Update – Northeastern Washington Moose Demography Study

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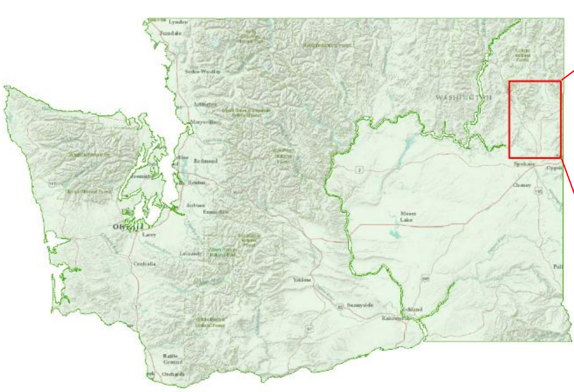
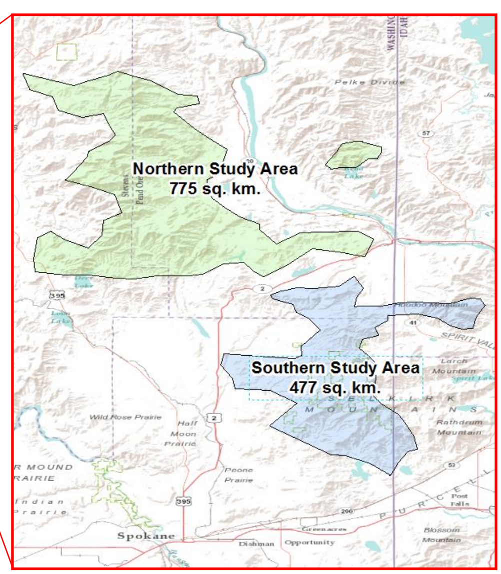
In cooperation with Washington Department of Fish and Wildlife (WDFW)

Introduction

We are currently four months into our third year of data collection studying the survival and reproduction of moose in NE Washington, as well as the behavioral strategies employed by these animals across the region's diverse habitats. We have recorded more than 700 approaches of GPS/VHF radio-collared adult female moose and their calves to estimate their fecundity (calf production) and survival. Additionally, we continue to obtain data regarding variation in risks and resources across our study area through: 1) camera-trapping for predator occupancy, 2) remote sensing for topographic and vegetation information, and 3) temperature recording within various habitat types to evaluate the availability of thermal refuge for moose.

Of the original 51 moose collared in winters 2013-14 and 2014-15 by WDFW personnel, 36 adult female moose are alive and on-the-air as of 28 September 2016 (17 = north, 19 = south). Calf production this year has mirrored that of the previous two years (approximately 0.68) and it remains to be seen if calf survival does the same (trends detailed below). Annual adult survival has averaged approximately 0.87 and the causes of mortality have been diverse. Data collection for this three-year project will be complete in June 2017, with results and conclusions presented in late fall 2017 (projected).





Images 1-2. Statewide and local study area maps.

Field work

Calf monitoring

With the assistance of volunteers and employees from The University of Montana, Washington Department of Fish and Wildlife and The Kalispel Tribe of Indians, year-round monitoring of collared moose and their dependent offspring continues. Collared adult females and their offspring are checked bi-monthly for general health and calf presence or absence beginning in May each year. Repeatedly monitoring these marked adults for calf presence provides the encounter history data needed to estimate calf survival rates throughout each year and across our study areas.

