitat assessments using BLM HAF methods at sage-grouse use sites (nests) and at random locations throughout available shrub-steppe habitat in the greater Curlew area by 30 June 2018.

Vegetation was sampled at 26 nest plots and 26 random plots using the BLM HAF/AIM sampling protocol. Data will be used to analyze vegetation characteristics of nests relative to available habitat and better understand differences in vegetation characteristics between successful and unsuccessful nests.

Objective 6: Maintain a sample of at least 30 adult sage-grouse (all female if possible) fitted with GPS transmitters (PTT) throughout the Curlew study area to assess adult survival, nest site selection, nest success, brood success, and seasonal movements by 30 June 2018.

Monitored 40 PTT-marked female greater sage-grouse in the Curlew study area for survival, nest site selection, nest success, brood success, and seasonal movements.

Objective 7: Provide 25 days field and technical support for high-elevation and Curlew sage-grouse projects by 30 June 2018.

IDFG wildlife research staff provided 25 days of technical support to the high-elevation and Curlew sage-grouse sub-projects.

Geographic Location

Study areas include the Shoshone Basin, Big Desert, Jim Sage Mountains, Sheep Creek, Pahsimeroi River Valley, Sand Creek desert, Lemhi River, Rockland Valley, Arbon Valley, and the Black Pine area. Idaho counties include Twin Falls, Cassia, Minidoka, Owyhee, Oneida, Blaine, Power, Butte, Cassia, Custer, Clark, Fremont, and Lemhi counties.

Prepared by: David Musil and Shane Roberts

Columbian Sharp-tailed Grouse Research

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs to understand the ecology of Columbian sharp-tailed grouse and the effects of landscape uses.

Purpose

Provide personnel and operating support for the Columbia Sharp-tailed Grouse research project (F13AF01005).

Expected Results

Allow PR funded research staff support for ongoing Columbian sharp-tailed grouse research projects in eastern Idaho (F13AF01005).

Project objective

1. Provide 15 personnel and operating support days for the research project evaluating effects of CRP-SAFE on Columbian Sharp-tailed Grouse by 30 June 2018
2. Provide 10 personnel and operating support days for the Tex Creek WMA Columbian Sharp-tailed Grouse research project by 30 June 2018.

Approach:

Analysis of statewide Columbian sharp-tailed grouse habitat, demographic, and harvest data collected through upland game survey and inventory management program.

Project accomplishments

Objective 1: Provide 15 personnel and operating support days for the research project evaluating effects of CRP-SAFE on Columbian Sharp-tailed Grouse by 30 June 2018

Wildlife research staff provided 15 days of personnel and operating support for research evaluating CRP-SAFE plantings and their impact on Columbian sharp-tailed grouse. Efforts included analyses and final report preparation for the NRCS Conservation Innovation Grant associated with the research, examinations of methods to utilize unmanned aerial vehicles to assess CRP-SAFE planting structure and composition, coordination with Idaho State University staff collaborating on UAV work, and test flights of UAVs in CRP-SAFE habitats.

Objective 2: Provide 10 personnel and operating support days for the Tex Creek WMA Columbian Sharp-tailed Grouse research project by 30 June 2018.

Wildlife research staff provided over 10 days of personnel support conducting analyses and assisting with preparation of a manuscript describing Columbian sharp-tailed grouse nest site selection and success in eastern Idaho that was submitted for publication in the Journal of Wildlife Management. The manuscript is currently proceeding through the peer-review process.

Geographic Location

Bonneville, Power, Teton, Jefferson, and Fremont counties, Idaho

Prepared by: Shane Roberts and David Musil

Evaluating effects of CRP-SAFE on sharp-tailed grouse vital rates

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs to understand the effects of CRP-SAFE on sharp-tailed grouse to provide technical support and guidance for farm bill program implementation to benefit upland game birds.

Purpose

To provide personnel support for F13AF10005 and other approved Columbian Sharp-tailed Grouse Research projects and evaluate the influence of CRP-SAFE projects on Columbian Sharp-tailed grouse populations.

Expected Results:

- Determine if vegetation in CRP-SAFE fields have met objectives to establish native grasses, forbs, and shrubs beneficial to Columbian sharp-tailed grouse
- Determine vital rates and population trends for Columbian sharp-tailed grouse associated with CRP-SAFE fields.