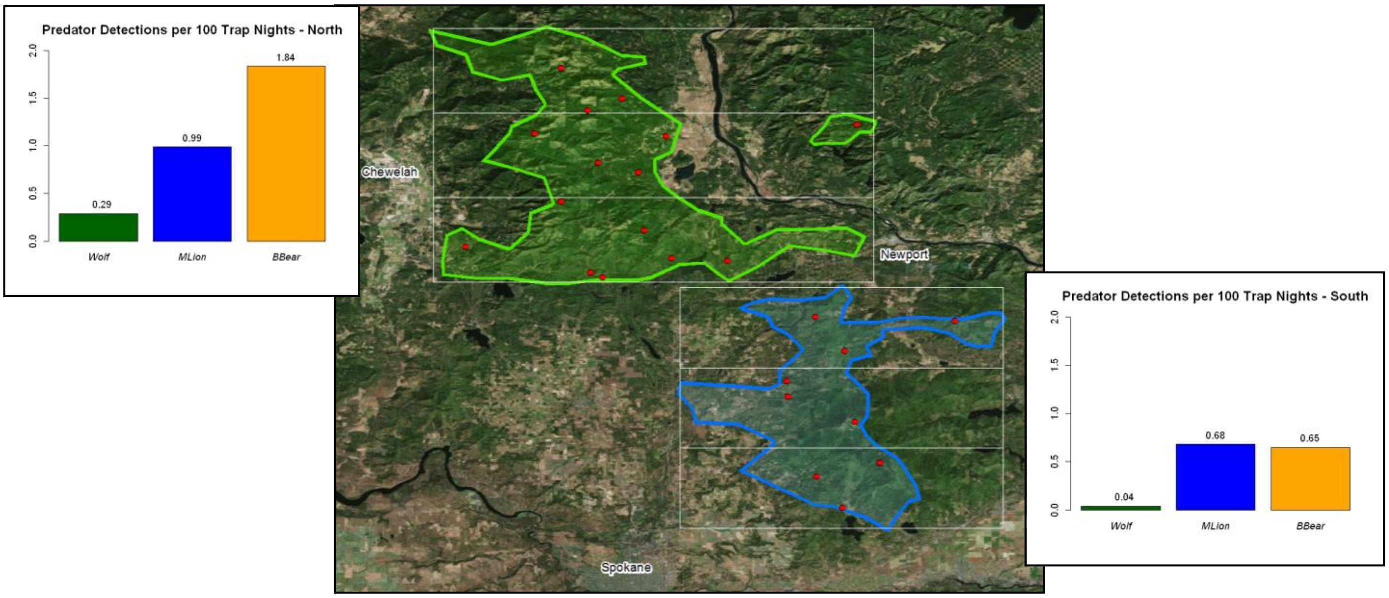
Image 3. Adult female 14186 with her 2014-2015 calf. Female 14186 has produced a calf and kept it alive for its first year of life each of the last three years. Understanding why some adult female moose are successful as mothers compared to others is one of several project objectives.

Predation risk

To understand the risk of predation faced by individual moose in our study we are currently employing a network of randomly-placed camera traps (n = 24) to detect predator species and estimate occupancy rates throughout our study areas. When triggered, these cameras provide a location-specific timeline of predator detections. For our purposes, the predator species of interest include black bears (*Ursus americanus*), mountain lions (*Puma concolor*) and gray wolves (*Canis lupus*). These three species are the most likely predators of moose in this region. Spatial variation in predator occupancy may help explain spatial variation in adult and calf moose survival if they exist. Camera arrays are placed for three-month intervals and collected for data download. We are currently deploying our fourth such rotation of cameras and will be rotating them twice more before spring 2017 when data collection ceases (total of 6 three-month rotations). To date, we have obtained 177 independent predator detections across our study areas (approximately 7,000 trap nights, data detailed below).

Images 4-7. Camera trap and trapping images obtained from stratified random sampling for predator occupancy across our study areas. Mountain lions and black bears are common detections in most areas, whereas gray wolves are rarely detected outside our northern sampling areas (see figures below).

Naïve metrics of predator occupancy indicate potential differences in wolf and black bear distributions between our study areas, less so for mountain lions. As cameras are continually rotated throughout our study areas, the additional data will determine if spatial estimates of predation risk are useful for understanding variation in adult and calf moose survival.

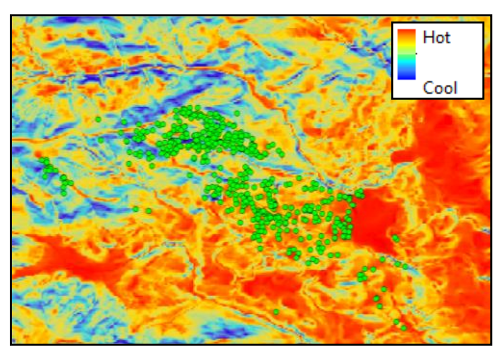


Figures 1-2 and Image 8. Sampling design for a single three-month rotation of game cameras (red dots) for estimating predator occupancy (proxy for predation risk). Data continues to come in, but naïve estimates indicate that detectable differences between our study areas currently relate to wolf and black bear presence – as hypothesized by local WDFW biologists. The data provided in the bar plots represent predator detections from three rotations thus far in the project (awaiting data on three more rotations).

Thermal refuge

Moose are a heat-sensitive species, therefore, selection of thermal refuge habitat is likely a significant contributing factor to the energy budgets, survival, and reproduction of moose – especially in their southern North American distribution (e.g. NE Washington). We continue to deploy temperature sensors randomly across elevations, slopes, aspects and habitat types to understand the effects of topography and forest structure on ambient temperatures experienced by our collared moose. Ten black-globe thermometers collect 15-minute temperature readings for 30-45 days and are then rotated to new locations within the study area. Currently, we have data on 60 such sites and anticipate no fewer than 60 additional sites before data collection ceases. In addition to temperature data, information recorded at these locations includes topography and vegetation type. These data will enable quality assessment of remotely sensed GIS layers as well as estimation of the influence of topography and vegetation type on daily and seasonal temperature fluctuations within each habitat. Gaining a thorough understanding of how topography and forest structure influence ambient temperature will allow us to map thermal refuge availability and evaluate potential selection or avoidance of those habitats by our GPS-marked animals.

Image 9. Raster composite of thermal refuge availability at a single point in time created by merging data layers of elevation, slope, aspect, and forest cover type. With additional information, we plan to increase this map's spatial resolution as well as make it dynamic to handle hourly changes in thermal refuge availability. (Green points represent locations used by moose 14185 during summer 2015 at 23-hour intervals).



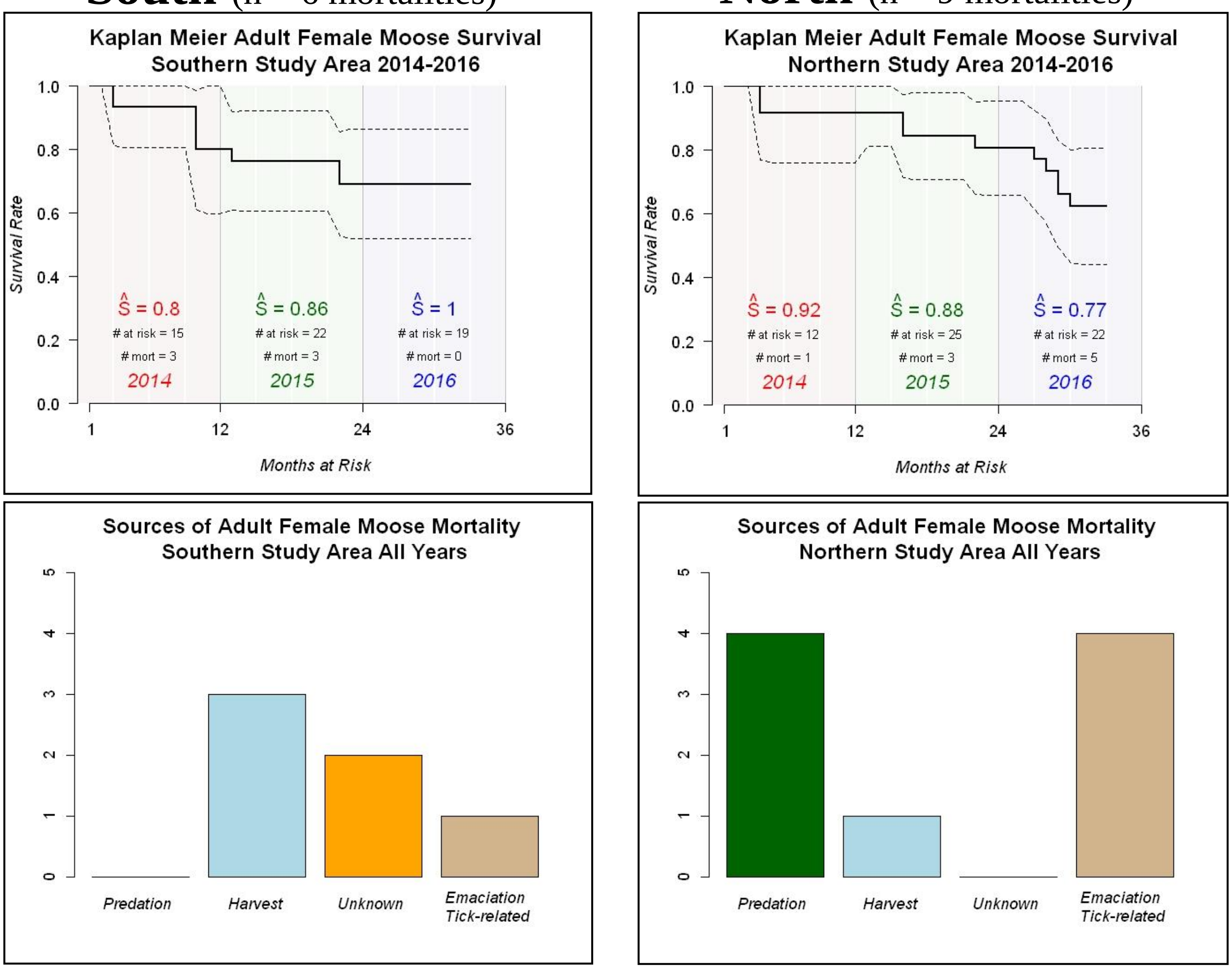
Variation in how moose select for or avoid certain habitats may help us understand the direct and indirect drivers of their survival and reproduction. Evaluating habitat selection in the context of balancing predation risk, thermo-regulation, and forage acquisition will not only provide useful demographic data, but also insight into how moose respond to co-occurring risks in their environment.