Project objectives:

1. Complete data analysis and develop a comprehensive report on the findings from this project by 30 June 2018

Approach:

We will complete data analysis and develop a comprehensive report on the findings from this project.

Project accomplishments

Objective 1: Complete data analysis and develop a comprehensive report on the findings from this project by 30 June 2018.

We completed all data analyses and developed a comprehensive final report that was submitted to the project's primary funding source (NRCS Conservation Innovation Grant 68-0211-15-099) in FY18.

Geographic Location

Power, Teton, Jefferson, and Fremont counties, Idaho

Prepared by: Shane Roberts

Gray wolf monitoring and ecology

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students, to obtain needed information. This project will help the Department and the Fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs contemporary vital rate and population level information for conservation and management of gray wolves.

Purpose

Survey rendezvous sites to quantify number of wolves present. Develop manuscript for peer-reviewed publication linking wolf harvest to pack size, recruitment, and territory size.

Expected Results

- Improve patch occupancy modeling for estimating wolf abundance and distribution.
- Evaluate link between wolf harvest level and pack size, recruitment, and territory size.
- Explore predator/prey relationships and how human harvest affects such interactions.

Project objectives

1. Survey 400 (200 in FY18) rendezvous sites for presence and quantifiable number of wolves by 30 June 2018.
2. Develop methodology to estimate statewide wolf abundance and deploy 850 (450 in FY18) remote camera stations by 30 June 2018.
3. Develop one manuscript to evaluate wolf harvest relative to pack size, recruitment, and territory size by 30 June 2018.

Approach:

1) Make patch occupancy model more robust for estimating wolf abundance and distribution. Increase efficiency and sample size of hunter survey: We want to implement a web-based survey that is sent electronically to all big game hunters in Idaho to document their wolf observations. Such an effort would allow for greater accuracy and precision in resulting patch occupancy model estimates. A web page can be established for big game hunters for which no email address is available.

a) Survey potential rendezvous site habitat for wolves: Harvest can change animal behavior and habitat selection. We re-evaluated a predictive habitat model in summer 2015 and found it remains useful for predicting the locations of wolf pack rendezvous sites. We will survey all historic and highly suitable rendezvous sites in GMUs 4, 28, 33, 34, and 35. We will conduct howl and sign surveys at all predicted rendezvous sites and record all wolf sign observed in the sites as well as any incidental sign encountered. When an active rendezvous site is found we will collect fecal samples from all pup and adult scats present. Scat samples will be sent to the University of Idaho's Conservation Genetics Lab for DNA genotyping. A major benefit of this approach is that, even when pups go undetected, genotypes from scat samples can still provide information about pack size as well as data useful for populating an overarching patch occupancy model. Lastly, fecal DNA can be coupled with genotypes of harvested wolves to estimate harvest levels, survival, and recruitment.

b) Statewide camera stations: During summer, we will deploy camera stations at historic and predicted rendezvous sites throughout Idaho. We placed a 686 km2 grid (26.2 km x 26.2 km) over the state and allocated 1 camera for each grid cell. We did not include several GMUs in southern Idaho that did not have strong management interest and have not been occupied by wolves since reintroduction in 1995. Grid cell size was chosen by estimating a wolf pack's territory size from satellite collared individuals in Idaho. This grid yielded 212 static camera stations with >90% power to detect a 20% statewide population change. We will also test the potential for estimating wolf abundance solely from cameras by deploying 1 camera/50 km2 in GMUs 4, 28, 33-35. We will compare estimates from camera stations to an independent estimate of abundance derived from rendezvous site surveys and subsequent genetic analyses. We will then compare estimates from rarefied camera station data (e.g., 1 camera/100 km2; 1 camera/200 km2, etc.) to an independent estimate of abundance and determine the most efficient camera station density for estimating wolf abundance. Cameras will be installed on existing vegetation (preferable large trees). When existing vegetation is not sufficient for camera mounting a t-post or fence post will be used. Any post installed for camera monitoring will be removed at the end of the study.

c) Combine data into a patch occupancy model: We will use wolf detection data from hunter surveys, rendezvous site surveys, camera stations, and radio-collared wolves (collared as part of management survey and monitoring efforts, not research) to populate a patch occupancy model that will estimate statewide wolf abundance and distribution. Currently the number of packs estimated from the model is multiplied by average pack size. Such an approach may lead to spurious population estimates if pack sizes are highly skewed and if small packs are more difficult to detect and accurately count. Incorporating pack size as a probability distribution that can incorporate all of the variation around pack size, rather than simply using an average, may be a good method to obtain more accurate abundance estimates. Furthermore, if management-led, radio-collar monitoring indicates there has been a change in average territory size or other patterns of space use the model can be appropriately adjusted to incorporate such new information. Lastly, we currently define an area as "occupied" if >2 wolves are detected. Simulations may show that different definitions of detection (e.g., >4 wolves) yield more accurate population estimates. Additionally, we propose to combine data from 2 concurrent study areas in southwest Alberta and southeast British Columbia to create a meta-patch occupancy model that can be used to explore how adjacent management entities actions might affect wolf occupancy in Idaho and Montana.

d) Collaboration with MTFWP study: Montana Fish, Wildlife, and Parks (MTFWP) recently initiated a study employing two PhD students at the Montana Cooperative Wildlife Research Unit (MTCWRU) to explore the influences of territory and pack size on patch occupancy estimates. Further, they aim to expand a monitoring framework that uses patch occupancy and adaptive management to test hypotheses about the effects of harvest on gray wolf populations. Specifically, they plan to 1) improve estimation of recruitment, 2) improve and maintain calibration of abundance estimates generated through patch occupancy modeling, and 3) develop a framework for dynamic, adaptive harvest management based on achievement of objectives 1 and 2. The goals of this study will require empirical data for testing and our proposed study would collect such data. Both Montana and Idaho can likely learn far more by collaborating closely and sharing insights as these studies progress.

2) Evaluate link between harvest level, wolf recruitment, and pack and territory size. We will continue to collect tissue samples and genotype every harvested wolf. Matching genotypes of harvested wolves to those detected during rendezvous site surveys permits estimation of harvest level, survival, and recruitment in the focal study areas. The Department and MTCWRU have genetically sampled packs in GMUs 28, 33-35 each year since 2008 and the resulting data are allowing us to answer timely questions about how harvest affects pack composition, size, and recruitment. Coupling data from our proposed focal study areas with simultaneous satellite-collar work provides an ideal opportunity to explore relationships between harvest and pack size and recruitment. Additionally, such highly detailed genetic and spatial use data can allow us to explore potential links between breeder turnover events and fluctuations in territory size and subsequent occupancy rates.

3) Explore predator/prey relationships and how harvest affects those interactions. Our rendezvous site surveys in focal study areas can provide highly-detailed data for packs of management interest. As part of another project, numerous radiocollared wolves and elk are available in the focal study areas. By having large numbers of both predator and prey we hope to learn more about the influence of wolves on elk abundance and also how human harvest of both wolves and elk might affect those relationships. Stenglein et al. (2010) found rendezvous site surveys and the resulting genotypes yielded more accurate pack counts than radio telemetry. Rendezvous site information will be a critical piece for understanding the effect of harvest on wolves and, in turn, the potential effects of variable wolf densities on elk.

Project accomplishments

Objective 1: Survey 400 (200 in FY18) rendezvous sites for presence and quantifiable number of wolves by 30 June 2018.

We surveyed 281 predicted rendezvous sites and collected 1,554 genetic samples from July 2017-June 2018. We will use data from rendezvous site surveys to generate an independent measure of abundance so that we can compare abundance estimates derived simultaneously from camera stations. An M.S. student at the University of Montana defended a proposal for this work on 17 September 2018. Further, DNA collected during rendezvous site surveys as well as tissue samples collected from harvested wolves allows us to estimate harvest rates for wolves in focal study areas. Laboratory analyses for DNA collected in 2017-2018 have been completed and we expect to produce wolf group pedigrees in the coming months.

Objective 2: Develop methodology to estimate statewide wolf abundance and deploy 850 (450 in FY18) remote camera stations by 30 June 2018.

We deployed 463 cameras to test a method for estimating wolf abundance and for statewide wolf population monitoring from 1 July 2017 – 30 June 2018. All images taken by cameras were analyzed and categorized by species and number of animals present. Subsequent wolf detection data were used in a patch occupancy model to generate estimates of wolf occupancy by region statewide (Table 5). Additionally, we surveyed big game hunters for wolf sightings in spring 2018. Subsequent wolf observation data were used in a patch occupancy framework in an attempt to estimate wolf population trend statewide. Recent analyses indicated poor model performance using data from hunter surveys, thus we are assessing potential changes to our survey methodology and are also considering removing hunter survey data from our occupancy model.