Preliminary findings

Adult survival

Annual adult female moose survival estimates and curves are presented below with bar plots of mortality causes by study area. 15 adult female mortalities have occurred (north = 9, south = 6) and from a variety of sources. Despite the descriptive figures below, with so few adult mortalities thus far, it is difficult to make inferences on drivers of adult survival. Additional time and further monitoring will be needed to detect variation in survival and cause-specific mortality if they exist. Importantly, it should be noted that many of the adult moose that succumbed to predation-related mortalities exhibited symptoms of poor body condition from winter tick infestation and/or old age (14 years old in one case), both of which may have pre-disposed them to predation.

South (n = 6 mortalities) **North** (n = 9 mortalities)



Figures 3-6. Kaplan Meier plots showing the annual survival rates by study area for 2.75 years of adult female moose data (2016 not yet complete). These survival plots are accompanied by bar-plots of cause-specific mortality by study area.

Pregnancy

Pregnancy data from blood serum collected at initial capture and fecal samples collected in years thereafter are currently being analyzed/interpreted and will be available soon.

Calf production

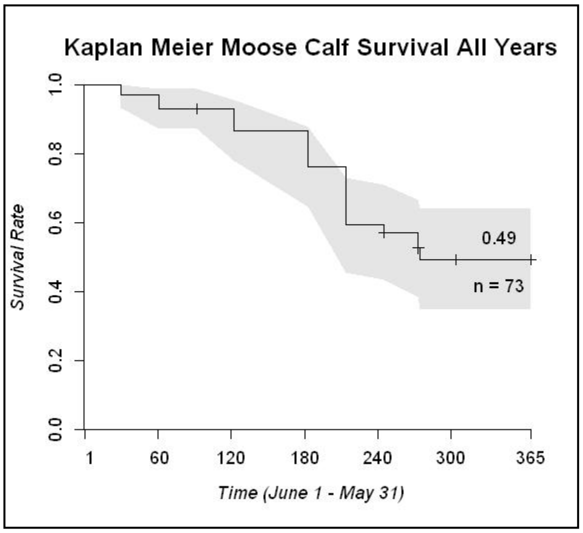
	2014-2015	2015-2016	2016-2017
Calf production	**0.71** *17/24*	**0.66** *29/44*	**0.68** *25/37*
Twinning rate	**0.08** *2/24*	**0.00** *0/44*	**0.03** *1/37*