Table 5. Estimated wolf occupancy from a model using images of wolves captured at camera traps in Idaho, summers 2016 and 2017.

Region	2016 Occupancy (95% CI)	2017 Occupancy (95% CI)
1	0.49 (0.45 – 0.56)	0.65 (0.64 – 0.68)
2	0.49 (0.44 – 0.56)	0.56 (0.53 – 0.60)
3 McCall	0.46 (0.43 – 0.51)	0.44 (0.40 – 0.48)
3 Nampa	0.37 (0.35 – 0.44)	0.42 (0.41 – 0.44)
4	0.35 (0.33 – 0.40)	0.15 (0.13 – 0.18)
5	0.02 (0.01 – 0.05)	0.01 (0.00 – 0.02)
6	0.22 (0.19 – 0.28)	0.27 (0.26 – 0.29)
7	0.46 (0.43 – 0.51)	0.38 (0.36 – 0.41)

Images from cameras are also being used to test a method for estimating wolf density from cameras. Estimates of wolf density from cameras will be compared to estimates derived from DNA sampling during rendezvous site surveys (see above). This work is being conducted with Dr. Paul Lukacs at The University of Montana and is expected to conclude in 2019. Lastly, images from cameras were also used to examine spatial and temporal overlap between humans, wolves, bears, and lions. A manuscript of those findings is in its second stage of revision with a peer-reviewed journal.

Objective 3: Develop one manuscript to evaluate wolf harvest relative to pack size, recruitment, and territory size by 30 June 2018.

This objective was met through the development of several publications. We recently published a manuscript entitled "Integrated population model to improve knowledge and management of

Idaho wolves" in the Journal of Wildlife Management. This work explores the effect of wolf harvest on wolf demography in Idaho. We also submitted a manuscript entitled "Stable pack abundance and distribution in a harvested wolf population" to the Journal of Wildlife Management. This paper uses population modeling as well as genetics to explore the effects of wolf harvest on wolf group stability and growth. Lastly, we recently completed analyses examining the effects of wolf breeding pair duration and breeding "sneaker" males on recruitment as a function of wolf harvest rate. We plan to complete a manuscript and submit for peer-review in the coming months.

Geographic Location

Big game hunter surveys and camera stations will be deployed statewide but rendezvous site surveys will be conducted in IDFG GMUs 4, 28, 33, 34, and 35 (Counties: Shoshone, Lemhi, and Boise). Cameras will be deployed in all GMUs in the State of Idaho. These GMUs overlap focal areas where radio-collared wolves and elk exist. These study areas encompass variability in wolf densities and harvest mortality rates. By focusing efforts in these areas we can untangle the relationship between pack size, recruitment, and level of harvest. This design will also provide detailed wolf abundance data that are necessary as we attempt to further understand predator/prey relationships, and the influence of human harvest on those relationships, within these focal study areas.

Prepared by: David Ausband

Mountain lion population monitoring

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students to obtain needed information. This project will help the Department and the fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs baseline information on mountain lion population trend and potentiality abundance in Idaho.

Purpose

Analyze and report on mountain lion data.

Expected Results:

- Mountain lion detection and camera efficacy at stations.
- Data used to populate an occupancy model and generate statewide population estimates.

Project objectives:

1. Survey deer & elk winter range for mountain lion presence and produce mountain lion abundance by 30 June 2018.
2. Collect DNA from captured or biopsy-darted mountain lion and produce mark-recapture abundance estimate for comparison with camera-based estimates of abundance by 30 June 2018.

Approach:

During September of each project year, in focal GMUs 33-35, 74, 75, and 77, we will move cameras used for wolf estimation to suitable habitat predicted by IDFG's mule deer and elk winter RSF model. We will affix cameras to existing vegetation where available or use t-posts or fence posts when vegetation is not suitable. Any post installed for camera deployment will be removed at the end of the study. Cameras will be active from 2 Oct – 30 April. Detections of mountain lions at camera stations will be used to estimate lion abundance with spatial mark-resight models. Mountain lion detection data will be rarified so that we can compare models populated with detections of single lions to extended models that include multiple states, including females with kittens as well as different time periods to assess closure. To provide a comparison and test of camera stations, we will tree lions in winter using hounds biopsy dart or chemically-immobilize them to obtain DNA samples (and radiocollar those immobilized) to generate an independent measure of abundance. We will attempt to enlist local hound hunters to tree lions and obtain samples by providing them with dart guns, sample kits, and reimbursement for expenses while sampling. The radiocollared animals will provide measures of space use for the spatial mark-resight models. We estimate up to 75 capture events per year of which we plan to radio collar at least 32 (16 males and 16 females) of those captured. The radio-collared animals will provide measures of space use for the spatial mark-resight models. We will also use backtracking of cougar tracks until hair or scat samples are located to attain DNA samples for mark-resight estimation.