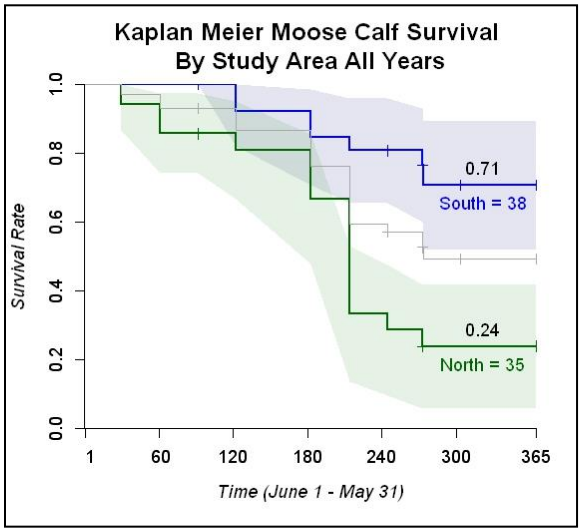
Table 1. Calf production and twinning rate estimates by study year as determined by on-the-ground monitoring (year 1 = 2014-15, year 2 = 2015-2016, year 3 = 2016-17). It is likely that some calves were born and died before they could be detected by field crews, however, we believe these cases to be few each year.

Ground monitoring adult female moose and their newborn calves has been challenging, however, repeatedly monitoring adults throughout spring and summer has provided reliable data on their productivity. Currently, we are not detecting any significant differences in calf production or twinning rates between study areas. It is possible that variation in these rates is driven by individual factors such as female age, home-range quality, and variation in habitat selection strategies.

Calf survival

Calf survival has been similar for each of the first two years of data collection (0.51, 0.48). Unlike adult survival, calf survival over the last two years varies significantly and consistently between study areas. Data from year-three could prove contrary to the previous two year's trends, however it appears that calf survival in the southern study area is higher than in the northern study area (see Kaplan-Meier survival plots below).





Figures 7-8. Kaplan Meier survival plots of overall calf survival as well as calf survival variation between study areas area. Collecting data on the biotic and abiotic characteristics in each study area (predation risk, habitat structure and composition, topography) may allow us to identify drivers of these trends. Because calves are not marked and vaginal implant transmitters were not used for exact birth timing in this study, June 1 each year was selected as the mean birth date for all calves observed.

Understanding the potential drivers of this variation is a primary objective of this project. We are considering multiple hypotheses regarding moose habitat use as it pertains to predation risk, thermo-regulation, and forage acquisition.

We continue to monitor the remaining radio-collared moose throughout northeastern Washington for survival as well as to collect the data needed to understand the environmental risks and resources they face. By late next year, we will have a better understanding of the region's moose population demographics as well as the ecological factors influencing it.

New Moose Project Technician – *University of Montana*

For the final year of data collection on this project, we have hired Liam Rossier as a full-time biological technician. He has volunteered on the project for more than a year already. He has proven his resourcefulness in the field and has dedicated hundreds of hours to tracking Washington's radio-collared moose. His history in Vermont (another moose state), his passion for hunting, and his interest in game management helped make him a clear choice for this challenging position. Don't hesitate to say hello if you see him in the field.

My name is William "Liam" Rossier and I am from a small town in Vermont called Vershire; population 600. Growing up in a rural setting gave me an appreciation for the outdoors and wildlife that roamed through our family's fifty-five acre farm. Throughout high school, my interest in wildlife grew into what I now consider to be both my vocation and avocation. After finishing my first year in the University of Montana Wildlife Biology Program I decided to take this year off from school in order to gain wildlife work experience, Montana residency, and to further my career in the field.

Acknowledgments:

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Image 10. Moose reporting flyer given to local landowners and posted throughout study areas. Public reporting of collared moose sightings have provided valuable supplementary data on calf presence which is cross-referenced with GPS data and our own ground monitoring efforts.