Comparisons of camera station model results to an independent measure of abundance will provide a test of whether cameras are useful for such a purpose. If justified, further analyses using rarified camera data can provide insights for the most efficient sampling approach to estimate mountain lion abundance from camera stations. If cameras are reliable for detecting lions and estimating lion abundance we will expand the pilot study to include other GMUs that capture variability in predictive covariates of lion occupancy across the state. Potential areas include GMUs in the northern Panhandle, Owyhees, and Middle Fork of the Salmon River. Data from such areas can be used to populate an occupancy model and generate statewide population estimates.

Project accomplishments

Objective 1: Survey deer & elk winter range for mountain lion presence and produce mountain lion abundance by 30 June 2018.

During September 2017, we deployed 147 cameras in suitable habitat predicted by IDFG's elk winter resource selection function model in focal study area GMUs 33-35, 75 and 77. One camera was placed in each 10 km^2 grid cell and was active from 2 Oct – 30 April. Cameras yielded >400,000 images and an M.S. student at The University of Montana is analyzing these images. Additionally, the student successfully defended a research proposal in February 2018. Lastly, the student recently completed simulation work assessing how different movement rates of lions might affect population estimates derived from cameras.

Objective 2: Collect DNA from captured or biopsy-darted mountain lion and produce mark-recapture abundance estimate for comparison with camera-based estimates of abundance by 30 June 2018.

In winter 2017/2018 we obtained 107 mountain lion DNA samples comprised of biopsy darts from treed lions as well as scat and hair from backtracking lions in the focal study areas (GMUs 33-35, 75 and 77). DNA analyses are currently underway at the University of Idaho. Estimates of lion density derived from DNA marking and camera images will be compared to assess potential biases and identify possible areas for improvement with these relatively new techniques.

Geographic Location

Camera stations, captures, and backtracking will be conducted in Boise, Valley, Franklin, Bannock, Bear Lake, and Caribou counties.

Prepared by: David Ausband

Mountain goat population trend and/or abundance

Need

The Idaho Department of Fish and Game and the Idaho Fish and Game Commission are mandated by State Law to preserve, protect, perpetuate, and manage all wildlife in Idaho. The state's big game mammals, upland game birds and other species are of great social and economic value, and the state holds a public trust responsibility to manage these species in a manner that will preserve, protect, and perpetuate them as natural resources owned jointly by the citizens of Idaho into perpetuity. Fulfilling Idaho's public trust responsibility to Idaho citizens requires knowledge about each species and its relationship to its environment. To obtain this critical information, Idaho maintains a staff of highly trained professional wildlife research biologists, assisted on occasion by graduate students to obtain needed information. This project will help the Department and the fish and Game Commission acquire the necessary biological information needed to carry out their mission. The Department needs to investigate the efficacy of methods for monitoring mountain goat populations that limit or eliminate the need for aerial-based data collection.

Purpose

We will investigate the efficacy of methods for monitoring mountain goat populations that limit or eliminate the need for aerial-based data collection. The approach will be to develop a ratio-estimator of abundance.

Expected Results:

A method to estimate mountain goat population size without the use of aerial surveys.

Project objectives:

1. Produce 2 local mountain goat abundance estimates from new techniques, compared to estimates derived from traditional mark-resight techniques, for at least two mountain goat populations by 30 June 2018
2. Deploy 20 remote cameras in mountain goat habitat to develop mountain goat occupancy model by 30 June 2018.
3. Capture and collar 60 mountain goats for mark-resight abundance estimation by 30 June 2018.

Approach:

We will investigate the efficacy of methods for monitoring mountain goat populations that limit or eliminate the need for aerial-based data collection. The approach will be to develop a ratio-estimator of abundance. The ratio-estimator consists of two-stage sampling within the distribution of a particular mountain goat population. As an initial step, we will develop an occupancy model to identify areas likely occupied by mountain goats. Data for the occupancy model will be derived from remote cameras placed in potential mountain goat habitat. Cameras will be attached to existing vegetation (e.g., trees) or removable t-posts installed to hold the camera. T-posts will only be used when existing vegetation is inadequate and will be removed after the study. We may also place salt/mineral licks to attract or position mountain goats in front of the camera.

Results of this occupancy model will be used to identify areas for the first stage of the ratio-estimator: a broad scale survey to obtain a spatially explicit index of abundance. We plan to utilize IDFG personnel and/or a citizen science program in which volunteers will survey potential ranges of a particular mountain goat population. The second stage of the ratio-estimator will be a sample of areas within the identified potential range within which we will estimate mountain goat abundance. The ratio of the first stage to the second stage will be used to estimate range-wide abundance. We will investigate several methods for estimating local abundance for the second stage. These methods include newly developed approaches for estimating abundance of unmarked animals using remote cameras; mark-resight from fecal DNA; intensive surveys from ground observers or UAVs; or infrared surveys from fixed-wing aircraft or UAVs.

We will compare estimates from these local abundance estimation methods with mark-resight estimates derived from collared mountain goats. Mountain goats will be captured for collaring with a combination of aerial net-gunning and aerial and ground-based chemical immobilization via darting. Captured goats would be collared with a GPS or marking collar and body measurements and blood samples collected. Up to 30 mountain goats will be captured and marked per population during June through October.

Project accomplishments

Objective 1: Produce 2 local mountain goat abundance estimates from new techniques, compared to estimates derived from traditional mark-resight techniques, for at least two mountain goat populations by 30 June 2018.

We began this fiscal year with an investigation of potential study sites, including assessments of mountain goat density, access to mountain goat terrain, resources available in the host region, and regional prior knowledge of populations at several locations across Idaho. We selected the Palisades Mountains in the Upper Snake Region for the first season of this research, as it met the above criteria the best. We used GPS collar data from mountain goats monitored during a prior research effort to identify the boundaries of the final study area within the Palisades Mountains. We hired 3 technicians to assist in executing the new field techniques for estimating mountain goat abundance and population trends. We decided to investigate the use of independent double-observer ground surveys and remote camera trap surveys to estimate mountain goat abundance and compare estimates from those methods with a minimum count obtained for an aerial helicopter survey. We randomly-selected 35 unique 500 x 500 m cells, within which to conduct ground and camera surveys, from a grid of cell overlaid across the entire study area. We ordered 35 cameras and accessories for remote camera trap surveys and continued to refine field protocols and methods for both survey methods. Due to the high-elevation habitats and associated snow pack limiting access until mid-summer and a delay in the remote camera order, all field work was delayed until the early part of FY19. Continued testing of protocols and production of population estimates will occur in FY19 and FY20.

Objective 2: Deploy 20 remote cameras in mountain goat habitat to develop mountain goat occupancy model by 30 June 2018.

As in Objective 1, the high-elevation study site and a delay in remote camera delivery resulted in all field work being conducted at the start of FY19 and will be reported in the next reporting cycle.

Objective 3: Capture and collar 60 mountain goats for mark-resight abundance estimation by 30 June 2018.

We modified the project objectives to utilize mountain goat abundance estimates from a helicopter aerial survey to compare with camera and ground survey-based mountain goat abundance estimates. This change negated the need to capture and collar mountain goats and allowed us to compare the development of new survey techniques to the current standard (aerial survey) of estimating mountain goat abundance in Idaho.

Geographic Location

Surveys, camera stations, DNA sampling, and capture may be conducted in Adams, Blaine, Boise, Bonner, Boundary, Bonneville, Clearwater, Custer, Elmer, Idaho, Lemhi, Shoshone, Valley, Teton, and Washington counties.

Prepared by: Molly McDevitt, Frances Cassirer, and Shane Roberts

Submitted by: IDAHO DEPARTMENT OF FISH AND GAME

Approved by:

Toby Boudreau Federal Aid Coordinator	Scott Reinecker, Chief Bureau of Wildlife

FEDERAL AID IN WILDLIFE RESTORATION

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sale of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. The Idaho Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be responsible, ethical hunters. Seventy-five percent of the funds for this project are from Federal Aid. The other 25% comes from license-generated funds.